United States
Environmental
Protection Agency

EPA Region 3
Philadelphia, PA

EPA 9-03-R-00013C
June 2003

Mountaintop Mining/Valley Fills in Appalachia Draft Programmatic Environmental Impact Statement

APPENDIX E

Terrestrial Technical Studies

APPENDIX E:

Terrestrial Study Category, **Appendix E**

Study Topic	File Date
Terrestrial Plant (Spring Herbs, Woody Plants) Populations of Forested and Reclaimed Sites	03/2003
Terrestrial Vertebrate (Breeding Songbird, Raptor, Small Mammal, Herpetofaunal) Populations of Forested and Reclaimed Sites	9/2002
Soil Health of Mountaintop Removal Mines in Southern West Virginia	1/2001
Soil and Forest Productivity	10/2002, presented in Chapter III.B.4
Bird Populations Along Edges	5/2002

These reports are included in the appendix in black and white. Color versions may be viewed on the following website. http://www.epa.gov/region3/mtntop/index.htm

<u>Terrestrial Plant (Spring Herbs, Woody Plants) Populations of Forested and Reclaimed Sites</u> by Dr. Steven N. Handel of the Department of Ecology, Evolution, and Natural Resources of Rutgers University

The objective of this study was the following:

> *To determine the patterns of terrestrial vegetation on areas affected by MTM/VF and on adjacent, non-mined areas in order to understand the potential for re-establishment of native vegetation.*

Researchers used 55 transects from mine sites examined in southern West Virginia ranging in age from 8 to 26 years since revegetation. Even on the oldest sites, invasion of native tree species onto reclaimed mines from adjacent forests was minimal, and restricted to the first several meters from the adjacent forest edge. The study supports the conclusions of other researchers that past mining reclamation procedures limited the overall ecological health and plant invasion of mined sites, and that these lands reclaimed in this manner will take much longer than observed in old field succession to return to pre-mining forest vegetation. Less soil compaction, smaller mine areas, establishing healthy soil profiles, less aggressive grass covers along with salvaging and redistributing native plant material would support the return of a healthier ecosystem, although pre-mining biodiversity may be difficult to achieve.

The opinions and views in the studies in this Appendix do not necessarily reflect the position or view of the agencies preparing this EIS. These appendix cover sheets are provided as an aid to the reader to summarize the studies and also do not necessarily reflect the opinions and views of the EIS agencies.

The mined areas studied were not designed, engineered, reclaimed or revegetated with a post mining land use (PMLU) of forest (commercial or otherwise). The questions remains what effect the reforestation initiative recently started will have on reestablishing a healthy forest ecosystem. Past reclamation practices have impeded returning these areas to forests, and without changes in these practices, existing forest would be converted to grasslands for many years.

Terrestrial Vertebrate (Breeding Songbird, Raptor, Small Mammal, Herpetofaunal) Populations of Forested and Reclaimed Sites by Drs. Petra Wood and John Edwards of West Virginia University

This study evaluated wildlife use of reclaimed mountaintop mining sites compared to intact forest habitat in southern West Virginia. The objectives of the study are as follows:

> *Quantify the richness and abundance of the wildlife community in relatively intact forest sites of the pre-mining landscape and in the grassland, shrub/pole, and fragmented forest sites of the post-mining landscape to provide objective data on gains and losses in terrestrial wildlife communities. Specifically, for species that require forested habitats, compare the abundance of species in intact and fragmented forests. Quantify nesting success of grassland birds on the reclaimed grassland sites because grassland birds are declining in the U.S. due partially to the loss of habitat, and there has been the suggestion that these newly created grasslands are providing important habitat for grassland species.*

Four different habitat types were evaluated: 1) grasslands and 2) shrub/pole habitats on reclaimed mines, 3) fragmented forests predominantly surrounded by reclaimed land, and 4) large tracts of intact forest (to represent what would have been present before mining). The number of bird species and the abundance of birds were highest in shrub/pole habitats on the mines since the mix of habitat conditions provided more niches for greater bird diversity. Shrub/pole habitats were dominated by bird species that typically use “edge” habitats. Golden-winged warblers, a species of concern known to use shrub habitat created by contour mines, were observed at only three stations (out of 33 shrub/pole stations), all on the Cannelton mine. Grassland habitats were dominated, by grassland bird species such as grasshopper sparrows and meadowlarks. Forest-interior bird species were significantly more abundant in intact forest than in any other habitat type; the cerulean warbler, a species of concern, occurred at higher densities in intact forests in the study area than has been reported from other locations in West Virginia. The report concluded that populations of forest birds may be adversely affected by the loss and fragmentation of mature forest habitat in the mixed mesophytic forest region, which has the highest bird diversity in forested habitats in the eastern United States. Fragmentation-sensitive species such as the cerulean warbler, Louisiana waterthrush, worm-eating warbler, black-and-white warbler, and yellow-throated vireo will likely be negatively impacted as forested habitat is lost and fragmented from mining. Extensive areas of grasslands are not natural habitats in the study area, and most of the grassland bird species that use the reclaimed mines have extensive breeding areas in North America. In contrast, some of the forest interior species that disappear after mining have small geographical ranges, and the core of their geographic range is centered on the forests of the study area.

Raptors were found to use the various habitats as would be expected depending on habitat requirements of each species. Species richness of small mammals did not differ between the four habitat types. Reclaimed grassland habitats may produce more *Peromyscus* spp. (white-footed and deer mice). The Allegheny woodrat, a species listed as threatened/endangered in nine states including Virginia and West Virginia, was present in ten out of 20 riprap drainage channels surveyed on two different mines; however, woodrat habitat in intact forests was not surveyed so a comparison of woodrat abundance on reclaimed mines vs. intact forests cannot be made. Abundance and richness of herpetiles did not differ significantly between the four habitat types, but a shift was observed from a majority of amphibian species in the two forested habitat types to a majority of reptile species on the reclaimed areas. In particular, salamanders decreased while snakes increased.

The study answered questions related to the effects of mountaintop mining on wildlife and their habitats, including species of concern. The researchers were not asked to evaluate game species. Although this is not a shortcoming from the standpoint of understanding the ecological implications of mountaintop mining (most game species are generalists and, therefore, poor indicators of ecological health) some may see this as an issue.

Bird Populations Along Edges by Dr. Ron Canterbury of the Department of Biology, Concord College

Shrub/forest edges were used by more forest interior bird species, interior-edge species, and edge species than other edge habitat types. Grassland birds were more abundant at edges between grasslands and fragmented forests than at other edge types. Forest interior birds generally declined in grassland/forest fragment edges as opposed to grassland/intact forest edge.
This study was designed to evaluate the following characteristics:

> *Specific habitat areas on mines and seasonal use of habitats by birds to fill in data gaps about bird use of mountaintop removal mines and edge habitats on the mines to determine the extent to which they are used by birds.*

Canterbury also documented winter use of habitats. American crows and dark-eyed juncos were the most abundant species observed in winter. Blue jay, Carolina chickadee, pileated woodpecker, sharp-shinned hawk, tufted titmouse, white-breasted nuthatch, and yellow-bellied sapsucker were more abundant in forest interior than in edge locations. European starlings, eastern bluebirds, eastern meadowlarks, and horned larks were abundant in mine grassland and shrub habitats.

During the spring migration period, mine grasslands were used by European starlings, turkey vultures, eastern meadowlarks, and tree sparrows. Field sparrows were the most common species observed in shrub habitats. Red-eyed vireos and wood thrushes were the most abundant migrants in forested habitats. During the fall migration season, no long-distance migrant that does not breed in the area was noted on mine grasslands; however, the migration counts were terminated early due to deadlines in the EIS process. The white-eyed vireo was the most abundant fall migrant in shrub habitats, while the Carolina chickadee was the most abundant fall migrant in forested habitats.

The study addresses another aspect of the effects of mountaintop mining on wildlife and their habitats. Bird use of mines during fall migration may not have been fully characterized, as migration counts were terminated early due to EIS deadlines.

Soil Health of Mountaintop Removal Mines in Southern West Virginia by John Sencindiver, Kyle Stephens, Jeff Skousen, and Alan Sexstone of West Virginia University

This study, was designed to evaluate physical, chemical, and microbiological properties of minesoils developing on reclaimed mountaintop removal coal mines in southern West Virginia. Minesoils of different ages and the contiguous native soils were described and sampled on three mines. Routine physical and chemical properties were determined as well as microbial biomass C and N, potentially minerizable N, and microbial respiration. All minesoils were weakly developed compared to native soils, but most had a transition horizon (AC) or a weak B horizon developing. The authors concluded that the minesoils are approaching stable, developed soils and should become more like the native soils as they continue to develop.

The study does not attempt to answer questions such as how long it might take the mined soils to become like native soils.

MOUNTAINTOP REMOVAL AND VALLEY-FILL MINING ENVIRONMENTAL IMPACT STUDY

BIRD POPULATIONS ALONG EDGES REPORT FOR TERRESTRIAL STUDIES

May 10, 2002

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Introduction

Problem Statement

Mountaintop mining is a method of removing soil and rock to expose multiple coal seams. Valley fills are produced when earth and rock, extracted from a mountaintop mining site, are placed into an adjacent valley. Mountaintop mining, like contour mining and logging activity, creates considerable edges and patchy habitats. The impacts of edges and patch size and type produced by mining activity are largely unknown. Despite a large number of avian edge studies in forest-dominated landscapes, studies in mine-altered landscapes are scarce. Likewise, recent effort has focused on breeding bird communities without much attention directed to avian stopover ecology and migration and relative abundance during the winter months. Because of increasing size of mountaintop removal/valley fill (MTRVF) operations as well as in the number of mining permit applications, West Virginia may continue to become increasingly fragmented. For example, there were at least 26 permits issued for operations on Kayford Mountain from 1971-1983 and at least 70 mountaintop removal permits issued since 1970. Although suburban sprawl and other factors contribute to forest fragmentation and edge effects, MTRVF has generated considerable concern as to whether it contributes to the commonplace phenomenon of edge effects. Edge effects include increased rates of nest parasitism by cowbirds, nest depredation, and changes in population structure. In this study, we quantified avian diversity and relative abundance along four treatment habitats. Habitats studied were young (grassland) reclaimed mines, older (shrub/pole) reclaimed mines, fragmented forests, and relatively large (intact) forests. Specifically, we sampled birds along ecotones where two treatment habitats joined and compared avian abundances in edge and interior habitats in contour and MTRVF mines. Data were collected in spring, summer, fall, and winter months in order to examine seasonal changes in avian species composition across treatment habitats.

Background and Justification

Edges or ecotones can be defined as areas created by the juxtaposition of distinctly different habitats or as zones of transition between habitat types (Ricklefs 1979). There is a tendency for increased variety and density of organisms at habitat junctions (Odum 1971, Alverson et al. 1988, Reese and Ratti 1998, Robinson 1988, Yahner 1988). During the last several decades, researchers have collected evidence that edge or ecotone habitats generally harbor higher avian diversity than interior forests. Others argue that edge populations are sinks, where reproductive output is inadequate to maintain local population levels. Sink populations must be replenished by emigration from source populations. However, most studies in forest-dominated areas have not documented a relationship among sink populations, nest predation, and edges (Yahner and Wright 1985, Small and Hunter 1988, Storch 1991, Rudnicky and Hunter 1993, Haskell 1995, Hanski et al. 1996). A few researchers have found higher nest predation and cowbird parasitism along edges (Brittingham and Temple 1983, Gates and Gysel 1978, Chasko and Gates 1982, Wilcove 1985, Martin 1988, Small and Hunter 1988, Robinson et al. 1995). Apparently, variation exists across edge types and spatial and temporal patterns.

Landscapes across the world are highly fragmented with little interior forests remaining, except for a few places such as eastern North America (Riitters et al. 2000). Clearly, many problems arise because of the variation in types (and causes) of fragmentation and the definition of forest (by size, vegetation, etc.). Nevertheless, studies of the effects of forest fragmentation on breeding birds have suggested that some bird species are sensitive to a reduction in forest area (e.g., see Whitcomb et al. 1981, Robbins et al. 1989). We know that many species of songbirds are declining (e.g., see Askins et al. 1990). This is true of both forest-interior and open-country species. Some specialists, however, argue that many forest species have recovered (from declines that probably started in the 1960s) with advancing forest regeneration in the Eastern U.S., and that we should therefore be more concerned with the sharp declines of many grassland and shrub/edge species (Hill and Hagan 1991, Peterjohn and Sauer 1994a and 1994b, Thomas and Martin 1996, Sauer et al. 2000). For example, data from the North American Breeding Bird Survey (BBS) indicate that populations of the Dickcissel and Henslow s Sparrows have declined by about 39% and 91%, respectively, during the last 30 years (Peterjohn et al. 1994b, Pruitt 1996, Herkert 1997). Hunter et al. (2001) documented that none of the 60 species of eastern, forest-associated landbirds are considered vulnerable in eastern North America at this time, and that only two non-disturbance dependent forest species (Bicknell s Thrush and Prothonotary Warbler) are on the Watch List. The Watch (Blue) List is a National Audubon Society and American Bird Conservancy documentation of avian species in rapid decline and before they are federally listed as threatened or endangered (Arbib 1971, Tate 1981, 1986, Ehrlich et al. 1988, Carter et al. 1996, Pashley et al. 2000). Of the 60 avian species in eastern North America that are not dependent upon disturbance, only 15% are declining. Therefore, Hunter et al. (2001) focused their attention on the rapid declines of grassland and shrubland birds (disturbance-dependent species). Studies show that Eastern North America had considerable pre-colonial shrub habitat and that many localized areas supported extensive areas of secondary succession (Litvaitis et al. 1999, Askins 2000, Hunter et al. 2001). Consequently, the prevailing view of the Eastern deciduous forest as the exclusive pre-colonial habitat is unfounded (Day 1953, Litvaitis et al. 1999), and the disappearance of shrub/grassland birds in the eastern U.S. is of great concern.

Despite the concern over disturbance-dependent species, many researchers have focused attention on forest-interior species in areas such as West Virginia, where large tracts of forest remain that harbor potentially viable source populations for species such as the Cerulean Warbler and Wood Thrush. A number of mature forest-associated species are dependent upon some disturbance that maintain small openings and are declining (W. Hunter, pers. comm.), and some argue that the forest-dwelling, short-distance migrants are no longer doing better than long-distance forest migrants (J. Confer, pers. comm., Sauer et al. 2001).

Mountaintop removal and valley fill mining creates grasslands and forest fragments of various sizes and degrees of isolation, in addition to a mosaic of edge types. As a consequence, species richness and abundance within different trophic assemblages may vary with forest size and structure (e.g., see Martin 1981). Some forest-interior species require a minimum forested area, while others (e.g., shrub guild) expand in number in patchy, fragmented habitat with increasing edge. Small patches of forest consist of mainly edge habitat (Forman and Godron 1981) and are dominated by birds that feed on a wide variety of food items along the edge (Martin 1981). Forest edge often supports a greater diversity and abundance of food than does forest interior (Ranney et al. 1981, Lovejoy et al. 1986, Fowler et al. 1993, but see Burke and Nol 1998, Robinson 1998), which may favor short-distance migrants at the expense of foliage insectivores. Foliage insectivores are predominantly long distance-migrants and many prefer large tracts of forest (Whitcomb et al. 1981). Thus, habitat change, such as that induced by MTRVF, is likely to produce trade-offs between forest-interior species (many of which are Neotropical migrants) and grassland/shrub guild birds (many of which are short-distance migrants or resident species). However, long-term studies on mine lands in secondary succession in southern West Virginia suggest that secondary succession occurs faster than predicted on contour mines and that edges created by mineland are, in fact, more diverse in avian species richness and abundance than interior forest (Canterbury et al. 1996, Canterbury and Stover 1999, Stover and Canterbury, in press). These contour mines were created by cutting into the hillsides and creating a level bench with highwalls. These studies further demonstrated that edge and shrub species occur in the same general area and territories as forest-species, and that the relative abundance of both groups is exceptionally high for short periods of time (up to 20 years after reclamation).

In this study, we test whether there is an edge effect, i.e., whether avian population structure is drastically altered by MTRVF induced-habitat changes. Specifically, we test for a relationship between avian species richness or density and edge, and whether there is a trade off between forest-interior species and disturbance-dependent (grassland and shrub-guild) birds? To determine the impact mountaintop mining on avian abundances along a mosaic of edge habitats, we quantify bird-habitat associations along edge habitats produced by MTRVFs and compare avian abundances at edges and interior plots throughout mine sites in southern West Virginia.

Many previous studies of birds on mine lands were conducted during the breeding season and often did not stress migration and winter season bird-habitat associations (see Brewer 1958, Yahner and Howell 1975, Chapman et al. 1978, Whitmore and Hall 1978, Allaire 1979, 1980, Whitmore 1979, 1980, Strait 1981, LeClerc 1982, Wray et al. 1982). We know very little about the impacts of edges on avian migration and stopover ecology and winter ecology. What avian species are using edge habitats of MTRVF in winter and migration periods? A major objective of this study was to assess seral and edge stage variation in bird distributions along mountaintop mine sites and intact forest watersheds during the winter and migration periods.

Winter is a time when populations are resident and relatively stable, and thus, provide important data on survivorship and interpretation of population trends (e.g., see Robbins 1981, Yahner 1993). Survivorship is highly dependent upon successful migration and/or winter ecology (Stearns 1992). Migration is also a critical time in the lives of migratory birds, especially the Nearctic-Neotropical migrants that breed in temperate North American and spend their winter in Central and South America. Neotropical migrants must find adequate fueling and shelter areas during migration and, thus, a changing landscape pattern may prove detrimental to their survival.

Stopover ecology of migrant landbirds is a pressing environmental issue, since many key stopover areas in North America have been degraded or destroyed by suburban sprawl and development. Consequently, monitoring programs have generally focused on delineating migration pathways and critical stopover habitats (Moore et al. 1990, Wilson et al. 2000). Studies of avian migration biology in West Virginia and throughout the Eastern U.S. have disclosed some interesting phenomena and trends. First, it is clearly documented that a substantial amount of shrub habitat in a mosaic of forests is needed for migrant landbirds (Hall 1999). This would implicate older (shrub/pole succession) mountaintop and contour mines as potentially important habitats for avian stopover. On the other hand, there may also be a need for forested ridgetop habitat where significant migratory flights occur. This latter type of habitat is where most migrants are captured for banding within the state at our two major banding stations (Allegheny Front Migration Observatory or AFMO in Grant County, and Three Rivers Migration Observatory or TRMO in Raleigh County).

Avian migration biology has been traditionally documented by labor-intensive mist-netting and bird banding (e.g., Winker et al. 1992, Morris et al. 1994), which is one of the most robust methods for determining species richness and abundances as well as estimating population trends (Karr 1981, Williams et al. 1981, Conner et al. 1983, Hagan et al. 1992, Rappole et al. 1993, Buckley et al. 1998). However, less labor-intensive methods (e.g., those that rely on count surveys) are often also employed. The line transect method of counting birds, for example, is one of the most frequently used and accurate assessment techniques to assess bird populations. The ecological literature on line transect methods is enormous. The line transect method is often employed in open terrain, but is also used along forest trails. Line transects in forested landscapes have been shown to be more useful for monitoring spring migrants than point counts (Wilson et al. 2000). Variable size transects are often employed in research protocols and include, for example, 100, 250, and 400 meter length transects (see Ralph et al. 1993 and Wilson et al. 2000).

Therefore, another objective of this study was to quantify avian relative abundances along transects during the spring and fall migration seasons at MTRVF sites. The study will serve as an indicator of which bird species are utilizing MTRVFs, but should not serve as a replacement for long-term bird-banding studies (see Canterbury and Stover 1998, Hall 1999). This is especially important since substantial between-year variation exists in migration patterns, as well as significant species-specific, temporal, and spatial variation in avian migration ecology.

Historical Perspective

In the late 1980s, studies suggested that forest-dwelling Neotropical migrants were in widespread decline (e.g., Terborgh 1989). Studies that now encompass a longer time span suggest that these early warnings were overstated. After decades of analyses, a much different, albeit murkier, overall picture for forest birds indicates that their populations are in relatively good shape. Overall populations of many forest dwelling species are stable or increasing (Rosenberg et al. 1999a, 1999b, Sauer et al. 2000), while grassland-dwelling birds tend to be worse-off (Knopf 1994, Herkert et al. 1993, Vickery and Herkert 1999, Sauer et al. 2000). Grassland bird populations have shown steeper, more consistent, and more geographically widespread declines than any other avian guild in North America (Knopf 1994, Ruth 1996, Askins 2000). BBS data from 1966-1993 show that almost 70% of the 29 grassland bird species had negative population trends (Peterjohn et al. 1994, Hunter et al.

2001). Grasshopper Sparrows have declined by nearly 70% during the past 25 years (average of 6% decline per year), while the Eastern Meadowlark is down 43% (Peterjohn et al. 1994).

Avian composition is noted to change with advancing secondary succession (Bock et al. 1978). Grassland birds distribute vertically in feeding height and horizontally by habitat preference (Cody 1968). Forest species are known to show vertical and horizontal distribution along a continuum from forest edge to mature forest (James 1971), while old field birds are known to be scattered along a cline in shrubbiness habitat (Posey 1974). Vegetation-bird associations of grassland birds are fairly well studied (e.g., Grzybowski 1983, citations in Swanson 1996). However, grasslands are considered by many to be the most endangered ecosystem worldwide (Herkert et al. 1993, Samson 1998) and support a group of birds whose distributions are not centered in heavily forested states (e.g., Pennsylvania, Gross in Crossley 1999). Some heavily forested states (e.g., West Virginia), and states with little forest cover (e.g., Ohio) have both experienced drastic declines of species such as the Bobolink and Henslow s Sparrow. The Henslow s and Bachman s sparrows, for example, have been nearly extirpated from West Virginia as breeding birds (Buckelew and Hall 1994, Canterbury, unpubl. data).

Population trends vary in space and time and much contradictory information exists. For example, the East Coast and Midwest have suffered significant forest bird losses, while bird populations in some Appalachian forests have been maintained or increased. Variation in avian population structure exists, where some forest-dwelling species are doing well in the Allegheny Plateau and Ohio Hills, but declining in the Southern Blue Ridge (W. Hunter, pers. comm.). The Cerulean Warbler has declined by 51% and the Wood Thrush and Eastern Wood-Pewee have declined by 41 and 34%, respectively (Sauer et al. 2000). Others, such as the Scarlet Tanager, show stable populations but significant local declines, such as along the Atlantic Coast (Rosenberg et al. 1999a). A close examination of forest-dwelling species associated with small forest openings and forest edges reveals that 45% of 30 species are undergoing long-term declines or are recently declining in eastern North America (see Table 5, p. 450-451 in Hunter et al. 2001). Conversely, some forest species, such as the Cerulean Warbler, are numerous and probably not declining in parts of West Virginia (see BBS data cited in Buckelew and Hall 1994, Rosenberg and Wells 1995, Rosenberg et al. 2000). West Virginia is the center of abundance for some forest species, such as the Cerulean Warbler and, thus, any manipulation to the forest and forest management practices should be evaluated.

Despite massive habitat changes (e.g., the entire eastern US was heavily logged during the late 1800s and today we are faced with rapid suburban sprawl), many forest species have shown resilience. Adaptation of forest dwelling species to mine-altered lands provides another example of the resilience of forest species (Canterbury and Stover 1999). Although a few eastern species, such as the Ivory-billed Woodpecker, Carolina Parakeet, and the Bachman s Warbler, disappeared, there is now more forest than a century ago and new trouble for the grassland and shrub birds. Advancing succession has favored forest-dwelling species over shrubland birds, but industry practices (logging and mining) have created a mosaic of habitats that can support both shrub and forest species (Canterbury and Stover 1999). The question remains for how long will shrub species, such as the Golden-winged Warbler, continue to thrive in the heavily forested, second-growth areas that dominate our contour mines in southern West Virginia (Canterbury et al. 1993, 1996)? Second-growth forests that may appear good habitat for Golden-winged Warblers, however, may be a trap or sink for forest-dwelling species such as the Cerulean Warbler. Such differences in source and sink populations may explain contradictory data and geographical variation in avian population declines.

The literature is full of papers that show a decline of forest-dwelling species (e.g., Wood Thrush) due to habitat fragmentation produced by agriculture and suburban sprawl (see review by Robinson [1988] and synopsis of Villard [1998]). A comparison of edge types created by mining/logging activity in heavily forested West Virginia with those created by agriculture and suburban sprawl should be made with caution, since these edge types are strikingly different and surrounded by different landscapes. It is not valid to assume that the fragmentation impacts due to mining will mirror those due to agriculture and small, patchy forested landscapes created by sprawl. Data from southern West Virginia suggest that some species of forest bird populations are depressed by increasing sprawl / development and burgeoning deer populations rather than mining and logging activities (Canterbury 1999, Canterbury 2000a, Stover and Canterbury, in press). This may explain why most forest-canopy species, such as the Red-eyed Vireo and Scarlet Tanager, are increasing, while a number of ground and understory nesting songbirds (e.g., Hooded and Kentucky warblers) are declining (Stover and Canterbury, in press).

Substantial research has documented that edge effects depend upon landscape context and percent forest cover in eco-regions (e.g., Appalachian) and that overall landscape must be considered in evaluating impacts of fragmentation (Donovan et al. 1997). Recent approaches have been aimed at forest management for declining songbirds (Thompson et al. 1992, 2000). Most studies that document negative impacts of fragmentation on forest-dwelling birds have been conducted in highly fragmented landscapes with agriculture edges (Herkert 1995, but see Hoover et al. 1995). It remains unknown whether negative effects occur in the highly forested West Virginia landscape with edges created mainly by logging and mining activities. Predation rates are often higher near the forest/farmland edge than in forest interior or large forest tracts (Gates and Gysel 1978, Wilcove 1985, Andrén and Angelstam 1988, Andrén 1992, Angelstam 1992, Hoover et al. 1995), but the same does not apply for edges between forests and clearcuts or edges produced by MTRVFs (Canterbury and Stover, in press). Variation in predation rates and number of predators in rural vs. suburban settings and forest/farmland mosaics exists (Yahner and Morrell 1991, Donovan et al. 1997). This may indicate that the notion of an ecological trap (by attracting birds to establish territories on edges where food supplies may be greater but nest predation is increased) [Gates and Gysel 1978]), may not apply in all fragmented landscapes (Wiens 1995).

A clearer picture about the impacts of MTRVF mining can be drawn if we consider bird populations across a variety of successional stages and edge types and document changes accordingly. Effort should be made try to conserve for the future rather than predict the past (i.e, what birds should be present and in what densities before mining disturbance). Many studies on mine-altered landscapes have compared pre-mined with post-mined lands or fragmented forest tracts with contiguous tracts. Such comparisons are problematic for at least two reasons. These include (1) a continuum of human-induced habitat alterations and (2) the misconception that the pre-colonial eastern landscape was almost entirely forested. Habitats will continue to be altered, whether through suburban sprawl, forestry industry, parks and tourism, agriculture, or even mining. It seems logical to document how birds respond to changing landscapes rather than to try to predict the presence or absence of forest species or document potential declines of forest-interior species in post-mined land as compared to pre-mined.

At the time of arrival of Europeans in North America about 50% (445 million ha.) of the land was forested (Yahner 1995). About three-fourths of this forested land was located in the eastern half of the continent and remained relatively undisturbed until the late 18th century (Rosenberg et al. 1999b). By 1850, an estimated 48 million ha. of forest in the eastern United States was converted to agriculture, and much of the remaining forest land was cut (Rosenberg et al. 1999b). Today, despite extensive fragmentation throughout the eastern U.S., many regions, such as the Appalachians are still heavily forested (Rosenberg et. al. 1999b). West Virginia, like many other areas in the Appalachian Region, is primarily covered in forest (76% of the land cover) and is the third most heavily forested state in the nation (West Virginia Forestry Association, pers. comm.). The amount of land in West Virginia affected by large scale surface coal mining, including mountaintop mining, is small but steadily increasing. Mountaintop removal mining dates back to the early 1970s and Arch Coal, for example, has conducted MTRVF mining since 1975. Since 1977, 0.6% of the total West Virginia land cover has been large scale surface mined (West Virginia Mining and Reclamation Association).

Mountaintop mining is a specific technique of land use that requires forest harvest before coal extraction. The current harvest of trees from West Virginia forests is exceedingly high and based on numerous economic motives. Despite the fact that much of the forest lands in West Virginia have been recently subjected to selective and clear-cutting, forestry practices have not been subjected to similar scrutiny as mining practices. Both logging and mining merit further study on whether they promote the loss of forest-dwelling birds due to fragmentation. Both techniques of mining and logging promote forest disturbance and an increase in gaps and edges. These methods of land use create habitat for shrub/edge species such as the Chestnut-sided and Golden-winged warblers, whose pre-European populations may have been maintained by naturally-induced modes of secondary succession.

Heavily forested states such as Pennsylvania had some open habitats, such as grasslands and old fields, prior to European settlement (Day 1953, Cronon 1983, Williams 1989, Gross in Crossley 1999, Askins 1994, 2000). Prior to European colonization, early-successional and shrub-dominated habitats were widely distributed throughout the northeastern United States (Litvaitis et al. 1999). Fires (including those intentionally set by aboriginal people), wind storms, and especially beavers (*Castor canadensis*) were likely the major forces that set back succession and perpetuated shrub habitats (Litvaitis 1993, Litvaitis et al. 1999, Hunter et al. 2001). These factors promoted the expansion and increase of shrub species, such as the Chestnut-sided Warbler. At present, shrubland birds, such as the Yellow-billed Cuckoo, Golden-winged Warbler, Prairie Warbler, and Field Sparrow are declining (Peterjohn et al. 1994). Only 1 (the Blue Grosbeak) of 16 Eastern shrubland bird species has shown a significant population increase since 1966 (Sauer et al. 2000). Loss of substantial amounts of early successional habitat is widespread, especially evident in the reforested northeastern United States, and has been documented as a major cause of the widespread reduction in shrubland bird species (Hill and Hagan 1991, Witham and Hunter 1992, Litvaitis 1993).

EIS REPORT

In eastern North America, shrub habitat is ephemeral and, if left to succeed, is replaced by forest at variable rates (Confer and Larkin 1998). In New York and West Virginia, for example, early successional fields are dominated by herbaceous growth for about 10-20 years and shrubs are abundant for about 15-30 years after cessation of farming (Confer and Larkin 1998, Canterbury, unpubl. data). Succession after clear-cutting is rapidly dominated by sapling growth (Confer 1998). Pimm and Askins (1995) described the regional shift in farmland abandonment which started in New England and moved westward across the United States with emphasis on local extirpation of both shrub and forest bird species. Although grassland birds as a group are in severe decline, management practices are underway and it is anticipated that the beef and dairy industry will maintain some pasture and hay fields (Confer and Larkin 1998). Despite the creation of successional habitats by these industries, they may not be good for grassland species because of frequent mowing and too much grazing. Similarly, previous declines in some forest-dwelling species have been reversed by advancing reforestation (Confer and Larkin 1998). In contrast, the shrub habitat has no economic incentive for management and the decline in the rate of farmland abandonment (Census of Agriculture 1992) may cause the shrub guild birds to surpass all other guilds in the rate of decline (Confer and Larkin 1998, Litvaitis et al. 1999). Practically, the only management of shrub habitat is usually on state land for game species and utility rights-of-way, which is not enough.

The trade-off between forested and non-forested lands will continue because of human population growth. The US population is currently estimated at 281.4 million (Census Bureau, http://www.census.gov), and increasing rapidly. The burgeoning human population and their destruction of habitats will continue to increase our demand for fuel and anthropogenic changes of the landscape. These pressures will lead to additional fragmentation of the eastern U.S. forests by additional mining and timbering. Therefore, as part of the environmental impact study (EIS), we include some data on a long-term study of birds in the southern West Virginia coalfields. This long-term study may facilitate management plans by providing a clearer picture of bird-habitat associations.

Methods

Study Areas and Selection of Sampling Plots

This research was part of a larger EIS study and a subcomponent of the terrestrial studies. The study areas included three mountaintop mining sites chosen for study by the Environmental Protection Agency (EPA), namely Hobet 21 (Boone County), Daltex (Logan County) and Cannelton (Kanawha/Fayette counties) in southwestern West Virginia. Major watersheds include Mud and Little Coal Rivers (Hobet 21), Spruce Fork (Daltex), and Twentymile Creek (Cannelton). The study areas are in the Allegheny Plateau physiographic province (Hall 1983). The Cannelton mine is approximately 2,474 ha. with 510 hectares (ha.) of shrub/pole habitat, while Daltex is approximately 2,834 ha. with 296 ha. of shrubland and Hobet 21 is about 4,394 ha. with 428 ha. of shrubland (Table 1). These mine sites and associated watersheds surveyed were thoroughly surveyed for availability of edge habitats. Edge habitat categories (treatments) studied corresponded with P. Wood s simultaneous study of interior treatments (grassland, shrubland, forest fragment, and relatively intact forest). However, edge studies precluded any robust selection of relatively intact forest, since the mineland had to abut forest tracts in order to be considered an edge. The following edge-types were studied: (1) intact (large) forest-grassland ecotone, (2) forest fragment (or woody patches)-grassland ecotone, (3) forest fragment-shrub ecotone and (4) shrub-grassland ecotone. These edges selected were comparable in vegetation and age to interior habitat plots chosen by P. Wood, except study points were placed at areas where two habitat types join. Table 2 shows the number of edge habitats studied at each site. Three of these habitat types or treatments (fragmented forest, young reclaimed mine or grassland, and older reclaimed mine or shrub/pole) are the results of mining activities. Intact forest sites are relatively large forest areas undisturbed by mining activities and located in the same watersheds as the mine sites or in adjacent watersheds near the reclaimed sites. These generally consist of large forest lands abutting mine property. Fragmented forest tracts are stands (islands) of small woodlots surrounded by reclaimed mine land and/or ravines with valley fill/overburden. Fragmented forests also included ridges bordered by reclaimed minelands and were typically harvested between 5-30 years ago by selective-cutting.

Intact and fragmented areas consist mostly of relatively mature hardwood trees, including oak species (red, white, black, etc.), hickory species (bitternut, pignut, and shagbark), maples (red and sugar), American sycamore, white ash, and black birch (see Appendix 1). Young reclaimed mine areas consisted mostly of grasses and were less than 20 years of age. These grasslands varied in slope and some areas were terraced. Tall fescue, sericea, autumn olive, black locust, European black alder, and pines (mainly Virginia pine) dominated young reclaimed habitat. Older reclaimed mine areas contained shrub and pole-size vegetation of approximately 10-32 years in age. Much of the older reclaimed areas, especially on Cannelton mine, were created by contour mining rather than MTRVF. The primary vegetation was similar to that of young reclaimed mines, except older reclaimed areas often harbored more black locust, as well as goldenrod species, blackberry/raspberry, multiflora rose, red maple, American sycamore, tuliptree, and sumac. The major distinguishing feature between young and older reclaimed areas was the presence of stands of pole-size trees in the latter habitat. Mine ages were estimated from the time of reclamation and age analysis of conifers throughout the study areas. Age data of reclaimed sites were obtained from Arch Coal and Cannelton Mining companies and from examination of permits.

Edge plots (point count stations and line transects) were selected based on vegetation type, i.e., where significantly large, relatively homogenous treatment habitats bordered each other. Edge plots were selected systematically to obtain at least 30 points per treatment and to survey all three of the mine sites and not just a few specific areas. Sampling plots were selected after P. Wood selected her interior plots and were placed at least 250 m away from her interior plots. This insured independence in data collection as well as avoided counting birds twice. In addition, plots were selected as randomly as possible by using a computerized random-number generator, taking into account the position of P. Wood s points, number of previously established edge plots in treatment habitats, and availability of suitable habitat on each mine site. To select plots, we GPS coordinates for used and available sites into a computer random-number generator and used the program to randomly select points. Edge points were also selected randomly within each mine site, and where chosen by habitat availability and size of watersheds and by the need to avoid proximity to interior plots.

Both ravine and ridgetop forest ecotones were studied. Grassland and forest fragment plots were located in the mines at ecotones, while intact forest treatment plots started at an ecotone on the periphery of the mines and extended into relatively large forest tracts. The lack of aerial photographs precluded precise confirmation of intact plots and the relative term intact was judged based on what we could see on the ground, from ridgetops, and from surveying the mines and adjacent landscape by car and examining topographic and mining maps. However, in March 2001 we obtained and examined aerial photographs and concluded correct assignment of edge treatments. Reclaimed grassland points were often placed in both head-of-hollow fills and on ridgetops above the valley fills.

Point counts in the Cannelton mine extended mainly along Sixmile Hollow of Hughes Fork, Hughes Creek, Bullpush, and Lynch Creek and tributaries of Smithers Creek (Table 3 and Figure 1). The ecotones were mainly grassland/forest fragments or shrub/forest fragments. Cannelton is an older mine site than Daltex and Hobet 21 and mining activity reclamation dates back to the mid 1980s through about 1992. The Cannelton mine also has considerably more contour mine areas than MTRVF and a higher percentage of reclaimed land in pole/shrub secondary succession. Consequently, most points were placed in shrub or pole/forest fragment ecotones and grassland/shrub ecotones. Ecotones extending east from Smithers Creek served as edge plots at the ecotone of intact forest and reclaimed mine. Relatively intact forest located along Ash Fork and Neil Branch of Twentymile Creek were too far from the reclaimed mine to warrant establishment of edge plots. Line transects were placed in Bullpush, Sixmile Hollow, and Jim Hollow (Figure 2).

Hobet 21 point counts were located mainly along tributaries of Mud River and Little Coal River. The area consists of mostly fragmented forest islands interspersed among grassland. Apparently, first order-streams had valley fills and second-order streams were left intact. The Hobet 21 mine is the largest surface mine in West Virginia and mountaintop removal was started in 1983 (J. McDaniel, pers. comm.). Older contour mine areas were reclaimed in 1975-1978 with black locust and fescue (e.g. Bragg Fork). Adkins Fork was permitted in 1975 (contour) and 1992 (mountaintop). Significant valley fill occurred in 1985-1987, but a variety of reclaimed valley-fills from 1988-1997 are prevalent. Some reclaimed areas are a result of point removal, where the tops of the mountains were removed, e.g., Big Buck Creek. European black alder, dogwood, and hawthorn were planted during reclamation. Edge points were established along intact forest of Hewitt Creek, while a variety of grassland/forest fragment and shrub or pole/forest fragment plots were established in Little Horse Creek, Big Horse Creek, Stanley Fork, Gum Hollow, Black Hog Hollow, and White Beech Hollow (Table 3 and Figure 3). Figure 4 shows localities of transects used for avian migration counts. The major watershed, Mud River, comprises 1,635 ha. and significant contour mining was permitted in 1975 and 1978. Significant contour mining is adjacent to Hobet 21, e.g., Hewitt Creek (a contour mine area reclaimed in 1989).

The Daltex mine consisted of mainly grassland and contained relatively little shrub/pole habitat, while edges along intact forest were located along Bend Branch of Spruce Fork. Both Daltex and Cannelton mines have significant amounts of their shrub/pole habitat created by contour mining, while Hobet 21 had more land cover in MTRVF. Left Fork of Beech Creek was contour mined in 1968-1969 and 1976-1978. Pigeonroost Branch was permitted in 1972-1974 and contour mines cover 181 ha. Table 3 and Figure 5 show location of point counts, while Figure 6 shows localities of transects.

Line transect localities were selected based on availability of treatment habitats. Elevation of the 40 transects was not normally distributed (Levene statistic = 6.42, $p < 0.004$), and varied significantly (Kruskal-Wallis test, $\times^2 = 10.02$, $p < 0.007$). Elevation of 12 transects at Cannelton averaged 409.6 m (range = 107 m), 15 transects at Daltex averaged 397.7 m (range = 199 m), while 13 transects at Hobet 21 averaged 349.2 m (range = 129 m).

Historical Study Sites and Areas Sampled Prior to the MTRVF EIS

In 1987, we started a long-term study of bird populations in the southern West Virginia coalfields (Canterbury 1990, Canterbury et al. 1993). We refer to these sites (prior to the MTRVF EIS data collection that started in 2000) as Historical Sites. As part of our contractual agreement, we offered the MTRVF EIS committee an analysis of these data for comparing mountaintop removal with contour mining. This was because most of the mined areas we examined, prior to the MTRVF EIS, were pre-law land use (before 1977) and a large number of the sites contained unreclaimed areas including highwalls with natural succession. However, a significant number of sites (mined areas) had reclaimed areas in which trees (mainly black locusts and conifer spp.) were planted. One of us (Tommy Stover) spent many years planting trees on mined areas, and so we know exactly when these trees were planted.

Most of the 80 mine sites that we have examined from 1987-2000 were contour mines and were dominated by shrub habitat and second-growth forest. Some of these sites, however, were partial mountaintop sites with minimal valley fill and overburden. Table 4 shows the historical sites studied. These sites are found in the Allegheny Plateau and mainly within southern West Virginia, extending south of northern Summersville (Nicholas County), west to Logan, east to the Greenbrier River and south to Mercer/McDowell counties. Counties thoroughly sampled included Kanawha, Nicholas, Boone, Logan, Mingo, McDowell, Wyoming, Raleigh, Fayette, Summers and Mercer. Sites sampled within Raleigh County and extending into Pax, Fayette County, West Virginia are noted in Figure 7.

Most sites studied were mined in the mid 1960s to the late 1970s, and mine ages were determined by interviewing miners and coal company personnel and examination of permits. Contour mines were generally older, smaller in size, and more heavily forested than MTRVFs. The shrub habitat on these historical sites was comprised mostly of black locust and red maple bordering mature and second-growth deciduous forests. Much of the land mined in the 1960s and 1970s is now second-growth forest (upland oak-hickory/Appalachian mixed-hardwood). Thus, natural forest succession and reforestation procedures (see Burger and Torbert 1997) have converted many of these 30-40 year old mines into second-growth forest. Remnants of pioneer (legumes and grasses) and shrub (black locust, autumn olive, and serecia) species remain in edges and forest patches in the contour mines. Edges along these historical sites were primarily transitional ecotones between shrub and extensive forest and forest-road edges. Relatively large grasslands (> 40 ha.) were rare on these mines (4% of the sites surveyed) and were more abundant in mountaintop rather than contour sites. Edges on historical MTRVFs were as described above, except there were some abrupt grassland-forest edges. In other words, edge sampling points at historical sites were selected as described for the three EIS MTRVF sites discussed above. Undisturbed sites bordering these mines were generally mature oak-maple-hickory forests. Dominate tree species included red maple, sugar maple, yellow poplar, red oak, hickory spp., sourwood, black birch, and black gum.

Outslope areas of reclaimed mine sites were dominated by black locust, red maple, sourwood, black birch, tulip tree, pitch pine and Virginia pine. Flat areas were dominated by pine spp., black locust and red maple. Highwalls and un-reclaimed areas were dominated by black locust. Reforestation occurred faster on outslope areas than flat tops. Reclamation practices (e.g., seed mix, whether trees were planted) were noted and used in analyses. Canterbury (1990) described the typical habitats of these mines, and some of these study sites are noted and described in Canterbury et al. (1993, 1996) and Canterbury and Stover (1999). Pitch, Virginia, and white pines were the most commonly found pines of these areas. Autumn olive, multiflora rose, goldenrod spp. and blackberry spp. predominate in the shrub and herb layers. Vegetation in these 80 mine sites is similar in composition and structure to the MTRVFs noted above, except contour mines are steeper (Sparks and Canterbury 1999, Watson and Canterbury 1999, Canterbury, unpubl. data).

Historical mine sites were classified by methods of mining activity, which included (1) contour/auger, (2) partial mountaintop with outslope and minimal valley fill (PMTRVF), (3) mountaintop removal and valley fill (MTRVF), and (4) mixed (combination of methods employed in about equal proportion). Data for classifying sites were obtained by examination of permits, interviewing miners and mine and forestry experts, and extensive field experience.

The following two paragraphs are descriptions of some of the historical mine sites studied. An extensive amount of mining has occurred in the area between Valley and Clear Fork districts of Fayette and Raleigh counties with discharge into tributaries and streams feeding Paint Creek and Clear Fork (Table 4). Much of the mined areas near Pax, West Virginia are contour mines. A study plot (29 ha.) was placed in the Plateau district of Fayette County that was permitted in 1985 and completely revegetated by 1989. Disturbance impacted Bee Branch, Georges Branch, Long Branch and Shotgun Hollow of Paint Creek of Kanawha River. The Coopertown mine in Boone County was a MTRVF and auger operation with approximate original contour (AOC) variance (Office of Surface Mining, OSM). The permit called for creating a level plateau along the ridgetop. A mountaintop-removal AOC variance, leaving a level plateau or gently rolling contour, is granted if it is capable of supporting certain postmining land uses (OSM). A permit was issued for this site in 1976 and about 39 ha. were disturbed. Valley fills are now well vegetated with trees (OSM). The ridgetop between two valley fills along the eastern AOC is forested, and disturbed areas are mainly in the shrub stage of secondary forest. A MTRVF site northwest of Gilbert disturbed about 35 ha. and had three valley-fills, while the mined areas were back-filled to within 12 m of the original contour (OSM).

The Sandlick/Stover area of Raleigh County have operations discharging into Harpers Branch and Sandlick Creek of Marsh Fork of Coal River (Table 4). The mining methods appear mixed with mountaintop-removal AOC variance and the initial application listed the operation as steep-slope mining and returning the land to AOC, but we found little evidence of the latter. We sampled several mine sites along Sandlick Creek that were permitted in 1978 and where no coal has been removed since 1993. One study plot was placed on an area permitted for 190 ha., where 11.3 % of the land has not been disturbed. All mined area have been completely revegetated and the area harbors dense locust stands with a breeding population of imperiled Golden-winged Warblers (Canterbury et al. 1993). Over the past several decades the Golden-winged Warbler has been gradually replaced by Blue-winged Warblers, and hybrids between the two species have been documented (Canterbury et al. 1996). However, the potential loss of elevation due to mining did not favor Blue-winged Warblers over Golden-winged Warblers, since both species readily coexist throughout the Marsh Fork and Sandlick watersheds where the habitat is heavily forested with some relatively old contour mines (mined in the 1960-1970s). The area to the west of Sandlick, namely Guyandotte (Bolt) Mountain harbors the highest known breeding population of Golden-winged Warblers (Canterbury et al. 1996; Buehler et al. 2002, Canterbury, submitted; (http://www.audubon.org/bird/iba/iba_map.html). Areas such as Peachtree Ridge, Pilot Knob and Coal River Mountain harbor large source populations of Golden-winged Warblers along contour mines, but Blue-winged are encroaching into these higher elevations (Canterbury et al. 1993, 1996). Despite encroachment of advancing Blue-winged Warblers, Golden-winged Warblers have remained relatively common throughout the southern West Virginia coalfields, which is true for both contour and MTRVFs (Canterbury and Stover 1999, Buehler et al. 2002).

Avian Species-richness and Abundance

Avian abundance was quantified by fixed-radius 50-m point count plots during the winter and breeding seasons and line transects during the migration periods (Ralph et al. 1993). All point counts and line transects were geographically referenced with a global positioning system (GPS) and downloaded into Garmin MapSource 3.02. The point count method is a standard, published technique for quantifying avian abundance along edge and other habitats and provides an index of relative abundance of species encountered. All point count stations were located along abutting habitat types within a 50-m radius and were placed at least 75 m from major strip mine roads. Counts were conducted using standardized methods of Ralph et al. (1993), such as 10 min. counts per point and conducting counts from 0630 to 1030 hrs. during the breeding season. Winter point counts were conducted from 0730 to 1600 hr because birds can forage at any time throughout the day during the winter months. We visited each edge point count twice during both the winter (January - mid April) and breeding (June - mid July) season. Plots were visited randomly between counts and not in the same order both times (Ralph et al. 1993). Surveys were not conducted during heavy snow fall or during windy or rainy weather. Percent cloud cover and wind speed (obtained with a wind meter) were recorded using standard scoring codes (Ralph et al. 1993). Seven observers with experience ranging from 2-14 years conducted point counts. Birds were counted at 134 edge plots during the winter and breeding seasons and were also counted at 80 interior treatment plots of P. Wood during the winter months. We recorded the number of birds per species seen or heard, as well as noted breeding pairs, number of flyovers, and whether each bird was observed within or outside the 50-m plot (aided by Bushnell range finder).

Three observers (each with 5 to 14 years experience) conducted migration counts. At 40 random sampling points per treatment habitat, we established 300-meter line transects throughout the three mine sites. Of the 40 line transects, we had 10 each in treatment habitat chosen by P. Wood during a pilot study. These included grassland, pole or shrub succession, forest fragment and forest plots. Transects were fixed width of 50 meters and started at edges and extended 300 meters into the appropriate treatment habitat. Migrants were counted from 0630 - 1200 hr. and counting times varied slightly between spring and fall migration periods, but were generally within 15 minutes of local sunrise and spanned three to four hours after sunrise. Birds were counted by walking the transects at a rate of 100m/10 minutes. Each transect was visited twice during the spring (April 11 - May 31, 2000) and fall migration (August 1 - September 10, 2000). We did not sample during the latter part of fall migration (i.e., no data collection in late September and October), because of the cut-off for ending the EIS. All birds were counted, including resident species, short-distance migrants, and Neotropical or long-distance migrants. Migrants are reported as number of birds observed per count in each habitat type along 300-meter transects extending from edges to interior plots.

Relative and total abundances were computed as the number of birds per point and birds/ha. Diversity of birds was calculated for each edge type with the Shannon-Weiner formula. When ecologists study an ecosystem they want to know what are the most important species and why are they important? So that different ecosystems or communities can be compared, standard measures of importance have been agreed on and studied. A species may be important because of its relative abundance, size, and dispersal, e.g., relative density measures the abundance of a species, relative to the abundances of the other species present. Once we have calculated a species' relative abundance, size, and dispersion, we use this as a measure of its total importance in the community. Importance Value (IV) can sum to 200 or 300 depending upon whether two or all three of these parameters are used. IV is used mainly to quantify vegetational communities, but plants and habitat structure often dictate occurrence of animals. We computed an importance value for each species in winter and summer as a means of comparing the presence of a given species to the total bird community (Yahner 1986, 1993, Rollfinke and Yahner 1990). An IV was the sum of a relative numerical component (RN) and a relative distribution component (RD), giving a maximum possible of 200 (Yahner 1986). The RN was the total number of detections of a given species with points pooled divided by the abundance recorded for the most abundant species. This is a way of comparing the abundance of a species relative to the most abundant species detected. The RD was computed as the proportion of the four edge type plots in which a given species was detected (Gutzwiller 1993). We classified high IV as 125, moderate as 50-124, and low as 49 (Yahner 1986, 1993, Rollfinke and Yahner 1990).

Birds were assigned to foraging height (low or high) and habitat guild (e.g., forest-interior, shrub, and edge, based on habitat preference). Birds were assigned to guilds and residency and migratory status based on the literature (see Hall 1983, Ehrlich et al. 1988, Buckelew and Hall 1994) and our 14 years of research experience with birds of West Virginia. For example, we assigned Downy Woodpecker and White-breasted Nuthatch to the trunk gleaner (bark forager) guild. Root (1967) and Yahner (1993) provide excellent examples of assigning avian species guilds. Typically three principal foraging guilds were used and noted as ground-shrub foragers (species that often feed on or < 2 m above the ground level), trunk-bark foragers (species that forage on tree trunks or large branches), and sallier-canopy foragers (species that often forage > 2 m above ground level in vegetation).

Edge type was used as the independent variable in analysis of variance (ANOVA), and we tested for differences in species richness, relative abundance, and foraging guilds (e.g., ground/shrub, bark, canopy) across habitat (treatment) types. Additional analyses are described in the Statistical Analyses section. Bird species that are typically difficult to survey with point counts, such as flocking and highly gregarious species, inconspicuous and non-vocal species, and species with large territories or home range, were excluded from the analyses of abundance, species richness, and guild structure. Avian nomenclature follows the American Ornithologists Union checklist of North American Birds (AOU 2000, see Appendix 2).

Topology and Spatial Variation

Because MTRVF produces forest fragments (patches) and edges of varying length and width, we assessed edge variation at each point by quantifying the length of each edge, aspect, elevation, and percent slope with GIS (see below). The area or size of a patch (e.g., in units of a map scale such as m^2 or a proportion of the total map/study area) may be subdivided into edge and interior (core) area, where edges are defined in terms of some buffering distance. Virtually all GIS package can quantify the area or perimeter (edge) of patches (e.g., polygons). We took GPS coordinates where habitats changed and plotted these coordinates on a topo map. We overlaid the topo maps with a grid of 999 boxes (2.5 acres each) that are typically used with 7.5-minute USGS topographic maps or aerial photographs with a scale of 1:24,000 (1 in. = 2,000 ft.) and determined the approximate length and width of edges. The total length of each edge was verified using a spatial analysis program (APACK, Boeder et al. 1995). Elevation was obtained from topological maps by plotting localities of points on maps, while aspect was recorded with a compass. Percent slope was obtained from a clinometer. Slope aspect was transformed using Beer s (1966) equation, where A = (COS(45-A)+1) x 2 + 1. In this equation A is the transformation index and A is the direction the slope faces in degrees (Frazer 1992). Slope transformations range from 5 (northeastern facing, mesic condition) to 1 (southwestern, xeric condition). We assigned an aspect index of 1 to dry, xeric ridgetop points and 5 to points in mesic valley floors, since they have no slope and aspect (Frazer 1992).

We quantified patch size of forest fragments and habitat variation among sites and treatments with FragsStats computer software, GIS, ANOVA, and product-moment correlation (see Statistical Analyses). GPS coordinates of all edge points were transferred to GIS (ARC/VIEW 3.2 or ARC/INFO software 3.4D GIS, ESRI 1987) and data from the WVDEP spatial data interface was used to develop GIS maps, which were created by delineating habitat patches along the points and transects. ArcView extensions spatial analyst, 3D analyst, TIFF 6.0 image support, geoprocessing, and MrSID image support were used in GIS analysis. We compared the number of birds (density estimates and species richness) in various edge habitats (treatments) and watersheds by topology (edge length and width, elevation, and slope) and vegetation (described below) using multiple regression. In other words, we used multiple regression analysis to examine which of these variables (slope, edge length, plant richness) were significant predictors of avian species abundance.

Vegetation Analysis

Vegetation analysis was used to quantify edge types among the watersheds and treatment habitats. Vegetation characteristics at each edge point were quantified in July - early September at the end of the growing season and after avian count surveys were completed. We used a modification of the James and Shugart (1970) circular sample-plot method to sample the vegetation within edge point counts. We placed four circular plots of 0.032 ha (20 m diameter or 10 m on either side of the edge) within the bird sampling plots and recorded (1) height and species of all trees 3 cm diameter at breast height (DBH), (2) the number of all woody stems < 3 cm DBH and 0.5 m tall within two perpendicular, 2 m wide x 20 m long transects, (3) a count of all vine stems or vine leaves that intersected the centerline of the two perpendicular transects, and (4) an estimation of vertical structural diversity by noting the presence or absence of vegetation at height intervals of 0-0.3 m, 0.31 - 4 m, 4.1 - 10 m, and > 10 m as observed with a sighting tube. Ground cover type was recorded as either green herbaceous (grasses, shrubs, ferns), bareground/rock, moss, woody debris (any material 4 cm diameter), water, or leaf litter. Percent ground cover and canopy cover was estimated using a 4 cm diameter ocular siting tube (James and Shugart 1970). Average canopy height was measured with a clinometer. Canopy cover and structural diversity was measured in shrub/pole and forest plots. Plants were identified using standard field guides and Strausbaugh and Core (1977). Diversity of shrubs and trees were calculated with the Shannon-Weiner formula (Magurran 1988), but we found plant species richness not to be a significant predictor of avian richness and abundances along edges.

Along grassland edges, a meter stick was randomly placed on the ground within each point count circle and a 6 mm diameter metal rod was passed vertically through the vegetation at each end of the meter stick and the number of contacts by different vegetative life forms (e.g., standing dead vegetation, grasses and sedges, forbs, shrubs 15 cm and shrubs 15 cm high) were counted in each successive 1 decimeter (dm) height interval (Rotenberry and Wiens 1980). Litter depth was measured from the surface of the ground to the top of the litter with a metric ruler.

We also performed a separate analysis of shrubland ecotones (abbreviates for variables measured are indicated in parentheses), in which we counted trees with DBH > 7 cm (TREE), shrub stems 3-5 m in height and 7 cm DBH (TALL), shrub stems 1-3 m tall and 7 cm DBH (SHORT), and standing dead trees greater than 7 cm DBH (DEAD). We estimated height (HEIGHT) of overstory trees with a clinometer and measured their DBH.

Statistical Analyses

Data were analyzed following Sokal and Rohlf (1981). We tested our data for normality (e.g., species richness and abundances) and for most of our datasets we found no evidence of deviation from normality (Levene statistic or Shapiro-Wilks test, $p > 0.05$). Non-normal data were transformed for parametric analysis. All percentage variables (i.e., slope, ground cover, and canopy cover) were arcsine-square root transformed (Sokal and Rohlf 1981). Pearson product-moment correlation was used to examine the relationship among all variables in this study, e.g., seral stage (age of succession) or treatment, edge length, edge type, elevation, percent slope, aspect, species richness, and relative abundance. Pearson product-moment correlation analysis was also used to examine the relationship among species diversity and vegetation components measured at shrub or pole/forest fragment edge study plots in MTRVFs. Significant correlations were further analyzed with general factorial ANOVA. Day of data collection in count studies was used as a covariate within analysis of covariance (ANCOVA) models, but was found not to be a significant covariate in each seasonal analysis. Habitat association data were analyzed with Principle Component Analysis (PCA). All data were analyzed with SPSS for Windows (Norusis 1993) and are reported as mean ( ) ± 1 standard error (SE). Graphs were constructed using SigmaPlot 5.0 and study plots were plotted with Garmin 3.02 topomap software.

Quality Control Procedures

Four treatment designs (habitats) selected by P. Wood and edge plots similar to these treatments were replicated at each site, but an unbalanced sampling design among edge plots was necessary because of the lack of specific treatment habitats in some areas and to avoid overlap with point counts in interior plots. Confounding variation was reduced by sampling with multiple replicates across edge types, which provided adequate statistical inferences about avian abundance and diversity among habitats or treatments. The selected edge points were representative of the edge habitats on the three mines and were selected to maintain sampling efficiency per unit time.

Quality control was also maintained by using 2-7 person teams from the SWVBRC and Concord College that minimally have two years of point count and avian research experience. Student assistants with two years experience were teamed with more experienced researchers and conducted trial point counts prior to initiating surveys. These included at least three practice sessions in each habitat type (grass, shrub, and forest) at the beginning of the winter and breeding seasons. These researchers also practiced completing standardized point count data sheets and placing birds within or outside 50-m radius circles with distance sampling verification (i.e., measuring off 50 meters). The Chief Naturalist of SWVBRC, Dollie Stover, has over 14 years of avian research experience and is highly respected as a birder by the West Virginia birding community. Allen Waldron of the SWVBRC has over 20 years of experience with forestry and botanical techniques, and five years of avian research experience. The PI was in the field 475 hours, comprising 60 field days, which insured quality control of data collection and that data collection adhered to standardized protocols (e.g, Hutto et al. 1986).

Quality control for winter point count data was insured, for example, by adhering to standard protocols, where data were collected only when wind speed was < 20 km/h, air temperature was > 0°C with no more than a light precipitation, and the ground was relatively snow-free (i.e, ground not completed covered with snow). The estimation of sampling error in bird surveys often involves replication in space or time (Gates 1981). The large sample sizes, i.e., number of point counts per treatment and edge type, improved the statistical power. Rarefaction was employed in this study. Rarefaction is a statistical technique for estimating the number of species expected in a random sample of individuals from a collection, and allows the comparison of the species richness of collections with varying numbers of individuals (James and Rathbun 1982). Data entry from field data sheets was checked by a second technician after entry for any potential errors. In summary, the standard sampling methods, experience of researchers identifying birds by sight and sound, and sound statistical approaches (e.g., habitat data analysis with PCA) used in this study insured quality control.

Methods used to Collect and Analyze Data from Historical Sites

Vegetation sampling followed procedures outlined above for MTRVFs, except that slight modifications were made in some shrubland plots for specific studies on the imperiled Golden-winged Warbler (see Canterbury et al. 1996, Sparks and Canterbury 1999, and Watson and Canterbury 1999). Other modifications in sampling design is shrub habitats included spot mapping and an intensive multiyear investigation of breeding populations of color-banded birds using netting, playback, and observation. These latter data are reported elsewhere (e.g., Canterbury et al. 1996), but are occasionally referred to in this report.

Point count methods on historical sites followed methods described above for the surveys on the MTRVFs. Point count data were collected in June at each site. All interior points were at least 250 m from the nearest edge. We placed at least 12 interior and 12 edge plots at each site with some sites (e.g., Peachtree Ridge) having 32 of each. Thus at each mine site, we conducted at least 24 point counts per year. Point count data were compared between edge and interior plots and we calculated avian relative abundances from these point count data as described in the methods for the MTRVF EIS study sites. Point counts were placed along contour mines and valley-fills of mountaintop sites.

In addition to point counts, singing male censuses (SMC) modified from the methods of the BBS and outlined in Hall (1983) and Canterbury et al. (1996) were taken at 32 sites. These SMCs started at the historical mine site and extended along roads and forested areas and were denoted as routes for estimating population trends. The SMC routes were not the same as point count stations. During the past 14 years, SWVBRC staff have conducted a multitude of BBS and SMC censuses on 80 mine sites, which consisted of relatively remote roads through extensively forested areas with contour mine edges (Stover and Canterbury 2001). These historical study sites averaged 79% forest cover and 21% shrub edge and other habitats (Canterbury, unpubl. GIS data). Researchers from the SWVBRC collected SMC and BBS data in June and followed the standardized BBS protocol. Many different methods have been used to analyze BBS and SMC data and there is little agreement on which are best (Thomas and Martin 1996). We used trend estimation (an exponential curve was fitted to the mean number of birds recorded per route in each year) and regression methods of Geissler and Sauer (1990) and Link and Sauer (1994). Due to the volume of this report, we have omitted graphs of population trends of southern West Virginia birds, but these can be obtained from the senior author.

Species recorded on fewer than 14 routes were omitted from trend analysis (Peterjohn et al. 1996). Migratory status was assigned to each species based on the most common wintering grounds of each species (Rappole et al. 1983). Permanent residents were delineated as those species in which most individuals breeding in West Virginia also winter in the state. Temperate migrants were considered species that winter mainly in the southern U.S. and have large migratory flights through the area (see Canterbury and Stover 1998, Canterbury et al. 1999, Canterbury 2000b). Central Neotropical migrants winter in Mexico, Central America, and the Caribbean, and southern Neotropical migrants winter mainly in South America. Considerable variation exists among species and some have large winter ranges encompassing southern U.S. to Panama, but we labeled each bird species by where the bulk of their winter populations occurs. For example, Central and southern Neotropical migrants were defined as those that winter primarily south of the U.S., and temperate migrants included those that winter extensively in North America but have some populations that winter south of the U.S. (Gauthreaux 1991). Similarly, some resident species such as the Song Sparrow have large winter populations consisting of short-distance migrants from farther north and are classified as both permanent residents and temperate migrants. For association with breeding population trends, each species abundance (per SMC route) was classified as either very abundant (VA, 50.0), abundant (A, 12.0-49.9), common (C, 4.0 - 11.9), fairly common (FC, 2.0 - 3.9), uncommon (U, 1.0 - 1.9), or rare (R, < 1.0) and these classifications correspond to regional abundances (Peterjohn et al. 1987). Routes were the typical 24.5 mile routes with 50 stops and observers recorded numbers of individuals of each species seen or heard within a 0.25 mile radius during a 3-min. period. Routes consisted mostly of forested areas with remote roads created mainly by contour mining. Population trends were estimated from data from these routes.

At TRMO (Metalton, Raleigh County), we placed 12 300-meter transects for counting birds and compared count data with mist-netting data. Procedures for counting birds along these transects followed standard methods (Ralph et al. 1993). We randomly picked three interior forest species (Ovenbird, Acadian Flycatcher, and Kentucky Warbler) and three shrub/edge species (Eastern Towhee, Northern Cardinal, and Indigo Bunting) and plotted the number of birds/40 ha. from edge to interior forest. Banding methods used at TRMO followed those described in Karr 1981, Moore et al. (1990), Morris et al. (1994), Pyle (1997), and Canterbury and Stover (1998). These methods allowed comparison between edge and interior areas.

The TRMO study site is described in Canterbury (1990), but has been modified slightly in recent years by selective logging and contour mining. The contour mine habitat characteristics are similar to the MTRVFs, except the contour mine at TRMO is smaller than the MTRVFs described above. We use bird banding data to illustrate what migrants potentially use mine habitats and show data collected from 1996-2000, where fall migrants were captured from late July to early November (see Canterbury and Stover 1998, Canterbury et al. 1999, Canterbury 2000b). This is important, since the MTRVF EIS data collected excluded October and much of September, which are suitable for bird migrations in southern West Virginia (Canterbury et al. 1999).

Vegetation quantification at 19 (12 contour and seven MTRVF) randomly selected historical mine sites followed the James and Shugart (1970) circular sample-plot method and GIS technology was performed for only three of these historical sites because of time constraints. These three historical sites (Peachtree Ridge, Highland Mountain, and Whitby) were selected because they are localities where the long-term data collection began and are areas where we have the most data, including avian reproductive success data (see Canterbury and Stover 1999 and Stover and Canterbury 2001). Statistical analyses of historical data follow procedures outlined above and those described in Canterbury et al. (1996). Association among variables were examined with Pearson product-moment correlations. Analysis of variance (ANOVA) and multiple regression analyses were the main types of tests employed. These latter tests were used to partition variation among measured variables and to test for significance in dependent variables (e.g., avian abundance, species richness) as explained by independent variables (e.g., mine size, mine age, type of mining in study plots, slope, elevation, canopy cover, herbaceous cover, tree density, tree size (height), stem density, and age of forest succession). A multiple regression was used to determine which habitat variables were significant predictors of five randomly chosen shrubland species. Nonparametric tests were used on non-normal datasets (see Sparks and Canterbury 1999, Watson and Canterbury 1999). For example, we used the Mann-Whitney U-test to examine difference in abundance between edge and interior plots at TRMO.

Results and Discussion

Avian Abundances across Seasons and Edge Habitat (Treatment) Types

Winter Season

Table 5 shows the average number of birds observed per point count in the winter season. This table also shows a comparison between interior and edge plots. Of the 59 species listed in Table 5, only seven species were more abundant in interior as opposed to edge plots. These are Blue Jay, Carolina Chickadee, Pileated Woodpecker, Sharp-shinned Hawk, Tufted Titmouse, White-breasted Nuthatch, and Yellow-bellied Sapsucker. Seven species were found in higher densities at forest fragment/grassland ecotones than in intact (large) forest/ grassland ecotone, forest fragment/shrub ecotone, and shrub/grassland ecotone (data not shown, but summarized as one-way ANOVA, F 2.95, p 0.05). These included the Eastern Meadowlark, European Starling, Horned Lark, Killdeer, Northern Harrier, and the Wood Duck. The remaining species did not vary by edge type during the winter (one-way ANOVA, $p > 0.05$). Overall, the American Crow and Dark-eyed Junco were the most abundant species observed during the winter, which is consistent with most Christmas bird counts in the regions (Canterbury 1998). These species also had the highest importancr values (Table 6). However, the high abundance of Eastern Bluebirds, Eastern Meadowlarks, and Horned Larks in MTRVF grasslands and shrub habitats are especially noteworthy in comparison to regional Christmas bird counts. During winter point counts, foraging-flocks of American Robins, Eastern Bluebirds, European Starlings, Horned Larks, Northern (Yellow-shafted) Flickers, or Wild Turkeys were noted almost daily in grasslands and shrub habitats. In addition, some species were higher in the winter than summer season. These included, for example, American Crow, Blue Jay, and Pileated Woodpecker. Reasons for these seasonal abundance differences vary. The American Crow congregates in large foraging and communal roosting areas (Canterbury and Stover 1992), while the Pileated Woodpecker may be more easily detected in winter than summer. Many overwintering Blue Jays, Dark-eyed Juncos, and Song Sparrows breed farther north and represent short-distance migration.

Spring Migration

The number of birds observed per transect during the spring migration period is shown in Table 7. Of the 29 species noted in predominantly grasslands, the European Starling, Turkey Vulture, Eastern Meadowlark, and Tree Sparrow were noted in highest numbers (from highest to lowest), respectively. Of the 63 species that were found in mainly shrub habitats, the Field Sparrow was the most abundant, followed by the White-throated Sparrow, American Robin, Blue-winged Warbler, and Chipping Sparrow (excluding the Wild Turkey since it does not migrate). Of the 40 species that predominated in forests, the Red-eyed Vireo and Wood Thrush were the most abundant migrants (excluding American Crow, which overwinters in the area). Table 8 shows the mean species richness and total abundance of birds detected along treatment habitats in spring. Fewer species were detected in intact forest, while shrub habitats harbored the greatest species richness. Similar trends were noted for density and total abundance estimates. We compared species richness and avian abundance along variable distances of the transect (0, 150, and 300 m) and found no differences (Table 9).

Breeding Season

Table 10 shows the average number of birds observed per point count in the breeding season. In general, the overall trend was higher abundance in shrub/forest fragment ecotones for forest interior species, interior-edge species, and edge species. Grassland species were significantly higher at grassland/forest fragment ecotones. Forest interior species generally declined in grassland/forest fragment plots as opposed to grassland/intact forest edge. Table 9 also shows a comparison of avian abundances between this study and southern West Virginia (at smaller contour mines in relatively late stages of secondary succession - see Canterbury et al. 1996, Canterbury and Stover 1999, and historical sites described above). For this comparison, we randomly picked sites in southern West Virginia with relatively similar habitat (vegetation and topography) and approximate age as the MTRVF sites. We selected 30 points in each edge habitat type in southern West Virginia from a pool of hundreds of counts distributed over 80 sites (Canterbury, unpubl. data). In general, the contour/partial mountaintop sites selected for this comparison were slightly older and smaller than the MTRVFs used in this study. However, a significant amount of similar edge habitat created by contour mining occurs on both the MTRFV sites and older contour mines in southern West Virginia.

Abundance of each forest interior species, except Louisiana Waterthush and Swainson s Warbler (no birds observed) and Yellow-throated Warbler, was slightly lower at the grassland/intact forest edges of the MTRVFs of this study than at similar habitats throughout southern West Virginia. This difference may be due to the slightly younger ages of the MTRVF grasslands as compared to the contour mines, but was not tested for significance (we chose not to test across studies - historical contour mine data and present MTRVF). A similar trend was noted for grassland/forest fragments, except for Cerulean Warbler (no birds observed, see Table 10), Eastern Wood-Pewee, Kentucky Warbler, Louisiana Waterthrush (no birds observed), Summer Tanager, and Yellow-throated Warbler. The latter two species were more abundant on MTRVFs than older contours, and are typically found in open woodlands. In general, similar trends were also noted during comparisons of the other two edge types, where birds were in slightly higher densities in older contours than at MTRVF shrub edges. These comparisons, however, should be interpreted with caution, because abundance estimates of birds on contour mines throughout southern West Virginia are based on 14-years of data and the MTRVF EIS study was only for one year. Likewise, each forest interior species should be examined carefully. For example, the Acadian Flycatcher was found in about equal numbers across all edge types in the MTRVFs, except grassland/shrub. It did not, for example, decline in comparison with the larger, relatively intact forest edge bordering the MTRVF mine sites. In the MTRVF sites of this study, forest-interior species were often found in the same relative densities in both grassland/intact forest edge and grassland/forest fragment edge, but exceptions did occur (e.g., Blue-headed Vireo, Cerulean Warbler, Eastern Wood-Pewee).

The species with the highest IV (ranked in descending order) during the summer (breeding season) were Red-eyed Vireo, Indigo Bunting, Grasshopper Sparrow, Field Sparrow, Common

Yellowthroat and Eastern Meadowlark (Table 11). Two of these are considered grassland species (Grasshopper Sparrow and Eastern Meadowlark), three are edge/shrub birds (Indigo Bunting, Field Sparrow, and Common Yellowthroat), while the species with the highest OV, the Red-eyed Vireo, is considered an interior-edge species of the eastern deciduous forest. Species richness varied from 10.02 (± 0.31 SE) in grassland/shrub, 12.05 (± 0.40) in grassland/intact forest, and 12.61 (± 0.37) in grassland/forest fragment to 15.56 (± 0.32) in shrub/forest fragment.

Table 10 shows a group of species listed in an Other category and not in a particular habitat. These are generally birds of large open habitats or aerial insectivores. The species in the Other category were generally more abundant in grassland/shrub edges. The Canada Goose, Green Heron, Black-billed Cuckoo, Eastern Kingbird, Eastern Wild Turkey, Rock Dove (Feral Pigeon), Chestnut-sided Warbler, Common Raven, House Wren, Rose-breasted Grosbeak, and Wood Duck were also observed during the breeding season, but were outside of standard point counts and not used in calculating abundance estimates. Reasons for this vary. For example, some are more abundant at higher elevations outside EIS study sites (e.g., Chestnut-sided Warbler and Rose-breasted Grosbeak), some require specialized or localized habitats such as open oak-hickory woodlands and localized areas with tent caterpillar or other lepidopteran outbreaks (e.g., Black-billed Cuckoo), and some occur in the vicinity of human dwellings (e.g., House Wren and Rock Dove).

Fall Migration

The most abundant birds observed in grasslands during the fall were Turkey Vulture, Mourning Dove, and Grasshopper Sparrow (Table 7). However, these probably represent post-breeding dispersal rather than migration, because data were collected too early for their migration cycles (Hall 1983). In grasslands, no long-distance migrant that does not breed in the area or in close vicinity of the MTRVFs was noted. This was probably due to a time limitation rather than habitat, since we observed migrants only from August to mid September. Optimal dates for many fall migrants in southern West Virginia span into late October (Canterbury and Stover 1998, Canterbury et al. 1999, Canterbury 2000b). In shrub habitat, the White-eyed Vireo was the most abundant, followed by the Tennessee Warbler and Gray Catbird. In forest habitat, the Carolina Chickadee was the most abundant species in fall season, the population in winter is generally higher than the breeding population (Hall 1983). This may represent an influx from the north. The Red-eyed Vireo was the most abundant long-distance migrant, but like the White-eyed Vireo and Gray Catbird in shrub habitat, it is often difficult to distinguish migrant from breeding individuals without banding. The Cape May Warbler and Swainson s Thrush may be better indicators of forest migrants along MTRVF, since they do not breed in the area (Table 7). Bird banding, rather than migration counts, is generally a more precise method for evaluating indicator species during migration. Table 12 shows the number of birds banded at TRMO during the past five seasons and the percentage of the total migrants captured on a contour mine in Raleigh County, West Virginia. Clearly, shrub habitats are valuable for migration for many avian species and migrants are not limited to mature forest tracts. However, shrub habitats may be important for migration only in the context of the surrounding landscape (i.e., contiguous forest).

Guild Analyses

The number of birds per guild type did not differ across edge habitats (Table 13, MANOVA, F 1.36, p 0.29), but did vary with season (F = 4.48, p 0.03). As expected, more birds were noted in summer than during the winter season. There was a significant difference in the number of low and high foraging birds across age of secondary succession (Figure 8, ^{2} = 7.41, $p < 0.02$). Table 14 shows linear regression analysis of species richness and relative abundance on length of edges along MTVFVs in southwestern West Virginia. Species richness within the five major trophic groups was significantly correlated with edge length. Areas with large amounts of edge and forested island patches contained significantly more omnivores, ground insectivores, and aerial insectivores (mainly flycatchers) and had fewer foliage and bark insectivores. The rate of increase (slope) of ground and aerial insectivore richness with edge length was high and indicates the importance of increasing amount of edge habitat to these species. This was further demonstrated by intercepts that did not differ from zero, which suggest that large tracts of forests are not preferred by these groups. In contrast, foliage and bark insectivores had higher intercepts, which indicate their preference for larger forest tracts and less edge. In addition, the negative slope of relative abundance of bark insectivores suggests that they prefer large tracts of forest and that abundance decreases with decreasing richness. Foliage insectivores, however, did not follow the same pattern as bark insectivores with regard to relative abundance, i.e., abundance increased with decreasing species richness. Omnivores and aerial insectivores increased abundance in fragmented landscapes (patches) according to their slopes in Table 14, while relative abundance declined in ground insectivores as species diversity increased in fragmented, high edge areas.

Habitat and Topology at Sampling Points

The percent slope of grassland/forest ecotones averaged 23.8 ± 2.61 (SE) and did not vary between intact and fragmented forests ($t = 0.12$, $p > 0.92$). Slopes were not as steep along shrub ecotones and averaged 17.51%. Aspect code varied from 2.10 ± 0.30 in grassland/forest ecotones to 1.95 ± 0.20 in shrub/forest ecotones. There was no difference between intact and fragmented forest aspects ($t = 0.19$, $p > 0.65$). Percent green ground cover varied along edge types and was highest in the grassland/forest fragment ecotone, where it averaged 69.23 ± 1.88 %. The percent litter cover (grand = 29.61 ± 1.40 % among the four edge types) did not vary much, since most plots were placed along forested ecotones that receive leaf-fall-off during the fall season, but was lower in shrub/grassland ecotones (= 12.73 ± 1.28%). Stem densities (no/ha of those < 3.0 cm DBH) of trees were lowest in grassland/intact forest ecotone (= 3,102.61) and highest along pole/forest fragment ecotones (= 5,200.11). Percent canopy cover varied from 37.69% along shrub/forest fragment ecotones to 9.81% along grassland/ shrub ecotones. The amount of woody debris was highest in shrub/intact forest ecotones (= 2.95 ± 0.32%) and lowest in grassland/shrub ecotones 0.75 ± 0.01%). Vine stem counts varied from 1.6% in grassland/shrub ecotones to 4.9% in shrub/intact forest ecotones.

The number of different vegetative life forms (i.e., standing dead vegetation, grasses and sedges, forbs, shrubs 15 cm and shrubs 15 cm high) were counted in plots along the four ecotone types and varied as expected. For example, there were significantly more grasses, sedges, forbs, and shrubs less than 15 cm high in grassland/forest ecotones, where *Sericea* *lespedeza* made up 20.4% of the vegetation. The highest number of shrubs > 15 cm high was noted in shrub/forest fragment ecotones, where it averaged 31.4%. As expected tree height increased with age of succession, but we found no significant difference in tree height between fragmented and intact forests ($t = 0.175$, $p > 0.85$). Plant species diversity did not differ significantly across edge types (one-way ANOVA, $F = 0.38$, $p > 40$), but was slightly higher in shrub/forest fragment ecotones. The species of plants identified on MTRVFs in this studies are listed in Appendix 1.

Pearson product-moment correlations among topology variables (percent slope, aspect, elevation, age of secondary succession, and edge length) and species richness are shown in Table 15. Avian species richness was significantly related only to edge length. Table 16 shows correlations among species richness and number of trees with DBH > 7 cm (live tree), shrub stems 3-5 m in height and 7 cm DBH (tall shrub), shrub stems 1-3 m tall and 7 cm DBH (short shrub), and standing dead trees greater than 7 cm DBH (dead tree). Table 16 also shows association of species richness with estimated height and DBH of overstory trees. Species richness was not significantly correlated with any of these vegetation components, which may indicate that species richness is driven by some other non-measured environmental variable such as food supply. On the other hand, perhaps the vegetation data in shrub/pole plots were too finely defined divided, so that species richness is due to a simple factor such as percent shrub cover.

In a principal component analysis, the first three principal components explained 63.9% of the total variance in the vegetation variables. Principal component (PC) I (stratification or vertical structural diversity) explained 31.4%, while PC II (open cover or amount of grass cover) counted for an additional 19.1% of the variance), and PC III (% shrubs) explained the additional 13.4%. The most significant factor explaining avian species richness among ecotone habitats in the breeding season was vertical structural diversity ($R^2 = 0.91$, $p < 0.001$). The influence of horizontal and vertical vegetation structure on bird communities is well studied (Brown 1992). Natural and human-induced disturbances play significant roles in structuring habitat and bird communities (Mushinsky and Gibson 1991). Disturbance caused by mining may create a mosaic of suitable niches and, like silvicultural disturbance, it may mimic the natural-intensity disturbance regime by creating habitat features required by open grassland and shrub species. In addition, edge habitat bordering mine land is suitable for many forest interior species linking a continuum of grassland, shrub, and forest species in the same general area.

Historical Dataset

Table 17 shows variables (percent slope and vegetation components) measured on 12 historical contour and seven MTRVF mines in southern West Virginia. These 12 contour and seven MTRVFs were randomly selected (among the 80 surveyed historical sites) for assessing vegetation because we could not quantify vegetation at all 80 sites. Vegetation was similar on these historical sites to those on the EIS MTRVFs, but contour mines were generally steeper, smaller in size, and had more advanced stages of succession.

Point count data pooled for all the historical sites showed that species richness was higher along edges 13.41 (± 0.88 SE) than interior plots (9.29 ± 0.69). This was a significant difference (paired t-test, $t = 93.7$, $p < 0.001$). The most abundant species on the 80 mine sites we have examined since 1987 were mostly shrub and forest-dwelling species (Canterbury et al. 1996, Canterbury and Stover 1999). These include, for example, Eastern Towhee, Golden-winged Warbler, and Field Sparrow of the edge / shrub guild, and the Red-eyed Vireo, Ovenbird, and Black-and-White Warbler of the forest-interior guild.

In this report, we compare bird populations at three of the historical sites (Peachtree Ridge, Highland Mountain and Whitby) where we have concentrated our efforts and produced GIS maps (see below). The number of individuals of the 15 most abundant bird species at these sites are listed in Canterbury and Stover (1999). The most abundant species was the Red-eyed Vireo (98 males per 100 ha.), which is considered a forest-interior species. This was followed by the Eastern Towhee, a habitat generalist of edge and shrub (79 males per 100 ha.). The imperiled Golden-winged Warbler was the third most numerous species at 77 males per 100 ha. Another forest-species, the Ovenbird, ranked fourth at 68 males per 100 ha. The Indigo Bunting (edge specialist) and the Black-and-White Warbler (forest-dwelling species) ranked fifth, with 52 males per 100 ha. for both species. Of the remaining 9 species, we found Chestnut-sided Warbler (shrub specialist, 44 males per 100 ha.), Hooded Warbler (forest-interior species, 39 males per 100 ha.), Field Sparrow (edge specialist, 36 males per 100 ha.), Yellow-breasted Chat (shrub specialist, 35 males per 100 ha.), Gray Catbird (shrub species, 27 males per 100 ha.), Wood Thrush (forest-interior species, 26 males per 100 ha.), Common Yellowthroat (shrub specialist, 24 males per 100 ha.), American Redstart (forest generalist, 23 males per 100 ha.), and Tufted Titmouse (forest generalist, 14 males per 100 ha.). Thus, five forest-interior species are rather abundant on these mine types.

Avian population trends from 1989-2000 in 32 southern West Virginia historical mine sites are shown in Table 18. Data were collected along SMC routes that consisted mainly of narrow contour mines surrounded by dense forest. Thus, the routes consisted of a combination of forest and mine habitats. Of the 15 most abundant species mentioned above, seven exhibited negative population trends and eight showed positive trends (Table 18). Of those with negative trends, four were significant. The three with nonsignificant downward trends were the Golden-winged Warbler (0.25% per yr.), Ovenbird (2.3% per yr.) and Common Yellowthroat (1.3% per yr.). The Golden-winged Warbler has shown a steep decline throughout its range since 1966 (7.6% per yr., Sauer et al. 2000), has virtually disappeared from Ohio (Peterjohn and Rice 1991) and the New England states (Confer 1992), and is considered to be declining in West Virginia, having dropped by 4.8% per year from 1966-1987 (BBS data cited in Buckelew and Hall 1994).

The Ovenbird has shown negative local and regional trends, but is not in an overall decline throughout its range (Sauer et al. 2000). Research has shown it is highly impacted by fragmentation throughout its range, but increased by about 18% in the Northeast during the 1994-1995 seasons (DeSante et al. 1998) and increased annually by 2.3% from 1966-2000 in West Virginia (Sauer et al. 2001). Although the Ovenbird is sensitive to habitat fragmentation (Robbins et al. 1989), it does occupy small (about 1 ha) forests tracts and is most likely not declining in West Virginia (BBS data cited in Buckelew and Hall 1994, Sauer et al. 2001). Yet, pairing success has been shown to increase away from edges in Missouri (Gibbs and Faaborg 1990, Villard et al. 1993, Van Horn et al. 1995), southern Ontario (Burke and Nol 1998), and Vermont (Ortega and Capen 1999). Missouri is a highly fragmented landscape (Geissman et al. 1986) and at the periphery of the Ovenbird s breeding range (Villard et al. 1993), and studies (see Sabine et al. 1996) in heavily forested landscapes contradict those of Gibbs and Faaborg (1990), Villard et al. 1993, and Van Horn (1995). Clearly, the data are mixed and contradictory for this well-studied, forest-interior species.

The shrub species are not as well studied as forest-interior species. Some relatively abundant and wide-ranging shrubland birds are declining. For example, the Common Yellowthroat has shown negative populations trends in West Virginia (BBS data cited in Buckelew and Hall 1994) and virtually rangewide (Sauer et al. 2000). Significant negative trends were noted in the Chestnut-sided Warbler (4.5% per yr.), Yellow-breasted Chat (3.5%), and Field Sparrow (7.3%) in our study sites in southern West Virginia (Table 18). Statewide BBS data have suggested that the Chestnut-sided Warbler is increasing in West Virginia, while the Yellow-breasted Chat and Field Sparrow have shown rangewide declines (BBS data cited in Buckelew and Hall 1994, Sauer et al. 2001). The only significant decline of forest-interior species of the most abundant 15 species at our southern West Virginia sites was the Hooded Warbler (4.3% per yr.), which is probably related to negative impacts of deer (Canterbury 2000a). Nonsignificant positive trends were noted in the Indigo Bunting (2.4% per yr.) and the Eastern Towhee (0.95% per yr.). Both these edge / shrub species, however, appear to be declining in many areas of their range (BBS data cited in Buckelew and Hall 1994, Sauer et al. 2000). Notable declines in the Eastern Towhee population are discussed in Hagan (1993).

Significant increases in the Tufted Titmouse (7.2% per yr.), Wood Thrush (3.0%), Gray Catbird (5.0%), Red-eyed Vireo (6.5%), Black-and-White Warbler (4.8%), and American Redstart (6.0%) were noted in southern West Virginia (Table 18). All of these are forest species, except the Gray Catbird. Further examination of Table 18, however, showed that there are some additional negative trends in forest-interior species. The Red-shouldered Hawk declined by 3.4% and Broad-winged Hawk by 10.8%. The Kentucky Warbler has declined by 7.5% in southern West Virginia and local extirpation of some populations has been noted (Canterbury, unpubl. data). There are numerous forest species that appear to be showing positive trends, and a significant number of shrub species are declining.

Figure 9 shows GIS maps for three historical sites (Peachtree Ridge, Highland Mountain, and Whitby). For each site, we have displayed (1) types of land cover, (2) location of roads, (3) location of water, (4) the distribution of elevation, (5) percent slope, and (6) location of houses. One feature displayed by these sites is that they are remote with relatively little fragmentation due to houses, except for a small cluster of houses in the Whitby area. This is believed to be an important factor in contributing to the relatively high densities of both shrub and forest-dwelling species (Canterbury and Stover 1999). Highland Mountain is the most forested of the three sites and had the highest number of Ovenbirds (88 males per 100 ha. as compared to 83 males per 100 ha. at Peachtree Ridge and 33 males per 100 ha. at Whitby). A similar trend holds for Black-and-White Warblers (63, 45, and 47 males per 100 ha. at Highland Mountain, Peachtree Ridge, and Whitby, respectively). However, Highland Mountain also had the highest density of Chestnut-sided Warblers, a shrubland species (Canterbury and Stover 1999). Peachtree Ridge had a higher percentage of total land cover disturbed by mining (Figure 9), but had the highest densities of the Wood Thrush, Red-eyed Vireo, and American Redstart (Canterbury and Stover 1999). Succession at Peachtree Ridge is older (Table 4). All three sites had about equal densities of Golden-winged Warblers (Canterbury and Stover 1999). Elevation and percent slope have been shown to be important predictors of the number of birds of some species, such as the Golden-winged Warbler, on contour and partial mountaintop mine sites (Canterbury et al. 1996, Canterbury and Stover 1999, Stover and Canterbury, in press). A sample of stepwise multiple regression models used to predict abundance of five shrub species is shown in Table 19. Similar analyses for forest-species are needed, such as the ongoing work by Rosenberg et al. (2000) on Cerulean Warblers.

The Cerulean Warbler is considered to be an area-sensitive forest species (Robbins et al. 1989, Rosenberg et al. 2000), but in southern West Virginia there is apparently no increase in number of birds in interior vs. edge plots and more Cerulean Warblers were found on contours than MTRVFs (Table 20, Canterbury 2000c). The Cerulean Warbler, however, is difficult to assess with point counts and Jones et al. (2000) recommend the variable circular plot method. The relatively large number of singing, male Cerulean Warblers in edge habitats may be predominantly first-time breeders (Canterbury 2000c), and area-sensitive species may not show negative impacts of forest fragmentation in moderately or heavily forested landscapes (Rosenberg et al. 1999b). Nevertheless, the Cerulean is a critically imperilled songbird (Robbins et al. 1992) and declined across its range by 2.7% per yr. from 1966-1991 (Peterjohn et al. 1996). Current estimate now is -3.5% per year from 1966-1999 (Sauer et al. 2000). Thus, additional work is needed where Cerulean and Golden-winged Warblers coexist, and where forest-interior and shrubland birds overlap breeding territories (Canterbury et al. 1996, Canterbury 2000c).

Figure 10 shows examples of bird density vs. distance from edge for three forest-interior and three shrub/edge species. In one case, the Ovenbird increased much more dramatically away from edges than did the Acadian Flycatcher and Kentucky Warbler, while shrub/edge species (Indigo Bunting, Eastern Towhee, and Northern Cardinal) declined toward the interior of a habitat. The Kentucky Warbler increased in number in interior forest as compared to edge (Figure 10), but has relatively high nesting success (73% of 22 nests successfully fledged young from 1987-1996) in edges not over-browsed by White-tailed deer (Canterbury and Stover, unpubl. data). Negative impacts of deer populations on understory nesting songbirds are growing (Casey and Hein 1983, Alverson et al. 1988, McShea and Rappole 1992, DeCalesta 1994, McShea et al. 1995).

Before we can adequately evaluate the impacts of mining on bird populations, data from multiple methods (e.g., song counts and mist-netting) must be considered. Tables 21 and 22 show samples of these data from TRMO (historical data and not MTRVF EIS sites), where guild abundance is compared between edge and interior plots as well as between methods (counts and mist-netting). Mist-netting produced more detections and the only guild with higher abundance in the forest interior was the bark-foraging guild (Table 21). Comparing the number of birds captured, we find that considerably more shrubland bird species were detected in a primarily forested habitat than in the other two habitats and by far the smallest number of captures were in grasslands (Table 22). It should be noted, however, that no canopy nets were used and these results would likely differ if canopy netting was conducted (see Stokes et al. 2000).

Summary

This report documents bird populations along edges at three large MTRVFs in southern West Virginia, and presents a comparison between bird populations along contour and MTRVF mines. The report incorporates 14 years of data from a long-term analysis of bird populations throughout the southern West Virginia coalfields. The report documents that, for the most part, both forest-interior and disturbance-dependent species are doing fairly well in the southern West Virginia coalfields. Yet, there are some exceptions and the decline of forest species such as Kentucky Warbler is of concern. We found the highest avian abundance in shrub/forest fragment ecotones in the MTRVF EIS sites, but some key forest-species, such as the Louisiana Waterthrush and Kentucky Warbler were in low numbers or missing from edges on the MTRVFs. Land use patterns in West Virginia are most likely why we have some of the best, if not the highest, concentrations of two umbrella species (Golden-winged and Cerulean warblers). The topology of West Virginia with large forests tracts with minimal disturbance (e.g., gaps, contour mine edges) may be why this is the only state that we know of that can claim to support vast populations of these two umbrella species. Yet, MTRVF mining has become a major method of vast landscape change, where Golden-winged and Cerulean warblers may disappear with the changing proportion of mature forest to cleared land. Both species are apparently doing much better on contour mines than MTRVFs, and this study documents that MTRVFs are considerably different from contour mines. Contour mining is not nearly as common as once was in the 1960s, for example, and has virtually been replaced by MTRVF mining. This may explain why these umbrella species are declining in West Virginia. Less individuals of these two umbrella species are returning each year to breed in West Virginia because of the advancing succession of contour mines and may be settling into areas where forest-contour mine edges are now suitable for breeding. This may explain why Tennessee, for example, has seen an increase in Golden-winged Warblers recently (anecdotal evidence seen throughout ListServs, *North American Birds*, *Birdscope*, and personal communications).

Recent declines in songbird populations have generated much concern in the lay and scientific community and sparked considerable research that has disclosed serious declines of interior forest species. A large number of studies have documented a correlation between decline of forest-interior bird species and edges (Wilcove 1985, Andrén and Angelstram 1988, Harris 1988, Martin 1988, Ratti and Reese 1988, Yahner 1988, Yahner and Scott 1988, Porneluzi et al. 1993, Paton 1994, Hoover et al. 1995, Linder and Bollinger 1995, Marini et al. 1995, Bayne and Hobson 1997, Donovan et al. 1997, Hartley and Hunter 1998, Keyser et al. 1998). Neotropical migrants have received the most attention thus far, but several studies have shown that patterns of population tends vary by geographic region and landscape pattern. The greater decline of Neotropical migrants compared to temperate migrants or residents has been well documented for Eastern forest-dwelling species during the last two decades (Robbins et al. 1989, Sauer and Droege 1992, Peterjohn and Sauer 1994b). However, there is evidence that non-forest breeding birds should be of even greater concern in some areas (Sauer and Droege 1992, James et al. 1992, Witham and Hunter 1992). Growing evidence suggests widespread, steep declines in grassland and shrub-breeding species (Knopf 1994, Vickery and Herkert 1999), and that temperate migrants are declining in equal or greater proportion to Neotropical migrants in some areas and habitats (Hagan et al. 1992, Witham and Hunter 1992, Bohning-Gaese et al. 1993). In West Virginia and elsewhere, there is considerable variation in population decline among forest, shrub, and grassland bird groups (Hall 1983, BBS data cited in Buckelew and Hall 1994, Sauer et al. 2001).

Examination of avian abundances across seasons shows that species relative abundance and species richness are generally highest in shrub habitats. We found that abundances of birds varied among the MTRVF edge types studied. The documentation of the occurrence of fairly good numbers of forest interior species along edge habitats, especially contour shrub edges bordering mature forest is nothing new to West Virginia ornithology (see Canterbury et al. 1996 and Canterbury and Stover 1999). This study documents that many bird species occur predominantly in shrub/forest fragment ecotones. Historical (and long-term) data collected since 1987 throughout southern West Virginia indicate that there is little evidence of negative impacts of forest fragmentation on relative abundance of most forest-dwelling birds, such as the Acadian Flycatcher, Wood Thrush, and Black-and-White Warbler. Despite centuries of habitat fragmentation, the population status and relatively high densities of eastern, forest-dwelling birds throughout their range support this assertion. Advancing forest succession and landscape-induced factors (highly forested states such as West Virginia and other areas throughout eastern North America) probably play important roles in regulating forest species populations. Most likely, we experience local declines of forest species in some areas and increasing, expanding source populations in others. The Acadian Flycatcher is the most numerous bird banded in highly fragmented forest patches during the breeding season in northeastern Ohio (J. Pogacnik, unpubl. data), and increasing in northern Ohio (Canterbury, unpubl. data), despite an annual 1.2% decline in West Virginia from 1966-2000 (Sauer et al. 2001). The Wood Thrush was found in about equal numbers throughout the forested ecotones of this study (Table 10), while the Black-and-White Warbler appears to be increasing in West Virginia and not impacted by deer herbivory.

A group of ground-nesting forest-species, including the Kentucky and Worm-eating warblers, appear to be declining and this may be due to impacts of deer herbivory. This is contradictory to that mentioned above for the Black-and-White Warbler, which has similar nesting habits to the Worm-eating Warbler. Microhabitat differences and ecological competition may explain why some ground-nesting birds of the deciduous forest are declining, while others are increasing.

The most significant analysis may be of priority species identified by Partners In Flight as in need of further study and conservation, and are declining significantly throughout much of their range. Table 23 shows priority species for the study area (Northern Cumberland Plateau Physiographic Province of West Virginia) and list nationally the species on the Watch List. At the national and local level, the Cerulean Warbler (hardwood and mixed mature forest guild) and Golden-winged Warbler (shrub-scrub guild) are of extremely high concern because of their continental population declines. The landscape pattern with the most birds, namely large forested areas with small edges or minimal disturbance from contour mines should be evaluated for a management option for these two species. Of the species of high priority for the hardwood and mixed mature forest of the Northern Cumberland Plateau, namely the Acadian Flycatcher, Yellow-throated Vireo, Wood Thrush, Yellow-throated Warbler, Worm-eating Warbler, Ovenbird, Louisiana Waterthrush, Kentucky Warbler, and Hooded Warbler, two are declining significantly and the others are increasing. The two with an overall continental decline are the Wood Thrush and Kentucky Warbler.

The highest priority bird species, other than the Golden-winged Warbler, in this region are forest-breeders (Cerulean Warbler, Worm-eating Warbler, and Louisiana Waterthrush) whose center of global abundance is along the Appalachian ridges most affected by MTRVF mining (Rosenberg and Wells 1995). Because the Golden-winged Warbler is apparently not being replaced by its sister species in MTRVFs (it would not occur on the Cannelton site, which is in an area that has experienced Blue-wing invasion since the late 1950s), focus should be directed mainly on the forest-interior species.

In closing, in our study of bird populations of southern West Virginia coalfields, we found that the highest avian richness and abundance occurred in shrub/pole habitat on MTRVFs and other mine types in southern West Virginia and that species diversity and abundances varied with edge type. The clearing of forests often results in edge effects, in which species diversity and densities are often higher than in interior forest (see Lay 1938, Johnston 1947, Anderson et al. 1977, McElveen 1979, Strelke and Dickson 1980). The considerable amount of edge created by MTRVF mining is apparently no exception to this pattern, but critical studies are needed to assess additional parameters, such as nesting success, before we make final decisions about the impacts of MTRVF. This is especially true since our work suggest that MTRVF edges differ from those heavily studied in the literature for which considerable impacts due to forest fragmentation have been documented. This study also does not consider any impacts of tropical deforestation on declining Neotropical migrants, nor does it consider the impacts of Brown-headed Cowbirds. Finally, this study, like all those conducted on forest fragmentation, should be evaluated in respect that numerous studies have documented the adverse effects of forest fragmentation.

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Table 1. Total land cover (ha.) of available habitats within MTVRV sites used in this study and percent secondary succession that resulted from reclamation of contour mining rather than MTRVF.

Habitat	Cannelton	Hobet 21	Daltex
Grassland	1,673	2,003	1,835
Shrub/pole	510 [a]	428	296 [a]
Forest Fragment	291	339	125
Total [b]	2,474	4,394	2,834
% Contour Mine	44%	17%	25%

[a] produced mainly by reclamation of contour mining.
[b] includes additional habitats other than the three treatment habitats shown.

Table 2. Distribution of 134 edge points per habitat and MTRVF site (watershed) in southwestern West Virginia.

Ecotone	Cannelton (Twentymile Cr.)	Daltex (Spruce Fork)	Hobet 21 (Mud River)	Total
Grassland / forest	2	17	17	36
Grassland / fragment[1]	25	3	10	38
Grassland / pole[2]	11	12	7	30
Pole / fragment[1]	6	10	14	30
Total	44	42	48	134

[1] = forest fragment, [2] = reclaimed pole-size succession

Table 3. Number of points (N) per watershed / stream in the MTRVF sites of southwestern West Virginia.

Watershed / Stream	Mine Site	N
Adkins Fork	Hobet 21	4
Beech Creek	Daltex	10
Big Horse Creek	Hobet 21	1
Bullpush	Cannelton	13
Gum Hollow	Hobet 21	5
Hewett Creek	Daltex	12
Horse Branch	Hobet 21	3
Hughes Fork	Cannelton	5
Hurricane Branch	Daltex	3
Jim Hollow of Hughes Fork	Cannelton	6
Lavender Fork	Hobet 21	6
Left Fork of Beech Creek	Daltex	3
Little Horse Creek	Hobet 21	5
Lynch / Smithers Creek	Cannelton	15
Rockhouse Fork	Daltex	12
Sally Fork	Hobet 21	6
Sixmile Hollow of Hughes Creek	Cannelton	5
Slippery Gut Branch	Hobet 21	4
Spruce Fork	Daltex	2
Spruce Lick	Hobet 21	4
Stanley Fork	Hobet 21	3
Sugartree Branch	Hobet 21	7

Table 4. Sample of historical mine sites examined during an on-going, long-term analysis of edge and shrub habitats in southern West Virginia.[a]

Mine	County	Coordinates[b] and Topo	Mine Type[c]	Years Studied	Size (ha)[d]	Mine Age[e]	Elev. (m)[f]
Ameagle (Mare Br.)	Raleigh	37° 56' 49" N 81° 22' 55" W Pax	Contour	12	14.8	1989	690
Artie (White Oak Creek)	Raleigh	37° 55' 53" N 81° 18' 22" W Pax	Mixed	9	91	1980	732
Bee & Georges Br. (Shotgun Hollow)	Fayette	37° 55' 43" N 81° 16' 57" W Pax	Contour MTRVF	5	97.2	1986 1995	629
Berry Branch	Raleigh	37° 40' 00" N 81° 17' 30" W Lester	MTRVF	1	150.7	1999	700
Beury Mt.	Fayette	37° 57' 24.7" N 81° 03' 45.8" W Thurmond	Mixed	12	33	1965	755
Big Branch	Wyoming	37° 45' 30.7" N 81° 27' 16.0" W McGraws	Contour	7	105	1985	758
Big Creek	McDowell	37° 16' 47.4" N 81° 34' 43.4" W Gary	Contour	1	97	1968	725
Bottom Creek	McDowell	37° 25' 47.4" N 81° 28' 17.5" W Keystone	Contour	1	43.7	1972	669
Brooklyn (Chestnut Flat)	Fayette	37° 34' 26" N 81° 02' 30" W Thurmond	Mixed	3	63	1980	685
Buffalo Fork	Raleigh	37° 53' 23" N 81° 17' 40" W Pax	MTRVF	5	120.2	1992	600

Table 4. Continued.

Cooperstown	Boone	38° 05' 18" N 81° 35' 11" W Sylvester	Mixed	13	39	1976	490
Crab Orchard (Thompson Ridge)	Raleigh	37° 42' 10" N 81° 14' W Crab Orchard	MTRVF	4	79.6	1970	723
Crane Creek	Wyoming	37° 45' 33.4" N 81° 31' 22.7" W Arnett	Contour	5	37.6	1969	964
Cunard	Fayette	37° 58' 29.1" N 81° 02' 25.1" W Fayettville	Mixed	12	88.5	1969	723
Dry Creek	Boone	37° 49' 44" N 81° 31' 41" W Pilot Knob / Arnett	PMTRVF	5	15.7	1994	700
East Gulf (Stonecoal Cr. & Willibet)	Raleigh	37° 37° 28" N 81° 11' 08" W Rhodell	Contour	12	83	1983	690
Eccles (Millers Camp Branch)	Raleigh	37° 46' 39.1" N 81° 15' 52.5" W Eccles	Contour	14	68.5	1983	703
Egeria	Mercer	37° 30' N 81° 12' W Odd	Contour	8	51.6	1974	879
Ellison Br.	Fayette	37° 54' 56.8" N 80° 53' 58.1" W Danese	Contour	4	47.3	1972	703
Ellis Creek (Marsh Fork)	Raleigh	37° 55' 37" N 81° 29' 32" W Whitesville / Dorothy	PMTRVF	6	10.2	1993	475

Table 4. Continued.

Ephraim Cr.	Fayette	37° 57' 02.5" N 80° 52' 59.3" W Danese	PMTMVF	5	48.6	1975	747
Garden Ground Mt.	Fayette	37° 54.4' N 81° 05.7' W Thurmond	Contour	12	159	1965	749
Gary	McDowell	37° 18' 50.2" N 81° 33' 09.2" W Gary	Mixed	3	370	1970	780
Ghent	Raleigh	37° 37' 10" N 81° 06' 43" W Flat Top	Contour	12	31.7	1972	903
Gilbert (Rich Creek)	Logan	37° 40' 55" N 81° 56' 10" W Gilbert	MTRVF	2	35	1998	570
Glen Rogers	Wyoming	37° 45' 33.2" N 81° 26' 45.4" W Glen Rogers	PMTMVF	3	85.9	1985	741
Guyandotte (Bolt) Mt.	Raleigh / Wyoming	37° 47' 10" N 81° 29' 48" W Arnett	Contour	12	28.5	1969	970
Harper	Raleigh	37° 48' 33" N 81° 15' 07" W Beckley / Eccles	Contour	14	2.5	1983	690
Harpers Br. (Sandlick Cr.)	Raleigh	37° 49' 25" N 81° 19' 56" W Eccles	Mixed	14	52.4	1983	712
Hazy Creek	Raleigh	37° 51' 17" N 81° 33' 24" W Pilot Knob	Contour	14	39.4	1987	722
Highland Mt.	Fayette	37° 55.3' N 81° 0.6' W Thurmond	MTRVF	11	108	1973	742

Table 4. Continued.

Kayford Mt.	Boone / Raleigh	37° 58' 23.1" N 81° 22' 09.9" W Whitesville	MTRVF	9	1,862	1971	746
Horse Creek	Raleigh	37° 55' 44" N 81° 19' 45" W Pax	Contour MTRVF	12	180	1987 1999	590
James Creek	Boone	37° 55' 27" N 81° 33' 53" W Whitesville	MTRVF	1	538	1999	600
Laurel Br. (Big Coal River)	Raleigh	37° 57 49" N 81° 27' 16" W Dorothy	Contour	5	6.84	1994	478
Lester	Raleigh	37° 44' 10" N 81° 17' 30" W Lester	Contour	12	20.4	1975	715
Lick Creek	Raleigh	37° 56' 05" N 81° 19' 29" W Pax	PMTRVF	6	42.5	1988	730
Little Brushy Fork (Little Marsh FK.)	Raleigh	37°55' 08" N 81° 29' 10" W Dorothy	Mixed	1	25.6	1999	591
Lillybrook	Raleigh	37° 38' 15.3" N 81° 13' 03.1" W Crab Orchard	PMTMVF Auger	8	63.8	1969 1998	697
Long Creek	Fayette	37° 57' 08.2" N 80° 52' 34.9" W Danese	Contour	2	71	1972	715
Low Gap Br. (Coon Hollow - Dorothy)	Raleigh	37° 56' 33" N 81° 30' 15" W Dorothy / Whitesville	Mixed	6	28	1993	602
Mann Mt.	Fayette	38° 02' 44.4" N 80° 53' 30.9" W Danese	MTRVF	7	82	1978	746

Table 4. Continued.

Manns Creek	Fayette	37° 59' 44.1" N 80° 53' 22.4" W Danese	MTRVF	4	150	1973	729
Maple Meadow	Raleigh	37° 45' 29.8" N 81° 21' 53.1" W Lester	Contour	14	133	1969	591
McAlpin	Raleigh	37° 41' 50" N 81° 17' 17" W McAlpin	Contour	12	60.2	1983	703
McDowell Branch	Raleigh	37° 54' 24" N 81° 22' 28" W Pax	MTRVF	12	28.5	1983	585
Meadow Fork	Fayette	37° 55' 31" N 81° 06' 10" W Thurmond	Contour	12	79.1	1966	725
Metalton	Raleigh	37° 46' 35" N 81° 17' 17" W Eccles	Contour	14	73.3	1974	602
Midway	Raleigh	37° 42' 40" N 81° 13' 41" W Crab Orchard	Contour	12	32.7	1982	600
Mill Creek	Raleigh	37° 51' 41.4" N 81° 08' 42.7" W Oak Hill	Contour	3	63.9	1969	664
Millers Fork	Raleigh	37° 48' 43" N 81° 27' 01" W Arnett	Contour	12	6.3	1982	587
Mount Hope (Sun Mine Rd.)	Fayette	37° 55' 28" N 81° 10' 37.6" W Oak Hill	Mixed	2	90	1983	609
Muddlety	Nicholas	37° 17' 21.4" N 81° 49' 43" W Summersville	MTRVF	7	219	1988	721

Table 4. Continued.

Odd (Piney Cr.)	Raleigh	37° 36' 43.5" N 81° 10' 24.0" W Odd	Contour	6	37	1972	848
Panther Br. (Clear Fork)	Raleigh	37° 56' 53" N 81° 27' 36" W Dorothy	Contour	6	20.6	1990	590
Payne Knob (Paint Creek)	Fayette	38° 00' 26" N 81° 19' 06" W Pax	MTRVF	3	59	1991	822
Peachtree Ridge	Raleigh	37° 50' 27.0" N 81° 28' 18.7" W Arnett	Contour	12	160	1962	939
Pinnacle Cr.	Wyoming	37° 33' 24" N 81° 29' 09" W Pineville	MTRVF	5	135	1979	856
Princewick (Stonecoal Creek)	Raleigh	37° 40' N 81° 15.7' W Crab Orchard	Contour	3	38	1966	727
Rock Creek (Left Fork)	Raleigh	37° 52' 22" N 81° 22' 25" W Arnett	PMTRVF	12	23.6	1981	579
Scarbro	Fayette	37° 50' 36" N 81° 10' 34" W Oak Hill	Contour	12	13	1983	600
Seng Creek	Boone	37° 59' 06" N 81° 37' 02" W Whitesville	MTRVF	3	49	1977	523
Shumate Creek	Raleigh	37° 51' 19" N 81° 31' 36" W Pilot Knob	Contour	7	28.7	1996	725
Slab Fork (Mill Branch)	Raleigh	37° 40' 34.7" N 81° 19' 12.0" W Lester	Contour	5	375	1973	689

Table 4. Continued.

Stover (Sandlick)	Raleigh	37° 50' 39" N 81° 20' 00" W Eccles	Mixed	8	171.3	1978	526
Sweenyburg	Raleigh	37° 50' 20" N 81° 15' 41" W Eccles	Contour	13	5.5	1988	550
Sycamore Creek	Raleigh	37° 52' 33" N 81° 23' 02" W Pax	MTRVF	13	37.2	1983	531
Table Rock	Raleigh	37° 47' 12" N 81° 02' 40" W Prince	Contour	12	56	1977	848
Tams	Raleigh	37° 40' 20" N 81° 18' 06" W	Contour	13	5.6	1983	700
Tams Creek (Paint Mt.)	Raleigh	37° 56' 21" N 81° 17' 01" W Pax	PMTRVF	5	8	1991	769
Tiller Camp Branch (Devil s Fork)	Raleigh	37° 33' 32" N 81° 16' 46" W Rhodell	Mixed	8	3.5	1990	605
Tommy Cr.	Raleigh	37° 35' 41" N 81° 14' 52" W Rhodell	Contour	12	24.5	1985	500
Toney Fork	Raleigh	37° 54' 48" N 81° 18' 04" W Pax	MTRVF	9	106.7	1989	800
Welch	McDowell	37° 24' 54" N 81° 33' 30" W Welch	MTRVF	6	77	1974	587
West Fork (Pond Fork)	Boone / Raleigh	37° 54' 51" N 81° 36' 02" W Whitesville	MTRVF	12	137	1988	500

Table 4. Continued.

White Oak Creek	Boone	37° 08' 40.9" N 81° 30' 42.9" W Whitesville	Mixed MTRVF	3	147	1985 1995	597
Whitby (Spencer Br.)	Raleigh	37° 39' 48.3" N 81° 10' 37.0" W Crab Orchard	Contour	12	175	1974	712
Workmans Creek	Raleigh	37° 53' 17" N 81° 21' 43" W Pax	MTRVF	13	142	1983	699

[a] Additional sites can be obtained from the senior author, including vast areas with old contour mining activity such as Rhodell, Raleigh County. These sites are also described in Canterbury et al. 1993, 1996, Canterbury and Stover 1999 and 2000c. [b] Center of the study area and empty blocks denote coordinates not yet obtained. [c] Primary mining method (see Canterbury and Stover 1999). [d] Land originally disturbed by mining activity (but 79% of this land is now second-growth forest). [E] Date of earliest surface mining activity, but permits may span several decades. [f] Modal value.

Table 5. Relative abundance (number/point) of birds observed during the winter season (January - April 10, 2000) at interior (n = 80) and edge (n = 134) points at MTRVFs of southwestern West Virginia.

	Interior	Edge
Species	**± 1 SE**	**± 1 SE**
American Crow	0.82 ± 0.27	3.04 ± 1.09
American Goldfinch	0.08 ± 0.02	0.08 ± 0.02
American Kestrel	0.00 ± 0.00	0.10 ± 0.03
American Robin	0.10 ± 0.06	0.70 ± 0.30
American Tree Sparrow	0.0 ± 0.0	0.12 ± 0.04
American Woodcock	0.0 ± 0.0	0.05 ± 0.02
Belted Kingfisher	0.0 ± 0.0	0.01 ± 0.005
Black-capped Chickadee	0.0 ± 0.0	0.03 ± 0.009
Blue Jay	0.12 ± 0.07	0.07 ± 0.02
Brewer s Blackbird	0.0 ± 0.0	0.01 ± 0.005
Brown-headed Cowbird	0.0 ± 0.0	0.05 ± 0.03
Canada Goose	0.0 ± 0.0	0.08 ± 0.05
Carolina Chickadee	0.27 ± 0.10	0.19 ± 0.08
Carolina Wren	0.10 ± 0.04	0.21 ± 0.09
Cedar Waxwing	0.14 ± 0.04	0.16 ± 0.05
Chipping Sparrow	0.02 ± 0.008	0.02 ± 0.008
Common Raven	0.0 ± 0.0	0.04 ± 0.01
Dark-eyed Junco	1.65 ± 0.72	1.87 ± 0.75
Downy Woodpecker	0.12 ± 0.05	0.17 ± 0.09
Eastern Bluebird	0.35 ± 0.12	1.13 ± 0.61

Table 5. Continued.

	Interior	Edge
Species	**± 1 SE**	**± 1 SE**
Eastern Meadowlark	0.10 ± 0.05	1.15 ± 0.63
Eastern Phoebe	0.00 ± 0.00	0.09 ± 0.03
European Starling	0.0 ± 0.0	2.27 ± 1.03
Field Sparrow	0.40 ± 0.11	0.80 ± 0.51
Golden-crowned Kinglet	0.02 ± 0.005	0.04 ± 0.02
Hairy Woodpecker	0.0 ± 0.0	0.04 ± 0.009
Hermit Thrush	0.12 ± 0.05	0.12 ± 0.04
Horned Lark	0.07 ± 0.03	0.65 ± 0.22
Killdeer	0.0 ± 0.0	0.29 ± 0.10
Mallard	0.12 ± 0.08	0.56 ± 0.20
Mourning Dove	0.07 ± 0.04	0.09 ± 0.04
Northern Cardinal	0.15 ± 0.07	0.22 ± 0.09
Northern Flicker	0.40 ± 0.18	0.64 ± 0.28
Northern Harrier	0.07 ± 0.04	0.17 ± 0.12
Northern Mockingbird	0.0 ± 0.0	0.04 ± 0.01
Peregrine Falcon[1]	---	---
Pileated Woodpecker	0.40 ± 0.16	0.23 ± 0.10
Red-bellied Woodpecker	0.02 ± 0.007	0.05 ± 0.01
Red-shouldered Hawk	0.04 ± 0.01	0.05 ± 0.009
Red-tailed Hawk	0.07 ± 0.02	0.17 ± 0.09
Red-winged Blackbird	0.22 ± 0.09	0.28 ± 0.10
Ring-necked Pheasant	0.0 ± 0.0	0.03 ± 0.01

Table 5. Continued.

	Interior	Edge
Species	**± 1 SE**	**± 1 SE**
Rock Dove	0.0 ± 0.0	0.07 ± 0.02
Rough-legged hawk	0.0 ± 0.0	0.03 ± 0.008
Ruby-crowned Kinglet	0.0 ± 0.0	0.04 ± 0.01
Ruffed Grouse	0.02 ± 0.01	0.03 ± 0.01
Sharp-shinned Hawk	0.05 ± 0.01	0.0 ± 0.0
Song Sparrow	0.37 ± 0.20	0.83 ± 0.31
Swamp Sparrow	0.0 ± 0.0	0.08 ± 0.05
Tufted Titmouse	0.32 ± 0.18	0.29 ± 0.18
Turkey Vulture	0.22 ± 0.10	0.70 ± 0.30
Vesper Sparrow	0.0 ± 0.0	0.12 ± 0.05
Water Pipit	0.0 ± 0.0	0.03 ± 0.009
White-breasted Nuthatch	0.17 ± 0.09	0.03 ± 0.01
White-throated Sparrow	0.12 ± 0.06	0.12 ± 0.06
Wild Turkey	0.0 ± 0.0	0.90 ± 0.41
Winter Wren	0.0 ± 0.0	0.02 ± 0.008
Wood Duck	0.15 ± 0.07	0.29 ± 0.14
Yellow-bellied Sapsucker	0.05 ± 0.02	0.0 ± 0.0
Gull species[2]	---	---

[1] Single bird observed on Cannelton mine. Incidental sightings (outside areas of point counts) included: Brown Thrasher, Bufflehead, Eastern Towhee, Golden Eagle, Greater Yellowlegs, Hooded Merganser, Lesser Yellowlegs, Marsh Wren, Ring-billed Gull, Rock Dove, and Savannah Sparrow. [2] = unidentified.

Table 6. Importance values (IV) of selected bird species in winter on MTRVFs.

Species	IV	Species	IV
High Occurence		**Low Occurence**	
American Crow	174	Turkey Vulture	44
Dark-eyed Junco	149	Wild Turkey	40
Moderate Occurence		American Robin	37
European Starling	97	Pileated Woodpecker	33
Eastern Bluebird	88	Horned Lark	29
Eastern Meadowlark	75	Mallard	27
Field Sparrow	63	Tufted Titmouse	24
Song Sparrow	63	Red-winged Blackbird	18
Northern Flicker	53	Carolina Chickadee	10

Table 7. Relative abundance (mean ± 1 SE) of birds detected along grassland, shrub, forest fragment, and intact forest transects within MTRVF EIS sites of southwestern West Virginia. Data collected during the spring and fall migration periods.

Species (by Habitat)	Spring Abundance	Fall Abundance
Grassland		
American Kestrel	0.10 ± 0.06	0.05 ± 0.006
Barn Swallow	0.51 ± 0.20	0.21 ± 0.10
Bobolink	0.21 ± 0.08	0.44 ± 0.18
Brown-headed Cowbird	0.13 ± 0.07	0.22 ± 0.10
Chimney Swift	0.29 ± 0.10	0.19 ± 0.12
Common Grackle	0.30 ± 0.10	0.33 ± 0.15
Common Nighthawk	0.01 ± 0.003	0.22 ± 0.12
Common Raven	0.06 ± 0.004	0.12 ± 0.05
Common Snipe	0.03 ± 0.005	0.04 ± 0.009
Eastern Bluebird	0.15 ± 0.08	0.24 ± 0.09
Eastern Kingbird	0.15 ± 0.09	0.23 ± 0.10
Eastern Meadowlark	0.57 ± 0.29	0.41 ± 0.22
European Starling	0.69 ± 0.30	0.40 ± 0.18
Grasshopper Sparrow	0.13 ± 0.07	0.58 ± 0.23
Great Blue Heron	0.08 ± 0.02	0.07 ± 0.04
Horned Lark	0.30 ± 0.18	0.40 ± 0.21
Killdeer	0.32 ± 0.19	0.20 ± 0.11
Mallard	0.12 ± 0.05	0.16 ± 0.05
Mourning Dove	0.43 ± 0.25	0.59 ± 0.30
Northern Harrier	0.06 ± 0.01	0.02 ± 0.009
Northern Rough-winged Swallow	0.29 ± 0.13	0.20 ± 0.09
Red-tailed Hawk	0.08 ± 0.04	0.03 ± 0.007

Table 7. Continued.

Species	Spring Abundance	Fall Abundance
Red-winged Blackbird	0.48 ± 0.23	0.38 ± 0.20
Rusty Blackbird	0.16 ± 0.06	0.0
Savannah Sparrow	0.25 ± 0.09	0.08 ± 0.04
Tree Swallow	0.61 ± 0.22	0.49 ± 0.25
Turkey Vulture	0.63 ± 0.22	0.92 ± 0.38
Vesper Sparrow	0.19 ± 0.09	0.0
Wood Duck	0.04 ± 0.003	0.0
Shrubland		
American Goldfinch	0.30 ± 0.12	0.45 ± 0.20
American Redstart	0.39 ± 0.17	0.10 ± 0.06
American Robin	0.59 ± 0.20	0.35 ± 0.16
American Woodcock	0.33 ± 0.19	0.06 ± 0.008
Baltimore Oriole	0.15 ± 0.06	0.12 ± 0.06
Bay-breasted Warbler	0.05 ± 0.02	0.15 ± 0.07
Black-billed Cuckoo	0.18 ± 0.10	0.23 ± 0.15
Blackpoll Warbler	0.02 ± 0.008	0.0
Blue Grosbeak	0.23 ± 0.13	0.08 ± 0.05
Blue-winged Warbler	0.59 ± 0.23	0.22 ± 0.12
Brown Thrasher	0.42 ± 0.19	0.28 ± 0.10
Carolina Wren	0.44 ± 0.21	0.33 ± 0.17
Cedar Waxwing	0.20 ± 0.13	0.09 ± 0.05
Chestnut-sided Warbler	0.20 ± 0.09	0.36 ± 0.15
Chipping Sparrow	0.59 ± 0.23	0.45 ± 0.19
Common Yellowthroat	0.40 ± 0.18	0.30 ± 0.18
Dark-eyed Junco	0.31 ± 0.17	0.0

Table 7. Continued.

Species	Spring Abundance	Fall Abundance
Eastern Phoebe	0.41 ± 0.21	0.35 ± 0.17
Eastern Towhee	0.46 ± 0.18	0.43 ± 0.20
Field Sparrow	0.68 ± 0.31	0.21 ± 0.10
Golden-winged Warbler	0.24 ± 0.14	0.11 ± 0.06
Gray Catbird	0.61 ± 28	0.55 ± 0.25
Great-crested Flycatcher	0.33 ± 0.19	0.11 ± 0.05
Hairy Woodpecker	0.20 ± 0.11	0.21 ± 0.08
House Finch	0.07 ± 0.03	0.0
House Wren	0.25 ± 0.10	0.25 ± 0.13
Indigo Bunting	0.45 ± 0.22	0.40 ± 0.19
Kentucky Warbler	0.08 ± 0.03	0.0
Least Flycatcher	0.17 ± 0.09	0.27 ± 0.15
Lincoln s Sparrow	0.10 ± 0.04	0.0
Magnolia Warbler	0.50 ± 0.21	0.29 ± 0.12
Mourning Warbler	0.18 ± 0.07	0.08 ± 0.05
Nashville Warbler	0.31 ± 0.13	0.21 ± 0.10
Northern Bobwhite	0.05 ± 0.001	0.02 ± 0.001
Northern Cardinal	0.33 ± 0.15	0.27 ± 0.14
Northern Flicker	0.39 ± 0.19	0.33 ± 0.15
Northern Mockingbird	0.12 ± 0.06	0.21 ± 0.09
Northern Waterthrush	0.13 ± 0.07	0.0
Orange-crowned Warbler	0.05 ± 0.01	0.0
Palm Warbler	0.16 ± 0.09	0.0
Pine Siskin	0.18 ± 0.07	0.0
Pine Warbler	0.12 ± 0.05	0.06 ± 0.02

Table 7. Continued.

Species	Spring Abundance	Fall Abundance
Prairie Warbler	0.40 ± 0.16	0.08 ± 0.04
Purple Finch	0.13 ± 0.06	0.0
Red-bellied Woodpecker	0.42 ± 0.22	0.40 ± 0.25
Red-headed Woodpecker	0.00	0.15 ± 0.09
Red-shouldered Hawk	0.15 ± 0.10	0.11 ± 0.007
Ruby-throated Hummingbird	0.20 ± 0.12	0.31 ± 0.15
Ruffed Grouse	0.30 ± 0.18	0.40 ± 0.23
Scarlet Tanager	0.46 ± 0.20	0.13 ± 0.05
Song Sparrow	0.38 ± 0.16	0.27 ± 0.10
Swamp Sparrow	0.14 ± 0.07	0.0
Tennessee Warbler	0.45 ± 0.20	0.63 ± 0.25
White-crowned Sparrow	0.16 ± 0.06	0.0
White-eyed Vireo	0.33 ± 0.17	0.65 ± 0.29
White-throated Sparrow	0.63 ± 0.27	0.0
Wild Turkey	0.63 ± 0.33	0.53 ± 0.29
Willow Flycatcher	0.31 ± 0.13	0.22 ± 0.12
Worm-eating Warbler	0.19 ± 0.08	0.13 ± 0.06
Yellow-breasted Chat	0.20 ± 0.08	0.11 ± 0.05
Yellow-billed Cuckoo	0.15 ± 0.04	0.29 ± 0.13
Yellow-rumped Warbler	0.52 ± 0.23	0.0
Yellow Warbler	0.31 ± 0.13	0.08 ± 0.04
Forest		
Acadian Flycatcher	0.56 ± 0.30	0.45 ± 0.20
American Crow	0.66 ± 0.28	0.49 ± 0.23
Barred Owl	0.06 ± 0.003	0.02 ± 0.001

Table 7. Continued.

Species	Spring Abundance	Fall Abundance
Belted Kingfisher	0.13 ± 0.07	0.25 ± 0.12
Black-and-White Warbler	0.30 ± 0.13	0.10 ± 0.04
Blackburnian Warbler	0.14 ± 0.05	0.09 ± 0.04
Black-throated Blue Warbler	0.12 ± 0.05	0.05 ± 0.01
Black-throated Green Warbler	0.31 ± 0.14	0.09 ± 0.03
Blue-gray Gnatcatcher	0.51 ± 0.23	0.28 ± 0.14
Blue Jay	0.46 ± 0.26	0.29 ± 0.12
Blue-headed Vireo	0.45 ± 0.20	0.08 ± 0.04
Broad-winged Hawk	0.16 ± 0.06	0.24 ± 0.13
Cape May Warbler	0.23 ± 0.09	0.19 ± 0.09
Carolina Chickadee	0.55 ± 0.21	0.61 ± 0.29
Cerulean Warbler	0.22 ± 0.12	0.0
Cooper s Hawk	0.05 ± 0.008	0.10 ± 0.004
Downy Woodpecker	0.59 ± 0.20	0.27 ± 0.14
Eastern Screech-Owl	0.09 ± 0.05	0.01 ± 0.004
Golden-crowned Kinglet	0.15 ± 0.04	0.0
Hermit Thrush	0.30 ± 0.18	0.0
Hooded Warbler	0.24 ± 0.12	0.14 ± 0.07
Louisiana Waterthush	0.14 ± 0.08	0.0
Northern Parula	0.16 ± 0.08	0.09 ± 0.05
Orchard Oriole	0.17 ± 0.08	0.05 ± 0.008
Ovenbird	0.35 ± 0.13	0.15 ± 0.09
Philadelphia Vireo	0.14 ± 0.06	0.09 ± 0.03
Pileated Woodpecker	0.18 ± 0.08	0.18 ± 0.08
Red-eyed Vireo	0.67 ± 0.26	0.51 ± 0.21

Table 7. Continued.

Species	Spring Abundance	Fall Abundance
Rose-breasted Grosbeak	0.15 ± 0.10	0.26 ± 0.12
Ruby-crowned Kinglet	0.29 ± 0.11	0.0
Sharp-shinned Hawk	0.02 ± 0.001	0.04 ± 0.001
Swainson s Thrush	0.32 ± 0.14	0.26 ± 0.12
Tufted Titmouse	0.31 ± 0.12	0.40 ± 0.18
Whip-poor-will	0.19 ± 0.08	0.0
White-breasted Nuthatch	0.22 ± 0.13	0.33 ± 0.15
Winter Wren	0.08 ± 0.01	0.0
Wood Thrush	0.63 ± 0.28	0.20 ± 0.12
Yellow-bellied Sapsucker	0.27 ± 0.15	0.0
Yellow-throated Vireo	0.17 ± 0.11	0.28 ± 0.14
Yellow-throated Warbler	0.20 ± 0.09	0.06 ± 0.02

Additional sightings: American Bittern, American Black Duck, American Coot, King Rail, Pied-billed Grebe, Solitary Sandpiper, and Spotted Sandpiper were on or near ponds in grasslands. Ringed-necked Pheasants were seen in grassland and shrub/pole habitats.

Table 8. Mean (± SE) avian species richness and total abundance along 300 meter line transects (50 meters fixed width) within four edge habitat types of the MTRVF sites in southwestern West Virginia. Data were compiled from spring migration counts from April 11 - May 31, 2000.

	Grassland	Shrub	Forest (fragment)	Forest (intact)	F[2] (p)
Species (within 50 meters)	12.31 ± 0.93	18.58 ± 1.29	9.16 ± 0.85	7.23 ± 0.49	38.5 (0.01)
Density[1] (within 50 meters)	8.35 ± 0.51	12.39 ± 0.83	6.59 ± 0.44	5.10 ± 0.40	32.0 (0.02)
Total Abundance	23.85 ± 1.3	30.98 ± 1.05	19.27 ± 1.12	12.34 ± 0.99	43.1 (0.01)

[1] Birds / ha. [2] One-way ANOVA comparing species richness, density or total abundance across edge types.

Table 9. Mean (± SE) avian species richness and abundance along 300 meter line transects (50 meters fixed width) within four edge habitat types of the MTRVF sites in southwestern West Virginia. Data were compiled from spring migration counts from April 11 - May 31, 2000. Data from fall migration counts (from August 1 - September 10, 2000) showed similarity with spring, and, thus, are not shown.

Spring	Grassland (Distance from edge, m)			Shrub (Distance from edge, m)		
	0	150	300	0	150	300
Species	12.02 (0.84)	12.66 (0.95)	12.90 (0.87)	19.0 (1.20)	18.29 (1.25)	18.56 (1.13)
Density[1]	8.30 (0.60)	8.44 (0.45)	8.23 (0.52)	12.47 (0.78)	12.26 (0.84)	12.38 (0.85)
	Forest (fragment) (Distance from edge, m)			Forest (intact) (Distance from edge, m)		
	0	150	300	0	150	300
Species	9.04 (0.82)	9.10 (0.90)	9.19 (0.81)	7.30 (0.49)	7.25 (0.45)	7.17 (0.51)
Density[1]	6.66 (0.43)	6.63 (0.45)	6.55 (0.50)	5.24 (0.45)	5.20 (0.40)	5.02 (0.40)

[1] Birds / ha. Two-way ANOVA was used to test for treatment differences in species richness or density across edge types and by distance. Dependent variables differed across habitats ($p < 0.05$), but did not vary within groups by distance ($p > 0.05$).

Table 10. Bird species observed (mean with standard errors in parentheses) during 50-m radius point count surveys on MTRVF (this study = TS) edges in June - mid July 2000 and throughout contour mine sites in southern West Virginia (sWV) during the breeding season. N = 30 points in each edge type selected at random throughout sWV.

	Habitats[1]									
Species	G/F		G/FF		G/S		S/FF		ANOVA Results[2]	
									F	p
	sWV	TS	sWV	TS	sWV	TS	sWV	TS		
Forest Interior Species										
Acadian Flycatcher	0.22^{B} (0.03)	0.18^{B} (0.02)	0.15^{C} (0.02)	0.14^{B} (0.02)	0.03^{D} (0.007)	0.02^{C} (0.006)	0.23^{B} (0.03)	0.19^{B} (0.03)	sWV 27.41 TS 17.91	 0.001 0.001
Black-throated Green Warbler	$0.08^{C,D}$ (0.01)	0.04^{B} (0.009)	$0.06^{B,C}$ (0.01)	0.03^{B} (0.004)	0.04^{B} (0.008)	0.04^{B} (0.004)	0.11^{D} (0.02)	0.10^{C} (0.02)	sWV 4.75 TS 8.68	 0.004 0.001
Blue-headed Vireo	0.12^{B} (0.03)	0.03^{B} (0.005)	0.04^{C} (0.007)	0.03^{B} (0.008)	0.02^{C} (0.004)	0.01^{B} (0.003)	0.15^{B} (0.03)	0.06^{C} (0.009)	sWV 12.10 TS 3.84	 0.001 0.025
Cerulean Warbler	0.10^{B} (0.00)	0.04^{B} (0.00)	0.00^{C} (0.00)	0.00^{C} (0.00)	0.00^{C} (0.00)	0.00^{C} (0.00)	0.31^{D} (0.08)	0.23^{D} (0.05)	sWV 14.02 TS 13.49	 0.001 0.001
Eastern Wood-Pewee	0.25^{B} (0.09)	0.18^{B} (0.03)	0.08^{C} (0.02)	0.08^{C} (0.02)	0.00^{D} (0.00)	0.00^{D} (0.00)	0.30^{B} (0.10)	0.18^{B} (0.08)	sWV 10.14 TS 8.00	 0.001 0.001

Table 10. Continued.

Species	Habitats								ANOVA Results[a]	
	G/F		G/FF		G/S		S/FF		F	p
	sWV	TS	sWV	TS	sWV	TS	sWV	TS		
Great-crested Flycatcher	0.08[B] (0.01)	0.07[B] (0.02)	0.10[B] (0.02)	0.07[B] (0.02)	0.08[B] (0.02)	0.10[C] (0.03)	0.13[C] (0.04)	0.12[C] (0.03)	sWV 3.15 TS 3.11	0.05 0.05
Kentucky Warbler	0.04 (0.008)	0.02 (0.006)	0.03 (0.009)	0.03 (0.007)	0.00 (0.00)	0.00 (0.00)	0.05 (0.008)	0.02 (0.007)	sWV 1.79 TS 1.30	0.18 0.277
Louisiana Waterthrush	0.00[B] (0.00)	0.00[B] (0.00)	0.00[B] (0.00)	0.00[B] (0.00)	0.00[B] (0.00)	0.00[B] (0.00)	0.08[C] (0.006)	0.03[C] (0.007)	sWV 44.20 TS 14.95	0.001 0.001
Ovenbird	0.23[B] (0.04)	0.10[B] (0.03)	0.18[B] (0.04)	0.16[C] (0.03)	0.00[C] (0.00)	0.00[D] (0.00)	0.29[D] (0.06)	0.20[C] (0.05)	sWV 30.06 TS 19.28	0.001 0.001
Pileated Woodpecker	0.08[B] (0.003)	0.05 (0.004)	0.06[B] (0.003)	0.03 (0.005)	0.02[C] (0.004)	0.03 (0.006)	0.10[B] (0.02)	0.05 (0.007)	sWV 7.33 TS 2.10	0.001 0.16
Scarlet Tanager	0.28[B] (0.07)	0.20[B] (0.05)	0.25[B,C] (0.06)	0.17[B,C] (0.03)	0.05[D] (0.006)	0.09[D] (0.01)	0.22[C] (0.06)	0.22[C] (0.05)	sWV 33.91 TS 20.83	0.001 0.001

Table 10. Continued.

Species	Habitats								ANOVA Results[a]		
	G/F		G/FF		G/S		S/FF			F	p
	sWV	TS	sWV	TS	sWV	TS	sWV	TS			
Summer Tanager	0.00^{B} (0.00)	0.03^{B} (0.006)	0.00^{B} (0.00)	0.05^{B} (0.007)	0.00^{B} (0.00)	0.00^{C} (0.00)	0.08^{C} (0.009)	0.10^{C} (0.02)	sWV	40.95	0.001
									TS	31.64	0.001
Swainson s Warbler	0.00^{B} (0.00)	0.00 (0.00)	0.00^{B} (0.00)	0.00 (0.00)	0.00^{B} (0.00)	0.00 (0.00)	0.04^{C} (0.006)	0.00 (0.00)	sWV	36.22	0.001
Wood Thrush	0.32^{B} (0.07)	0.30^{B} (0.08)	0.29^{B} (0.08)	0.27^{B} (0.08)	0.00^{C} (0.00)	0.00^{C} (0.00)	0.30^{B} (0.06)	0.25^{B} (0.05)	sWV	50.88	0.001
									TS	45.96	0.001
Worm-eating Warbler	0.19^{B} (0.06)	0.13^{B} (0.04)	$0.16^{B,C}$ (0.04)	$0.10^{B,C}$ (0.01)	0.00^{D} (0.00)	0.00^{D} (0.00)	0.12^{C} (0.02)	0.08^{C} (0.02)	sWV	29.15	0.001
									TS	25.33	0.001
Yellow-throated Warbler	0.06^{B} (0.004)	0.08^{B} (0.005)	0.04^{B} (0.006)	0.06^{B} (0.003)	0.00^{C} (0.00)	0.00^{C} (0.00)	0.04^{B} (0.005)	0.05^{B} (0.007)	sWV	10.41	0.001
									TS	14.93	0.001
Interior-edge Species											
American Redstart	0.09^{B} (0.003)	0.11^{B} (0.02)	0.14^{C} (0.02)	0.14^{C} (0.03)	0.14^{B} (0.04)	0.15^{C} (0.03)	0.35^{D} (0.08)	0.26^{D} (0.06)	sWV	64.71	0.001
									TS	42.17	0.001

Table 10. Continued.

Species	Habitats: G/F		G/FF		G/S		S/FF		ANOVA Results[a]	
	sWV	TS	sWV	TS	sWV	TS	sWV	TS	F	p
American Robin	0.24^{B}	0.18^{B}	0.30^{C}	0.22^{C}	0.20^{B}	0.12^{C}	0.24^{B}	0.12^{C}	sWV 4.61	0.005
	(0.06)	(0.05)	(0.09)	(0.07)	(0.04)	(0.02)	(0.05)	(0.03)	TS 9.88	0.001
Black-and-white Warbler	0.27^{B}	0.25^{B}	0.22^{C}	0.21^{C}	0.03^{D}	0.03^{D}	0.23^{C}	$0.23^{B,C}$	sWV 28.05	0.001
	(0.08)	(0.05)	(0.03)	(0.04)	(0.005)	(0.007)	(0.05)	(0.06)	TS 25.91	0.001
Blue-gray Gnatcatcher	0.15^{B}	0.17^{B}	0.18^{B}	0.19^{B}	0.11^{C}	0.13^{C}	0.25^{D}	0.26^{D}	sWV 18.75	0.001
	(0.04)	(0.05)	(0.05)	(0.06)	(0.02)	(0.02)	(0.06)	(0.08)	TS 16.39	0.001
Carolina Chickadee	0.10	0.11	0.08	0.10	0.08	0.10	0.11	0.11	sWV 1.33	0.28
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.04)	(0.02)	TS 1.27	0.31
Carolina Wren	0.20^{B}	0.22^{B}	0.24^{C}	0.30^{C}	0.14^{D}	0.16^{D}	0.31^{E}	0.38^{E}	sWV 46.84	0.001
	(0.05)	(0.04)	(0.07}	(0.05)	(0.04)	(0.05)	(0.07)	(0.08)	TS 67.05	0.001

Table 10. Continued.

Species	G/F sWV	G/F TS	G/FF sWV	G/FF TS	G/S sWV	G/S TS	S/FF sWV	S/FF TS	ANOVA Results[a] sWV F	sWV p	TS F	TS p
Downy Woodpecker	0.11 (0.02)	$0.13^{C,D}$ (0.03)	0.11 (0.04)	0.10^{C} (0.02)	0.10 (0.03)	0.05^{B} (0.009)	0.13 (0.02)	0.15^{D} (0.04)	2.56	0.07	3.95	0.01
Eastern Phoebe	0.13 (0.02)	0.15 (0.04)	0.16 (0.02)	0.15 (0.02)	0.13 (0.02)	0.12 (0.04)	0.15 (0.02)	0.15 (0.03)	1.12	0.34	0.91	0.43
Eastern Towhee	0.21^{B} (0.04)	0.18^{B} (0.05)	0.17^{C} (0.02)	0.17^{B} (0.04)	0.24^{B} (0.04)	0.16^{B} (0.04)	0.33^{D} (0.08)	0.22^{C} (0.02)	16.02	0.001	13.89	0.001
Hairy Woodpecker	0.05 (0.006)	0.04^{B} (0.005)	0.05 (0.007)	0.07^{B} (0.005)	0.03 (0.007)	0.02^{C} (0.004)	0.05 (0.004)	0.07^{B} (0.003)	0.79	0.48	3.40	0.047
Hooded Warbler	0.28^{B} (0.07)	0.23^{B} (0.05)	0.23^{C} (0.03)	0.20^{B} (0.04)	0.00^{D} (0.00)	0.00^{C} (0.00)	0.32^{E} (0.08)	0.30^{D} (0.07)	22.71	0.001	31.96	0.001
Northern Flicker	$0.12^{B,C}$ (0.02)	$0.14^{B,C}$ (0.03)	$0.14^{C,D}$ (0.04)	0.16^{C} (0.03)	0.10^{B} (0.02)	0.11^{B} (0.02)	0.18^{D} (0.05)	0.20^{D} (0.04)	15.10	0.001	19.23	0.001

Table 10. Continued.

Species	Habitats: G/F		G/FF		G/S		S/FF		ANOVA Results[a]	
	sWV	TS	sWV	TS	sWV	TS	sWV	TS	F	p
Northern Parula	0.16^{B} (0.02)	0.10^{B} (0.01)	0.10^{C} (0.02)	0.10^{C} (0.02)	0.02^{D} (0.006)	0.00^{C} (0.00)	0.14^{B} (0.03)	0.11^{B} (0.02)	sWV 8.97 TS 7.85	0.001 0.001
Red-bellied Woodpecker	0.06^{B} (0.007)	0.09^{B} (0.003)	0.10^{C} (0.02)	0.09^{B} (0.004)	0.03^{B} (0.005)	0.03^{C} (0.004)	0.12^{C} (0.03)	0.13^{D} (0.02)	sWV 20.93 TS 18.41	0.001 0.001
Red-eyed Vireo	0.78^{B} (0.04)	0.71^{B} (0.06)	0.73^{C} (0.05)	0.67^{C} (0.05)	0.62^{D} (0.04)	0.60^{C} (0.05)	1.25^{E} (0.04)	1.05^{E} (0.08)	sWV 67.96 TS 60.08	0.001 0.001
Ruby-throated Hummingbird	0.18^{B} (0.04)	0.20^{B} (0.02)	0.22^{C} (0.05)	0.20^{B} (0.04)	0.22^{C} (0.05)	0.23^{C} (0.03)	$0.25^{C,D}$ (0.06)	0.27^{C} (0.05)	sWV 18.17 TS 14.59	0.001 0.001
Tufted Titmouse	$0.24^{B,C}$ (0.04)	$0.20^{B,C}$ (0.02)	0.20^{B} (0.02)	0.18^{B} (0.02)	0.13^{D} (0.01)	0.10^{D} (0.008)	0.26^{C} (0.04)	0.24^{C} (0.03)	sWV 38.61 TS 47.22	0.001 0.001
White-breasted Nuthatch	0.08^{B} (0.006)	0.10^{B} (0.009)	0.04^{C} (0.005)	0.06^{C} (0.005)	0.02^{D} (0.003)	0.02^{D} (0.005)	$0.06^{B,C}$ (0.008)	$0.08^{B,C}$ (0.02)	sWV 10.35 TS 15.69	0.001 0.001

Table 10. Continued.

Species	Habitats								ANOVA Results[a]	
	G/F		G/FF		G/S		S/FF		F	p
	sWV	TS	sWV	TS	sWV	TS	sWV	TS		
Yellow-billed Cuckoo	$0.13^{B,C}$ (0.04)	0.10^{B} (0.02)	0.10^{B} (0.008)	$0.13^{B,C}$ (0.02)	0.16^{C} (0.04)	0.16^{C} (0.03)	0.27^{D} (0.05)	0.25^{D} (0.04)	sWV 3.37 TS 4.08	 0.05 0.01
Yellow-throated Vireo	0.15^{B} (0.07)	0.19^{B} (0.07)	0.12^{B} (0.05)	$0.22^{B,C}$ (0.08)	0.05^{C} (0.008)	0.07^{D} (0.01)	0.26^{D} (0.07)	0.24^{C} (0.08)	sWV 17.04 TS 13.67	 0.001 0.001
Edge Species										
American Crow	0.13 (0.05)	0.08 (0.03)	0.16 (0.07)	0.10 (0.04)	0.13 (0.05)	0.07 (0.01)	0.15 (0.06)	0.10 (0.05)	sWV 2.03 TS 1.96	 0.16 0.17
American Goldfinch	0.16 (0.06)	0.12 (0.04)	0.17 (0.08)	0.12 (0.06)	0.18 (0.06)	0.15 (0.07)	0.18 (0.07)	0.14 (0.05)	sWV 0.83 TS 0.97	 0.47 0.387
Baltimore Oriole	0.06 (0.03)	0.08 (0.04)	0.04 (0.008)	0.07 (0.01)	0.04 (0.01)	0.06 (0.02)	0.06 (0.02)	0.08 (0.02)	sWV 0.77 TS 0.81	 0.50 0.48
Blue Grosbeak	0.00 (0.00)	0.00^{B} (0.00)	0.00 (0.00)	0.00^{B} (0.00)	0.00 (0.00)	0.08^{C} (0.04)	0.00 (0.00)	0.17^{D} (0.08)	TS 40.51	 0.001

Table 10. Continued.

	Habitats									
Species	G/F		G/FF		G/S		S/FF		ANOVA Results[a]	
									F	p
	sWV	TS	sWV	TS	sWV	TS	sWV	TS		
Blue Jay	0.14 (0.08)	0.18 (0.07)	0.16 (0.08)	0.18 (0.06)	0.13 (0.05)	0.15 (0.07)	0.16 (0.07)	0.18 (0.08)	sWV 2.05 TS 0.82	 0.16 0.48
Blue-winged Warbler	0.14^{B} (0.06)	0.10^{B} (0.06)	0.10^{B} (0.05)	0.12^{B} (0.06)	0.38^{C} (0.07)	0.50^{C} (0.06)	1.22^{D} (0.06)	1.02^{D} (0.07)	sWV 70.09 TS 67.34	 0.001 0.001
Brown Thrasher	0.05^{B} (0.01)	0.04^{B} (0.009)	0.08^{B} (0.04)	0.06^{B} (0.02)	0.17^{C} (0.10)	0.20^{C} (0.09)	0.15^{C} (0.07)	0.20^{C} (0.08)	sWV 35.91 TS 43.82	 0.001 0.001
Brown-headed Cowbird	0.10^{B} (0.03)	0.03^{B} (0.005)	0.13^{B} (0.04)	0.05^{B} (0.02)	0.17^{C} (0.08)	0.12^{C} (0.06)	0.10^{B} (0.05)	0.05^{B} (0.01)	sWV 23.85 TS 17.54	 0.001 0.001
Cedar Waxwing	0.07^{B} (0.02)	0.04^{B} (0.02)	0.07^{B} (0.03)	0.07^{C} (0.03)	0.06^{B} (0.02)	0.04^{B} (0.007)	0.10^{C} (0.04)	0.12^{D} (0.05)	sWV 3.36 TS 3.73	 0.05 0.018
Chipping Sparrow	0.10^{B} (0.04)	0.08^{B} (0.02)	0.15^{C} (0.06)	0.12^{B} (0.06)	0.20^{D} (0.07)	0.23^{C} (0.08)	0.22^{D} (0.07)	0.27^{D} (0.08)	sWV 53.48 TS 63.10	 0.001 0.001

Table 10. Continued.

Species	G/F sWV	G/F TS	G/FF sWV	G/FF TS	G/S sWV	G/S TS	S/FF sWV	S/FF TS	ANOVA Results[a] F	ANOVA Results[a] p
Common Yellowthroat	0.18^{B} (0.06)	0.22^{B} (0.09)	0.20^{B} (0.08)	0.25^{B} (0.10)	0.82^{C} (0.07)	0.85^{C} (0.05)	0.57^{D} (0.05)	0.64^{D} (0.03)	sWV 59.85 TS 64.04	 0.001 0.001
Eastern Bluebird	0.13 (0.04)	0.16 (0.05)	0.18 (0.03)	0.20 (0.03)	0.16 (0.04)	0.15 (0.04)	0.10 (0.02)	0.13 (0.02)	sWV 1.30 TS 0.66	 0.277 0.541
Field Sparrow	0.26^{B} (0.05)	0.28^{B} (0.05)	0.38^{B} (0.05)	0.45^{C} (0.15)	1.21^{C} (0.07)	1.07^{D} (0.08)	0.50^{D} (0.04)	0.66^{E} (0.07)	sWV 86.56 TS 79.10	 0.001 0.001
Golden-winged Warbler	0.11^{B} (0.02)	0.02^{B} (0.007)	0.13^{B} (0.02)	0.04^{B} (0.009)	0.10^{B} (0.02)	0.02^{B} (0.007)	0.42^{C} (0.05)	0.36^{C} (0.04)	sWV 42.19 TS 100.79	 0.001 0.001
Gray Catbird	0.07^{B} (0.03)	0.02^{B} (0.007)	$0.10^{B,C}$ (0.02)	0.05^{B} (0.009)	0.16^{C} (0.03)	0.11^{C} (0.04)	0.38^{D} (0.05)	0.31^{D} (0.05)	sWV 34.39 TS 45.49	 0.001 0.001
Indigo Bunting	0.50^{B} (0.07)	0.54^{B} (0.08)	0.48^{B} (0.08)	$0.57^{B,C}$ (0.10)	0.88^{C} (0.10)	0.65^{C} (0.11)	1.50^{D} (0.11)	1.20^{D} (0.12)	sWV 108.63 TS 90.44	 0.001 0.001

Table 10. Continued.

Species	G/F sWV	G/F TS	G/FF sWV	G/FF TS	G/S sWV	G/S TS	S/FF sWV	S/FF TS	ANOVA Results[a] F	ANOVA Results[a] p
Mourning Dove	0.05 (0.007)	0.07 (0.02)	0.07 (0.02)	0.08 (0.02)	0.05 (0.009)	0.09 (0.02)	0.07 (0.02)	0.10 (0.04)	sWV 1.77; TS 1.28	sWV 0.18; TS 0.28
Northern Bobwhite	0.03 (0.01)	0.03 (0.02)	0.03 (0.02)	0.04 (0.02)	0.04 (0.01)	0.04 (0.02)	0.03 (0.02)	0.03 (0.009)	sWV 1.65; TS 1.10	sWV 0.20; TS 0.31
Northern Cardinal	0.11^{B} (0.03)	0.15^{B} (0.04)	0.15^{B} (0.02)	0.17^{B} (0.06)	0.09^{B} (0.02)	0.10^{B} (0.04)	0.61^{C} (0.07)	0.55^{C} (0.06)	sWV 67.06; TS 59.28	sWV 0.001; TS 0.001
Orchard Oriole	0.09^{B} (0.03)	0.11^{B} (0.02)	$0.05^{B,C}$ (0.01)	0.05^{C} (0.01)	0.02^{C} (0.007)	0.03^{C} (0.007)	0.06^{B} (0.01)	0.06^{C} (0.02)	sWV 4.64; TS 6.37	sWV 0.004; TS 0.001
Prairie Warbler	0.05^{B} (0.01)	0.07^{B} (0.02)	0.04^{B} (0.02)	0.07^{B} (0.02)	0.27^{C} (0.03)	0.35^{C} (0.05)	0.55^{D} (0.05)	1.09^{D} (0.04)	sWV 114.75; TS 138.75	sWV 0.001; TS 0.001
Song Sparrow	0.17^{B} (0.03)	0.14^{B} (0.03)	0.25^{C} (0.04)	0.20^{C} (0.05)	0.32^{D} (0.04)	0.28^{D} (0.05)	$0.21^{B,C}$ (0.04)	0.14^{B} (0.02)	sWV 5.63; TS 4.21	sWV 0.001; TS 0.037

Table 10. Continued.

Species	Habitats								ANOVA Results[a]	
	G/F		G/FF		G/S		S/FF		F	p
	sWV	TS	sWV	TS	sWV	TS	sWV	TS		
White-eyed Vireo	0.05[B] (0.01)	0.08[B] (0.02)	0.05[B] (0.01)	0.10[B] (0.02)	0.27[C] (0.04)	0.33[C] (0.05)	0.24[C] (0.03)	0.27[C] (0.04)	sWV 42.35 TS 26.81	0.001 0.001
Willow Flycatcher	0.00[B] (0.00)	0.00[B] (0.00)	0.00[B] (0.00)	0.00[B] (0.00)	0.20[C] (0.03)	0.12[C] (0.02)	0.11[D] (0.02)	0.10[C] (0.02)	sWV 43.54 TS 21.48	0.001 0.001
Yellow Warbler	0.06[B] (0.02)	0.10[B] (0.03)	0.10[B] (0.03)	0.11[B] (0.02)	0.24[C] (0.04)	0.31[C] (0.04)	0.06[B] (0.01)	0.07[B] (0.01)	sWV 22.64 TS 29.35	0.001 0.001
Yellow-breasted Chat	0.18[B] (0.04)	0.15[B] (0.05)	0.21[B] (0.05)	0.20[B] (0.03)	0.20[B] (0.03)	0.20[B] (0.04)	1.27[C] (0.05)	1.00[C] (0.05)	SWV 238.08 TS 200.65	0.001 0.001
Grassland Species										
Bobolink	0.00[B] (0.00)	0.00[B] (0.00)	0.04[C] (0.01)	0.03[C] (0.008)	0.05[C] (0.01)	0.03[C] (0.007)	0.00[B] (0.00)	0.00[B] (0.00)	sWV 9.23 TS 8.75	0.001 0.001
Dickcissel	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.03 (0.002)	0.00 (0.00)	0.03 (0.002)	0.00 (0.00)	0.00 (0.00)	TS 2.15	0.14

Table 10. Continued.

Species	Habitats								ANOVA Results[a]	
	G/F		G/FF		G/S		S/FF		F	p
	sWV	TS	sWV	TS	sWV	TS	sWV	TS		
Eastern Meadowlark	0.32[B] (0.04)	0.40[B] (0.05)	0.36[B,C] (0.04)	0.71[C] (0.04)	0.42[C] (0.04)	0.76[C] (0.05)	0.00[D] (0.00)	0.00[D] (0.00)	sWV 43.98 TS 120.59	 0.001 0.001
Grasshopper Sparrow	0.30[B] (0.03)	0.38[B] (0.04)	0.37[B] (0.04)	0.48[B] (0.04)	0.53[C] (0.05)	1.81[C] (0.07)	0.11[D] (0.02)	0.26[D] (0.04)	sWV 29.92 TS 348.62	 0.001 0.001
Horned Lark	0.11[B] (0.02)	0.19[B] (0.03)	0.16[C] (0.03)	0.23[C] (0.03)	0.19[C] (0.02)	0.29[C] (0.04)	0.00[D] (0.00)	0.00[D] (0.00)	sWV 25.12 TS 35.89	 0.001 0.001
Red-winged Blackbird	0.22[B] (0.02)	0.22[B,C] (0.05)	0.24[B] (0.04)	0.26[C] (0.04)	0.85[D] (0.07)	0.90[D] (0.07)	0.15[D] (0.03)	0.19[B] (0.05)	sWV 165.97 TS 189.73	 0.001 0.001
Vesper Sparrow	0.08[B] (0.02)	0.05[B] (0.03)	0.07[C] (0.01)	0.05[C] (0.01)	0.05[B] (0.02)	0.08[B] (0.02)	0.00[C] (0.00)	0.00[C] (0.00)	sWV 4.45 TS 4.29	 0.005 0.038

Table 10. Continued.

Other Species	Habitats: G/F sWV	G/F TS	G/FF sWV	G/FF TS	G/S sWV	G/S TS	S/FF sWV	S/FF TS	ANOVA Results[a] F	p
American Kestrel	0.09^{B} (0.03)	0.10^{B} (0.02)	$0.12^{B,C}$ (0.03)	0.16^{C} (0.03)	0.15^{C} (0.03)	0.17^{C} (0.04)	0.03^{D} (0.008)	0.01^{D} (0.004)	sWV 9.38 TS 20.59	 0.001 0.001
Bank Swallow	$0.07^{B,C}$ (0.02)	0.06 (0.01)	0.10^{C} (0.03)	0.09 (0.02)	0.11^{C} (0.03)	0.08 (0.02)	0.03^{B} (0.009)	0.04 (0.01)	sWV 3.91 TS 1.18	 0.011 0.321
Barn Swallow	$0.10^{B,C}$ (0.03)	0.06 (0.01)	$0.14^{C,D}$ (0.02)	0.08 (0.02)	0.15^{D} (0.03)	0.09 (0.02)	0.08^{B} (0.02)	0.05 (0.01)	sWV 3.97 TS 1.02	 0.01 0.387
Chimney Swift	0.23 (0.04)	0.27^{C} (0.02)	0.26 (0.05)	0.32^{C} (0.03)	0.22 (0.03)	$0.26^{B,C}$ (0.02)	0.19 (0.03)	0.20^{B} (0.03)	sWV 1.43 TS 4.42	 0.238 0.005
Killdeer	0.04^{B} (0.01)	0.07^{B} (0.01)	$0.07^{B,C}$ (0.0)	$0.10^{B,C}$ (0.0	0.09^{C} (0.02)	0.13^{C} (0.03)	0.0^{D} (0.00)	0.00^{D} (0.00)	sWV 7.62 TS 16.79	 0.001 0.001
Mallard	0.11^{B} (0.03)	0.20^{B} (0.03)	0.13^{B} (0.01)	0.20^{B} (0.02)	0.14^{B} (0.03)	0.22^{B} (0.02)	0.00^{C} (0.00)	0.00^{C} (0.00)	sWV 34.12 TS 50.27	 0.001 0.001

Table 10. Continued.

Species	G/F sWV	G/F TS	G/FF sWV	G/FF TS	G/S sWV	G/S TS	S/FF sWV	S/FF TS	ANOVA Results[a] F	p
Tree Swallow	0.25[B] (0.02)	0.20[B] (0.02)	0.30[B,C] (0.03)	0.32[C] (0.02)	0.32[C] (0.04)	0.38[C] (0.03)	0.09[D] (0.01)	0.08[D] (0.01)	sWV 26.06	0.001
									TS 51.68	0.001
Turkey Vulture	0.04 (0.009)	0.03[B] (0.008)	0.08 (0.02)	0.06[C,D] (0.02)	0.06 (0.009)	0.08[D] (0.01)	0.04 (0.009)	0.05[B,C] (0.009)	sWV 2.59	0.07
									TS 4.46	0.005

[1] G/F = grassland/forest (intact) ecotone, G/FF = grassland/forest fragment or island ecotone, G/S = grassland/shrub ecotone, and S/FF = Shrub/forest fragment ecotone. The S/FF ecotone is generally the result of roads and contour mines that are approximately 30 years in secondary succession, and, thus, is young forest bordered by mature forest. Most of these latter forests are quite large and fragmented by mainly roads and a few scattered houses (see Canterbury et al 1996). [2] One-way ANOVA was used to test for mean abundance differences across habitat types. Results from sWV and this study (TS) were tested separately. Means with different letters are significantly different (Duncan s multiple comparisons test). The reader should compare means within each study (either SWV or TS) and not across studies.

Table 11. Importance values (IV) of selected bird species in summer on MTRVFs.

Species	IV	Species	IV
High Occurence		**Low Occurence**	
Red-eyed Vireo	200	Northern Cardinal	49
Indigo Bunting	193	Ruby-thr. Hummingbird	42
Grasshopper Sparrow	190	Wood Thrush	35
Field Sparrow	170	Song Sparrow	32
Common Yellowthroat	150	Blue-gray Gnatcatcher	30
Eastern Meadowlark	127	White-eyed Vireo	30
Moderate Occurence		N. Rough-winged Swallow	25
Blue-winged Warbler	115	Eastern Towhee	24
Red-winged Blackbird	100	Hooded Warbler	24
Prairie Warbler	99	Black-and-White Warbler	20
Yellow-breasted Chat	90	Tufted Titmouse	20
Carolina Wren	63	Yellow-throated Vireo	19
Chimney Swift	60	Horned Lark	15
Tree Swallow	53	Carolina Chickadee	10

Table 12. Number of birds (total and mean) banded during five fall migration seasons (1996-2000) in southern West Virginia at Three Rivers Migration Observatory (TRMO) and percent (%) of total that were captured on a contour mine (10% of the TRMO observatory area) in Raleigh County, West Virginia.

Species	Total	Mean	%
Grassland			
Common Grackle	13	2.6	0%
Eastern Bluebird	17	3.4	58.8%
Eastern Kingbird	1	0.2	0%
Eastern Meadowlark	1	0.2	100%
European Starling	1	0.2	0%
Grasshopper Sparrow	15	3.0	100%
Horned Lark	1	0.2	100%
Mourning Dove	40	8.0	0%
Red-winged Blackbird	6	1.2	33.3%
Savannah Sparrow	1	0.2	100%
Shrubland			
American Goldfinch	1842	368.4	20%
American Redstart	203	40.6	7.9%
American Robin	48	9.6	6.2%
Baltimore Oriole	6	1.2	0%
Bay-breasted Warbler	71	14.2	31%
Black-billed Cuckoo	2	0.4	0%
Blackpoll Warbler	24	4.8	3%
Blue Grosbeak	2	0.4	100%
Blue-winged Warbler	22	4.4	31.8%
Brown Thrasher	41	8.2	24.4%
Carolina Wren	128	25.6	27.3%

Table 12. Continued.

Species	Total	Mean	%
Cedar Waxwing	75	15.0	14.7%
Chestnut-sided Warbler	80	16.0	40%
Chipping Sparrow	178	35.6	42.1%
Common Yellowthroat	322	64.4	31.1%
Dark-eyed Junco	182	36.4	2.7%
Eastern Phoebe	74	14.8	18.9%
Eastern Towhee	150	30.0	22%
Field Sparrow	191	38.2	31.9%
Golden-winged Warbler	22	4.4	36.4%
Gray Catbird	467	93.4	19.3%
Great-crested Flycatcher	2	0.4	0%
Hairy Woodpecker	3	0.6	33.3%
House Finch	1695	339.0	0.6%
House Wren	81	16.2	14.8
Indigo Bunting	520	104.0	36.5%
Kentucky Warbler	22	4.4	18.2%
Least Flycatcher	18	3.6	22.2%
Lincoln s Sparrow	87	17.4	37.9%
Magnolia Warbler	405	81.0	5.7%
Mourning Warbler	14	2.8	0%
Nashville Warbler	46	9.2	30.4%
Northern Cardinal	266	53.2	18.4%
Northern Flicker	2	0.4	0%
Northern Mockingbird	12	2.4	0%
Northern Waterthrush	26	5.2	23.1%

Table 12. Continued.

Species	Total	Mean	%
Orange-crowned Warbler	2	0.4	0%
Palm Warbler	96	19.2	27.1%
Pine Siskin	711	142.2	0%
Pine Warbler	6	1.2	0%
Prairie Warbler	19	3.8	26.3%
Purple Finch	14	2.8	0%
Red-bellied Woodpecker	9	1.8	11.1%
Ruby-throated Hummingbird	557	111.4	20%
Scarlet Tanager	62	12.4	12.9%
Song Sparrow	695	139.0	14.8%
Swamp Sparrow	195	39.0	11.8%
Tennessee Warbler	1131	226.2	22.1%
Traill s Flycatcher	38	7.6	13.2%
White-crowned Sparrow	18	3.6	27.8%
White-eyed Vireo	40	8.0	37.5%
White-throated Sparrow	440	88.0	15.7%
Worm-eating Warbler	48	9.6	37.5%
Yellow-breasted Chat	9	1.8	22.2%
Yellow-billed Cuckoo	7	1.4	28.6%
Yellow-rumped Warbler	338	67.6	10.4%
Yellow Warbler	20	4.0	0%
Forest			
Acadian Flycatcher	18	3.6	0%
Belted Kingfisher	1	0.2	0%
Black-and-White Warbler	45	9.0	20%
Blackburnian Warbler	22	4.4	0%

Table 12. Continued.

Species	Total	Mean	%
Black-throated Blue Warbler	59	11.8	30.5%
Black-throated Green Warbler	84	16.8	31%
Blue-gray Gnatcatcher	80	16.0	15%
Blue Jay	106	21.2	17%
Blue-headed Vireo	69	13.8	42%
Cape May Warbler	18	3.6	22.2%
Carolina Chickadee	178	35.6	22.5%
Cerulean Warbler	1	0.2	0%
Downy Woodpecker	42	8.4	26.2%
Eastern Screech-Owl	2	0.4	0%
Golden-crowned Kinglet	42	8.4	11.9%
Hermit Thrush	29	5.8	34.5%
Hooded Warbler	107	21.4	34.6%
Louisiana Waterthush	10	2.0	0%
Northern Parula	22	4.4	9.1%
Orchard Oriole	1	0.2	0%
Ovenbird	120	24.0	25.8%
Philadelphia Vireo	2	0.4	0%
Red-eyed Vireo	139	27.8	23%
Rose-breasted Grosbeak	28	5.6	0%
Ruby-crowned Kinglet	171	34.2	16.4%
Sharp-shinned Hawk	5	1.0	0%
Swainson s Thrush	144	28.8	22.2%
Tufted Titmouse	209	41.8	35%
White-breasted Nuthatch	27	5.4	0%

Table 12. Continued.

Species	Total	Mean	%
Winter Wren	38	7.6	18.4%
Wood Thrush	26	5.2	26.9%
Yellow-throated Vireo	22	4.4	27.3%
Yellow-throated Warbler	10	2.0	20%

Birds were classified into habitat categories based on primary place of capture.

Table 13. Mean number of detections per foraging guild during winter and breeding seasons on edge plots (N = 38) of MTRVF sites in southwestern West Virginia. Data analyzed for 38 randomly selected point counts of the 134 plots due to time constraints.

	G/F	G/FF	G/S	S/FF	G/F	G/FF	G/S	S/FF
	Winter				**Breeding**			
Foraging Guild								
Ground-shrub	6	6	8	10	9	12	15	13
Trunk-bark	3	3	2	5	6	4	4	8
Sallier-canopy	6	4	4	8	11	10	7	14

G/F = grassland/forest (intact), G/FF = grassland/forest fragment, G/S = grassland / shrub (pole), and S/FF = shrub (pole) / forest (fragment). Data were normally distributed (Shapiro-Wilks test, $p > 0.13$).

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Table 14. Relationship between edge length and number of species and individuals (singing males/point) in major trophic groups.

Trophic group	Slope	Intercept	R	p
Species richness				
Omnivores	0.73	0.4	0.88	0.001
Bark Insectivores	0.40	0.9	0.79	0.01
Ground Insectivores	0.63	0.6	0.92	0.001
Foliage Insectivores	0.22	1.2	0.64	0.05
Aerial Insectivores	0.69	0.3	0.93	0.001
Abundance				
Omnivores	0.85	0.6	0.80	0.01
Bark Insectivores	-0.30	5.0	-0.58	0.05
Ground Insectivores	-0.19	2.2	0.75	0.02
Foliage Insectivores	0.25	1.9	-0.60	0.05
Aerial Insectivores	0.61	0.8	0.69	0.05

Table 15. Pearson product-moment correlations (r) among variables measured on three MTRFV sites in southwestern West Virginia.

	Percent Slope	Aspect	Elevation (meters)	Seral Stage	Edge Length (meters)
Species Richness	-0.371	-0.325	-0.386	-0.108	0.951[*]
Percent Slope		0.993[**]	-0.275	0.925[*]	-0.164
Aspect			-0.383	0.888	-0.093
Elevation (m)				-0.129	-0.647
Seral Stage[a]					0.015

[a] Young reclaimed grassland (3-22 years), shrub/pole succession (12-30 years), and forested land (35 years). [*] $p < 0.05$, [**] $p < 0.01$.

Table 16. Pearson product-moment correlations among species diversity and vegetation components measured at shrub or pole/ forest fragment edge study plots in MTRVFs of southwestern West Virginia.

	Species Richness	Live Tree	Tall shrub	Short shrub	Dead tree	Tree height	Tree DBH
Species Richness		-0.235	-0.018	0.007	0.374	-0.145	0.074
Live Tree	-0.235		0.869**	0.799**	-0.703**	-0.778**	-0.897**
Tall shrub	-0.018	0.869**		0.983**	-0.721**	-0.971**	-0.887**
Short shrub	0.007	0.799**	0.983**		-0.871**	-0.957**	-0.871**
Dead tree	0.374	-0.703**	-0.721**	-0.640*		0.540*	0.710**
Tree height	-0.145	-0.778**	0.917**	-0.957**	0.540*		0.921**
Tree DBH	0.074	0.003	-0.887**	-0.871**	0.710**	0.921**	

Abbreviations for each vegetation category are defined in the text. * $p < 0.05$, ** $p < 0.01$.

Table 17. Percent slope and vegetation components (mean ± 1 SE) at edge and interior plots at 12 historical contour and seven historical MTRVF mines in southern West Virginia[a]. Comparisons were made using factorial ANOVA. Data were normally distributed (Levene statistic, $p > 0.05$). NS = no significant difference.

	Contour		MTRVFs		
Variable	Interior	Edge	Interior	Edge	$p < 0.05$
% Slope	38.7 ± 6.4	41.6 ± 7.5	33.8 ± 6.1	37.5 ± 7.0	NS
Tree Height (m)	22.9 ± 2.5	18.5 ± 2.1	20.3 ± 2.5	17.9 ± 1.8	NS
Litter Depth (cm)	4.0 ± 1.4	3.4 ± 1.1	3.8 ± 1.1	3.5 ± 0.9	NS
Percent Ground Cover	40.5 ± 2.2	37.9 ± 1.7	39.2 ± 2.0	35.6 ± 1.5	NS
Percent Canopy Cover	48.1 ± 2.3	39.0 ± 2.3	41.2 ± 2.4	36.5 ± 2.7	NS
Shrub Height (cm)	34.5 ± 6.0	40.7 ± 7.5	32.8 ± 6.6	37.0 ± 7.0	yes
Stem density / ha[b]	3.9 ± 0.05	3.2 ± 0.08	3.6 ± 0.06	3.0 ± 0.05	NS
Basal area[c]	112.5 ± 13.1	100.3 ± 10.6	104.7 ± 12.6	90.2 ± 10.9	yes

[a] All data were collected in July - August at the end of the growing season. A clinometer was used to measure tree height and slope; all other measures followed James and Shugart (1970). [b] log-transformed values. [c] We used a 10-factor prism to estimate basal area at 0.032 ha. vegetation plots within the study areas (Hovind and Rieck 1970).

Table 18. Population trends (percent annual change) of breeding birds of sWV coalfields (n = 32 historical sites). Data collected from 1989-2000. Methods follow from Geissler and Sauer (1990) and the BBS.

Species	Migratory Status[1]	Status & Abundance (birds per route)[2]	Distribution (out of 32 routes)	Trend (% annual change) ± SE	p
Great Blue Heron	Temperate migrant	FC (2.4)	25	8.4 (± 3.8)	0.01
Green Heron	Central neotropical migrant	R (0.81)	23	- 2.6 (± 1.7)	0.12
Wood Duck	Temperate migrant	R (0.43)	23	- 2.0 (± 1.3)	0.15
Mallard	Temperate migrant	C (4.0)	27	- 0.9 (± 0.06)	0.68
Canada Goose	Permanent resident	FC (3.1)	20	11.6 (± 1.9)	0.001
Turkey Vulture	Temperate migrant	FC (2.7)	32	4.4 (± 1.8)	0.03
Cooper s Hawk	Permanent resident Temperate migrant	R (0.85)	26	6.3 (± 2.0)	0.02
Sharp-shinned Hawk	Temperate and central neotropical migrant	R (0.05)	19	2.4 (± 1.7)	0.12
Red-tailed Hawk	Permanent resident Temperate migrant	R (0.61)	27	2.8 (± 0.9)	0.09
Red-shouldered Hawk	Temperate migrant	R (0.12)	20	- 3.4 (± 2.0)	0.04

Table 18. Continued.

Broad-winged Hawk	Southern neotropical migrant	R (0.10)	18	- 10.8 (± 2.4)	0.001
American Kestrel	Permanent resident Temperate migrant	R (0.05)	14	- 5.1 (± 1.1)	0.02
Killdeer	Temperate migrant	U (1.3)	15	- 4.7 (± 1.2)	0.03
Mourning Dove	Permanent resident	A (15.6)	32	14.4 (± 1.6)	0.001
Black-billed Cuckoo	Southern neotropical migrant	C (4.9)	32	- 3.3 (± 0.8)	0.04
Yellow-billed Cuckoo	Southern neotropical migrant	FC (2.6)	25	- 5.9 (± 1.2)	0.02
Chimney Swift	Southern neotropical migrant	FC (2.9)	23	2.5 (± 1.1)	0.16
Ruby-throated Hummingbird	Central neotropical migrant	FC (3.3)	32	6.1 (± 0.8)	0.02
Belted Kingfisher	Temperate migrant	U (1.4)	29	0.8 (± 0.9)	0.72
Red-headed Woodpecker	Temperate migrant	R (0.75)	14	- 15.4 (± 2.8)	0.001
Red-bellied Woodpecker	Permanent resident	C (5.6)	30	8.0 (± 1.3)	0.015
Downy Woodpecker	Permanent resident	C (4.1)	24	2.9 (± 0.7)	0.10
Hairy Woodpecker	Permanent resident	U (1.2)	18	1.5 (± 0.9)	0.23
Northern Flicker	Temperate migrant	C (5.6)	29	- 6.5 (± 1.4)	0.02

Table 18. Continued.

Pileated Woodpecker	Permanent resident	R (0.73)	22	4.8 (± 1.5)	0.035
Eastern Wood-Pewee	Southern neotropical migrant	C (6.7)	32	1.9 (± 0.8)	0.18
Acadian Flycatcher	Southern neotropical migrant	FC (3.5)	29	3.5 (± 1.0)	0.04
Willow Flycatcher	Central and southern neotropical migrant	FC (2.0)	29	- 5.0 (± 1.2)	0.02
Least Flycatcher	Central neotropical migrant	R (0.16)	14	- 7.9 (± 1.0)	0.01
Eastern Phoebe	Temperate migrant	FC (2.0)	30	- 5.8 (± 1.3)	0.02
Great-crested Flycatcher	Central neotropical migrant	FC (2.5)	32	1.5 (± 0.7)	0.20
Eastern Kingbird	Southern neotropical migrant	U (1.1)	20	- 0.9 (± 0.9)	0.65
Horned Lark	Permanent resident Temperate migrant	U (1.7)	15	- 8.0 (± 1.2)	0.01
Tree Swallow	Temperate migrant	R (0.5)	28	1.2 (± 0.9)	0.24
Northern Rough-Winged Swallow	Southern neotropical migrant	U (1.8)	27	4.8 (± 1.5)	0.03
Bank Swallow	Southern neotropical migrant	U (1.3)	22	1.6 (± 2.0)	0.20

Table 18. Continued.

Barn Swallow	Southern neotropical migrant	C (10.2)	30	- 6.5 (± 1.8)	0.02
Blue Jay	Permanent resident Temperate resident	A (13.0)	32	0.8 (± 0.5)	0.72
American Crow	Permanent resident Temperate resident	A (25.3)	32	17.0 (± 1.9)	0.001
Carolina Chickadee	Permanent resident	FC (3.9)	32	- 1.4 (± 0.9)	0.22
Tufted Titmouse	Permanent resident	A (14.1)	32	7.2 (± 2.0)	0.01
White-breasted Nuthatch	Permanent resident	FC (2.8)	31	3.5 (± 1.0)	0.04
Carolina Wren	Permanent resident	C (10.7)	32	1.7 (± 0.8)	0.19
House Wren	Temperate migrant	C (4.0)	18	5.9 (± 2.4)	0.02
Blue-gray Gnatcatcher	Central neotropical migrant	C (4.5)	26	3.9 (± 0.7)	0.04
Eastern Bluebird	Permanent resident Temperate migrant	C (4.2)	30	2.2 (± 0.9)	0.09
Wood Thrush	Central neotropical migrant	A (17.5)	32	3.0 (± 0.5)	0.047
American Robin	Permanent resident Temperate migrant	A (14.6)	32	4.1 (± 0.9)	0.03
Gray Catbird	Central neotropical migrant	C (9.0)	32	5.0 (± 1.1)	0.02

Table 18. Continued.

Brown Thrasher	Temperate migrant	C (6.6)	32	- 3.7 (± 0.8)	0.04
Cedar Waxwing	Temperate migrant	FC (3.1)	30	0.4 (± 0.7)	0.83
White-eyed Vireo	Central neotropical migrant	C (10.4)	29	- 7.0 (± 1.3)	0.01
Blue-headed Vireo	Central neotropical migrant	FC (2.5)	15	1.1 (± 0.4)	0.24
Yellow-throated Vireo	Central neotropical migrant	FC (3.7)	32	1.5 (± 0.5)	0.20
Red-eyed Vireo	Southern neotropical migrant	A (27.9)	32	6.5 (± 0.9)	0.02
Blue-winged Warbler	Central neotropical migrant	C (9.2)	23	7.2 (± 0.6)	0.01
Golden-winged Warbler	Central and southern neotropical migrant	A (17.0)	29	- 0.25 (± 0.2)	0.90
Northern Parula	Central neotropical migrant	FC (3.3)	20	0.35 (± 0.1)	0.81
Yellow Warbler	Central neotropical migrant	R (0.6)	14	- 1.6 (± 0.3)	0.19
Chestnut-sided Warbler	Central and southern neotropical migrant	C (6.7)	25	- 4.5 (± 0.5)	0.03
Black-throated Green Warbler	Central neotropical migrant	U (1.7)	15	1.0 (± 0.7)	0.30

Table 18. Continued.

Prairie Warbler	Central neotropical migrant	C (7.2)	24	- 9.0 (± 2.0)	0.001
Cerulean Warbler	Southern neotropical migrant	A (12.0)	26	- 1.3 (± 0.7)	0.22
Black-and-White Warbler	Central neotropical migrant	A (15.6)	32	4.8 (± 0.8)	0.03
American Redstart	Central neotropical migrant	A (13.9)	32	6.0 (± 1.0)	0.02
Worm-eating Warbler	Central neotropical migrant	C (9.1)	25	- 1.9 (± 0.5)	0.17
Ovenbird	Central neotropical migrant	A (16.5)	32	- 2.3 (± 0.9)	0.12
Kentucky Warbler	Central neotropical migrant	FC (3.7)	20	- 7.5 (± 0.6)	0.01
Common Yellowthroat	Central neotropical migrant	C (7.3)	27	- 1.3 (± 0.7)	0.22
Hooded Warbler	Central neotropical migrant	A (14.4)	32	- 4.3 (± 1.0)	0.03
Yellow-breasted Chat	Central neotropical migrant	C (7.2)	26	- 3.5 (± 0.8)	0.04
Scarlet Tanager	Southern neotropical migrant	C (10.5)	32	6.1 (± 1.2)	0.02
Northern Cardinal	Permanent resident	A (18.6)	32	- 2.9 (± 0.7)	0.05

Table 18. Continued.

Rose-breasted Grosbeak	Southern neotropical migrant	C (7.0)	23	4.1 (± 0.9)	0.03
Indigo Bunting	Central neotropical migrant	A (25.7)	32	2.4 (± 0.8)	0.06
Eastern Towhee	Permanent resident Temperate migrant	C (10.7)	32	0.95 (± 0.5)	0.33
Chipping Sparrow	Temperate and central neotropical migrant	C (8.9)	32	- 4.9 (± 0.7)	0.03
Field Sparrow	Temperate migrant	C (11.7)	27	- 7.3 (± 0.9)	0.01
Vesper Sparrow	Temperate migrant	U (1.9)	16	- 16.2 (± 1.2)	0.001
Grasshopper Sparrow	Central neotropical migrant	FC (3.5)	20	- 7.9 (± 0.9)	0.01
Song Sparrow	Permanent resident Temperate migrant	A (16.1)	29	- 6.4 (± 1.0)	0.02
Red-winged Blackbird	Temperate migrant	C (9.6)	24	- 8.1 (± 1.3)	0.01
Eastern Meadowlark	Temperate and southern neotropical migrant	FC (3.7)	19	- 8.5 (± 0.8)	0.01
Brown-headed Cowbird	Temperate migrant	U (1.4)	15	- 9.1 (± 1.5)	0.001
Orchard Oriole	Central neotropical migrant	FC (2.2)	15	1.7 (± 1.0)	0.19

Table 18. Continued.

Baltimore Oriole	Central neotropical migrant	R (0.6)	14	- 1.2 (± 0.9)	0.22
American Goldfinch	Permanent resident Temperate migrant	C (11.4)	32	- 7.4 (± 1.3)	0.01

[1] Hall (1983), Rappole et al. 1983, and Ehrlich et al. (1988). [2] Peterjohn et al. 1987. The 32 routes were mainly along narrow contour mines running along forested slopes and ridges.

Figure 9. GIS data enclosed. Six maps for each of three sites (Peachtree Ridge, Highland Mountain, and Whitby).

Table 19. Independent variables included in stepwise multiple regressions of abundances of five species of shrubland birds on contour mines in southern West Virginia.

Species	R^2	Independent Variables[a]
Golden-winged Warbler	0.73	+ edge length (0.15) + elevation (0.14) + slope (0.07).
Chestnut-sided Warbler	0.69	+ elevation (0.22) - canopy cover (0.09) + shrub height (0.03).
Indigo Bunting	0.56	- tree height (0.25) + edge length (0.11) + shrub height (0.05)
Eastern Towhee	0.35	- tree height (0.38) + edge length (0.11) + shrub height (0.06)
Field Sparrow	0.27	+ edge length (0.21) + elevation (0.10) - tree height (0.07).

[a] Independent variables are listed in order in which they were included in the model. All variables listed were significant ($p < 0.05$).

Table 20. Abundance (mean with standard errors in parentheses) of a few selected forest species during 50-m radius point count surveys on historical contour mine (n = 30) and historical MTRVF (n = 12) sites throughout southern West Virginia during the breeding season (June).

	Contour		MTRVF[a]			
Species	Edge	Interior	Edge	Interior	ANOVA Results[b] F	p
Acadian Flycatcher	0.15 (0.04)	0.19 (0.03)	0.15 (0.05)	0.13 (0.03)	2.26	0.09
Black-throated Green Warbler	0.07 (0.02)	0.08 (0.01)	0.03 (0.009)	0.05 (0.01)	2.06	0.13
Blue-headed Vireo	0.11 (0.03) - A	0.12 (0.03) - A	0.03 (0.007) - B	0.04 (0.009) - B	3.90	0.05
Cerulean Warbler	0.25 (0.04) - A	0.28 (0.04) - A	0.06 (0.007) - B	0.04 (0.005) - B	4.78	0.02
Eastern Wood-Pewee	0.16 (0.02) - A, B	0.20 (0.08) - B	0.11 (0.03) - A	0.13 (0.03) - A	3.87	0.05
Great-crested Flycatcher	0.12 (0.01)	0.09 (0.007)	0.10 (0.03)	0.08 (0.04)	2.10	0.12
Kentucky Warbler	0.04 (0.004)	0.06 (0.006)	0.04 (0.003)	0.04 (0.007)	1.19	0.32
Louisiana Waterthrush	0.08 (0.003) - A, B	0.15 (0.02) - C	0.05 (0.009) - A, B	0.10 (0.02) - A	4.06	0.04
Ovenbird	0.22 (0.08) - A	0.30 (0.10) - B	0.15 (0.07) - C	0.20 (0.10) - A	5.13	0.01
Scarlet Tanager	0.20 (0.12)	0.20 (0.09)	0.17 (0.11)	0.19 (0.09)	1.99	0.17
Wood Thrush	0.23 (0.12)	0.25 (0.08)	0.20 (0.11)	0.22 (0.08)	3.82	0.06
Worm-eating Warbler	0.15 (0.05) - A, B	0.18 (0.07) - B	0.11 (0.03) - A	0.11 (0.05) - A	4.10	0.04

[a] Includes partial MTRVFs. [b] One-way ANOVA was used to test for mean abundance differences across habitat types. Means with different letters are significantly different (Duncan s multiple comparisons test).

Table 21. Guild abundance in edge (shrub/forest) and interior forest plots at Metalton, Raleigh County, West Virginia during the breeding season (June). Data collected from 1996-2000. Values are ± 1 SE for captures per 100 mist-net hours (n = 12 days) and number of birds detected per 300-meter transect (n = 12)[a].

	Nets			Transects		
Guilds	Edge	Interior	p[b]	Edge	Interior	p[b]
Ground-shrub	22.4 ± 3.4	18.9 ± 3.7	0.01	18.0 ± 3.1	16.9 ± 2.7	NS
Trunk-bark	12.3 ± 2.9	13.5 ± 2.7	NS	10.4 ± 2.8	11.5 ± 2.1	NS
Sallier-canopy	25.1 ± 2.8	20.7 ± 3.0	0.01	20.9 ± 2.7	17.7 ± 2.2	0.05

[a] Transect methods were same as those reported for methods of the migration counts on MTRVFs. [b] Mann-Whitney U-test. NS = not significant (p > 0.05).

Table 22. Summary of captured birds at TRMO (Metalton contour edges and intact forest) during the breeding season from 1996-2000.

Habitat Group	Captured	Recaptured[a]
Grassland Species	49	12
Shrub	451	181
Woodland	268	86

[a] Does not include multiple recaptures for single birds. Habitats (grassland, shrub, and forest) were sampled equally with the same net hours.

Table 23. Partners in Flight West Virginia Northern Cumberland Plateau priority bird species grouped by habitats and occurrence as either higher on contour or MTRVF in southern West Virginia. The continental population trend from the BBS is shown.

Species			
Forest Interior	Watch List[a]	Higher Numbers in which Forest Edge[b]	Continental Trend[c]
Acadian Flycatcher		Contour	+
Black-throated Green Warbler		Contour	+
Cerulean Warbler	EH	Contour	-*
Eastern Wood-Pewee		Contour	-*
Kentucky Warbler	M	Contour	-*
Louisiana Waterthrush		Contour	+
Ovenbird		Contour	+*
Scarlet Tanager		Contour	-
Summer Tanager		MTRVF	-
Wood Thrush	MH	Contour	-*
Worm-eating Warbler	MH	Contour	+
Yellow-throated Warbler		MTRVF	+
Interior-Edge Species			
American Redstart		Contour	-
Black-and-White Warbler		Contour	+
Blue-gray Gnatcatcher		MTRVF	+*
Carolina Wren		MTRVF	+*
Hooded Warbler		Contour	+
Northern Parula		Contour	+*
Red-bellied Woodpecker		Equal	+*
Yellow-billed Cuckoo		Equal	-*
Yellow-throated Vireo		MTRVF	+*

Table 23. Continued.

Edge Species	Watch List[a]	Higher Numbers in which Forest Edge[b]	Continental Trend[c]
Blue-winged Warbler	M	Contour	+
Brown Thrasher		MTRVF	-*
Common Yellowthroat		MTRVF	-*
Chipping Sparrow		Equal	-
Eastern Towhee			
Field Sparrow		MTRVF	-*
Golden-winged Warbler	EH	Contour	-*
Gray Catbird		Contour	-
Indigo Bunting		MTRVF	-*
Prairie Warbler	M	MTRVF	-*
White-eyed Vireo		Contour	+
Willow Flycatcher		Contour	O
Yellow Warbler		MTRVF	+*
Yellow-breasted Chat		Contour	-*
Grassland Species			
Eastern Meadowlark		MTRVF	-*
Grasshopper Sparrow		MTRVF	-*
Horned Lark		MTRVF	-*
Red-winged Blackbird		MTRVF	-*

[a] Watch List species are identified by Partners in Flight as in need for conservation at the national level (codes, adapted from Hunter et al. 2001 and Carter et al. 1996, 2000; EH = extremely high priority, MH = moderately high priority, M = moderate priority). [b] Taken from data used to compile this report and noted as occurring higher on contour vs. MTRVF or in about equal numbers at both mine types. [C] Continental population trends were taken from Hunter et al. (2001) and the BBS 1966-1999 data (Sauer et al. 2000), and are adapted from Carter et al. (2000) as follows: -* = significant decrease, - = possible decrease, O = trend uncertain, + = stable or possible increase, +* = significant increase.

Appendix 1. Common and scientific names of plants found on edge sampling points.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Agrimony spp.	*Agrimonia* spp.	X	X	X	X
Alternate-leaf dogwood	*Cornus alternifolia*	X	X	X	X
Giant ragweed	*Ambrosia trifida*	X	X	X	X
American basswood	*Tilia americana*	X	X		X
American beech	*Fagus grandifolia*	X	X		X
American elm	*Ulmus americana*	X	X	X	X
American hazelnut	*Corylus americana*	X	X	X	X
American Holly	*Ilex opaca*	X			X
American sycamore	*Platanus occidentalis*	X	X	X	X
Aster spp.	*Aster* spp.	X	X	X	X
Autumn olive	*Elaeagnus umbellata*	X	X	X	X
Bedstraw spp.	*Galium* spp.	X	X	X	X
Beechdrops	*Epifagus virginiana*	X	X		X
Beggar s-lice stickseed	*Hackelia virginiana*	X	X	X	X
Bicolor lespedeza	*Lespedeza bicolor*	X	X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Bigtooth aspen	*Populus grandidentata*	X	X	X	X
Birdsfoot-trefoil	*Lotus corniculatus*	X	X	X	X
Bitternut hickory	*Carya cordiformis*	X	X		X
Black birch	*Betula lenta*	X	X	X	X
Black cherry	*Prunus serotina*	X	X	X	X
Black gum	*Nyssa sylvatica*	X	X	X	X
Blackjack oak	*Quercus marilandica*	X	X	X	X
Black locust	*Robinia pseudo-acacia*	X	X	X	X
Black nightshade	*Solanum americanum*			X	
Black oak	*Quercus velutina*	X	X		X
Black poplar	*Populus nigra*	X	X		X
Black snakeroot	*Sanicula canadensis*	X			
Black willow	*Salix nigra*		X	X	X
Black walnut	*Juglans nigra*	X			X
Bladdernut	*Staphylea trifolia*		X		X
Blueberry	*Vaccinium spp.*	X	X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat G/F	G/FF	G/S	S/FF
Blue curls	*Trichostema dichotomum*	X	X	X	X
Blue vervain	*Verbena hastata*	X	X	X	X
Box Elder	*Acer negundo*	X	X	X	X
Broad beech fern	*Phegopteris hexagonoptera*	X			X
Broad-leaved cattail	*Typha latifolia*	X	X	X	X
Broomsedge	*Andropogon virginicus*	X	X	X	X
Buffalo-bur	*Solanum rostratum*	X	X	X	X
Buffalonut	*Pyrularia pubera*				X
Buttercup spp.	*Ranunculus* spp.		X	X	
Butternut	*Juglans cinerea*	X	X		X
Carex spp.	*Carex* spp.	X	X	X	X
Catalpa spp.	*Catalpa* spp.	X	X		X
Catnip	*Nepeta cataria*	X	X	X	X
Chestnut oak	*Quercus prinus*	X	X		X
Chicory	*Cichorium intybus*	X	X	X	X
Christmas fern	Polystichum acrostichoides	X			X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Cicely spp.	*Osmorhiza* spp.	X	X		X
Cinnamon fern	*Osmunda cinnamomea*	X			X
Clover spp.	*Trifolium* spp.	X	X	X	X
Coltsfoot	*Asarum virginicum*	X	X	X	X
Common burdock	*Arctium minus*	X	X	X	X
Common chickweed	*Stellaria media*	X	X	X	X
Common clubmoss	*Lycopodium clavatum*	X	X	X	X
Common dandelion	*Taraxacum officinale*	X	X	X	
Common elderberry	*Sambucus canadensis*	X			
Common greenbrier	*Smilax rotundifolia*	X	X	X	X
Common Joe-Pye weed	*Eupatorium fistulosum*	X	X	X	X
Common mouse-ear chickweed	*Cerastium vulgatum*	X	X	X	X
Common pigweed	*Amaranthus hybridus*	X	X	X	X
Common purslane	*Portulaca oleracea*	X	X	X	X
Common ragweed	*Ambrosia artemisiifolia*	X	X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Common teasel	*Dipsacus sylvestris*		X	X	
Common thistle	*Cirsium vulgare*	X	X	X	X
Cottonwood	*Populus deltoides*	X	X		X
Crab apple spp.	*Pyrus* spp.			X	X
Crabgrass	*Digitaria sanguinalis*	X	X	X	X
Crown vetch	*Coronilla varia*	X	X	X	X
Cucumber tree	*Magnolia acuminata*	X	X		X
Cudweed	*Gnaphalium obtusifolium*	X	X	X	X
Curly dock	*Rumex crispus*	X	X	X	X
Cutleaf grapefern	*Botrychium dissectum*	X	X	X	X
Deertongue grass	*Panicum clandestinum*	X	X	X	X
Deptfork pink	*Dianthus armeria*	X	X	X	X
Devilweed	*Lactuca canadensis*	X	X	X	X
Eastern hemlock	*Tsuga canadensis*	X	X		X
Eastern redbud	*Cercis canadensi*	X	X		X
Elephant s-foot	*Elephantopus carolinianus*	X	X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
English daisy	*Bellis perennis*	X	X	X	X
European black alder	*Alnus glutinosa*	X	X	X	X
Fall phlox	*Phlox paniculata*	X	X	X	X
Fescue spp.	*Festuca spp.*	X	X	X	X
Field cress	*Lepidium campestre*	X	X	X	X
Field pennycress	*Thlaspi arvense*	X	X	X	X
Field sorrel	*Rumex acetosella*	X	X	X	X
Field sow thistle	*Sonchus arvensis*	X	X	X	X
Flame azalea	*Rhododendron calendulaceum*	X	X		X
Flowering dogwood	*Cornus florida*	X	X	X	X
Flowering wintergreen	*Polygala paucifolia*	X	X	X	X
Goldenrod spp.	*Solidago spp.*	X	X	X	X
Greenbrier	*Smilax spp.*	X	X	X	X
Great mullein	*Verbascum thapsus*	X	X	X	X
Great plaintain	*Plantago major*	X	X	X	X
Ground-ivy	*Glechoma hederacea*	X	X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Groundpine	*Lycopodium flabelliforme*	X	X		X
Groundpine (tree clubmoss)	*Lycopodium obscurum*	X	X		X
Hairy-body cocklebur	*Xanthium italicum*	X	X	X	X
Hawkweed spp.	*Hieracium spp.*	X	X	X	X
Hawthorn species	*Crataegus spp.*			X	X
Hay-scented fern	*Dennstaedtia punctilobula*	X	X	X	X
Henbit	*Lamium amplexicaule*	X	X	X	
Hercule s club	*Aralia spinosa*				X
Honeylocust	*Gleditsia triacanthos*	X			X
Honeysuckle	*Rhododendron spp.*	X	X	X	X
Horse-nettle	*Solanum carolinense*		X		X
Indian strawberry	*Duchesnea indica*	X	X	X	X
Intermediate wood fern	*Dryopteris intermedia*	X			X
Interrupeted fern	*Osmunda claytoniana*	X	X		X
Ironwood	*Carpinus caroliniana*	X	X	X	X
Japanese honeysuckle	*Lonicera japonica*		X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Japanese knotweed	*Polygonum cuspidatum*	X	X	X	X
Japanese spiraea	*Spiraea japonica*	X	X	X	X
Jewelweed	*Impatiens pallida*	X	X		X
Jimson weed	*Datura stramonium*	X	X	X	X
Knotweed	*Polygonum spp.*	X	X	X	X
Kudzu	*Pueraria lobata*	X	X	X	X
Laciniate wild teasel	*Dipsacus laciniatus*	X	X	X	X
Lamb s quarters	*Chenopodium album*	X	X	X	X
Large-flowered tickseed	*Coreopsis grandiflora*	X	X	X	X
Little Bluestem	*Andropogon scoparius*	X	X	X	X
Loblolly pine	*Pinus taeda*	X			X
Long-leaved summer bluets	*Houstonia longifolia*	X	X	X	X
Loosestrife spp.	*Lysimachia spp.*	X	X	X	X
Mallow spp.	*Malva spp.*	X	X	X	X
Maple-leaf arrowood	*Viburnum acerifolium*	X	X		X
Maple leaf viburnum	*Viburnum acerifolium*				X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
May-apple	*Podophyllum peltatum*	X	X	X	X
Milkweed spp.	*Asclepias spp.*	X	X	X	X
Mimosa	*Albizia julibrissin*			X	
Mockernut hickory	*Carya tomentosa*	X			X
Moth mullein	*Verbascum blattaria*	X	X	X	X
Mountain laurel	*Kalmia latifolia*	X	X	X	X
Multiflora rose	*Rosa multiflora*	X	X	X	X
Mustard spp.	*Brassica spp.*	X	X	X	X
New York fern	*Thelypteris noveboracensis*	X			X
Oakleaf goosefoot	*Chenopodium glaucum*	X	X	X	X
Ohio buckeye	*Aesculus glabra*	X	X	X	X
Parsnip	*Pastinaca sativa*	X	X	X	X
Partridge berry	*Mitchella repens*	X			
Pasture thistle	*Cirsium pumilum*	X	X	X	X
Pawpaw	*Asimina triloba*	X	X		X
Persimmon	*Diospyros virginiana*	X	X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat G/F	G/FF	G/S	S/FF
Philadelphia fleabane	*Erigeron philadelphicus*	X	X	X	X
Pignut hickory	*Carya glabra*	X	X		X
Pitch pine	*Pinus rigida*	X	X	X	X
Poison ivy	*Toxicodendron radicans*	X	X	X	X
Pokeweed	*Phytolacca americana*	X	X	X	X
Prickly lettuce	*Lactuca scariola*	X	X	X	X
Princess-tree	*Paulownia tomentosa*	X	X	X	X
Purple dead-nettle	*Lamium purpureum*	X	X	X	
Purple sneezeweed	*Helenium flexuosum*	X	X	X	X
Queen Anne s lace	*Daucus carota*	X	X	X	X
Raspberry/blackberry	*Rubus spp.*	X	X	X	X
Rattlesnake fern	*Botrychium virginianum*				X
Redbud	*Cercis canadensis*	X	X	X	X
Red cedar	*Juniperus virginiana*		X	X	X
Red maple	*Acer rubrum*	X	X	X	X
Red mulberry	*Morus rubra*	X			X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Red oak	*Quercus rubra*	X	X		X
Red pine	*Pinus resinosa*	X	X	X	X
River birch	*Betula nigra*				X
Rhododendron	*Rhododendron maximum*	X	X		X
Rock spikemoss	*Selaginella rupestris*	X	X	X	X
Rose pink	*Sabatia angularis*			X	X
Sassafras	*Sassafras albidum*	X	X	X	X
Scarlet Oak	*Quercus coccinea*	X	X		X
Scotch pine	*Pinus sylvestris*	X	X	X	X
Serviceberry	*Amelanchier spp.*	X	X		X
Shagbark hickory	*Carya ovata*	X	X		X
Shortleaf pine	*Pinus echinata*	X			X
Small-headed sunflower	*Helianthus microcephalus*	X	X		X
Smooth-body cocklebur	*Xanthium pennsylvanicum*	X	X	X	X
Smooth forked-chickweed	*Paronychia canadensis*	X	X	X	X
Smooth sumac	*Rhus glabra*	X	X	X	X

Appendix 1. Continued.

		Habitat			
Common Name	Scientific Name	G/F	G/FF	G/S	S/FF
Sourwood	*Oxydendrum arboreum*	X	X	X	X
Spicebush	*Lindera benzoin*	X			X
Spotted knapweed	*Centaurea maculosa*		X	X	X
Spreading dogbane	*Apocynum androsaemifolium*	X	X	X	X
Staghorn sumac	*Rhus typhina*	X	X	X	X
Star flower	*Trientalis borealis*		X		X
Stinging nettle	*Urtica dioica*	X	X		X
Strawberry-tomato	*Physalis pruinosa*	X	X	X	X
Striped maple	*Acer pensylvanicum*	X	X		X
Sugar maple	*Acer saccharum*	X	X	X	X
Sweetbrier	*Rosa eglanteria*	X	X	X	X
Sweet fern	*Comptonia peregrina*	X	X	X	X
Sweetgum	*Liquidambar styraciflua*	X	X		
Switch grass	*Panicum virgatum*		X	X	
Tall ironweed	*Vernonia altissima*	X	X	X	X
Tall thistle	*Cirsium altissimum*	X	X	X	X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
Tartanian honeysuckle	*Lonicera tatarica*			X	X
Teaberry	*Gaultheria procumbens*	X	X		X
Thinleaved sunflower	*Helianthus decapetalus*	X	X		X
Timothy	*Phleum pratense*		X	X	
Trailing arbutus	*Epigaea repens*	X	X		X
Tree of heaven	*Ailanthus altissima*	X	X	X	X
Tumbleweed	*Panicum capillare*	X	X	X	X
Umbrella tree	*Magnolia tripetala*	X	X		X
Upland willow	*Salix humilis*			X	X
Vetch spp.	*Vicia spp.*	X	X	X	X
Violet spp.	*Viola spp.*	X	X	X	X
Virginia creeper	*Parthenocissus quinquefolia*	X	X	X	X
Virginia pine	*Pinus virginiana*	X	X	X	X
Virginia strawberry	*Fragaria virginiana*	X	X	X	X
White ash	*Fraxinus americana*	X	X		X
White-flowered leafcup	*Polymnia canadensis*	X	X		X

Appendix 1. Continued.

Common Name	Scientific Name	Habitat			
		G/F	G/FF	G/S	S/FF
White oak	*Quercus alba*	X	X	X	X
White pine	*Pinus strobus*	X	X	X	X
Wild grape	*Vitis spp.*	X	X	X	X
Wild indigo	*Baptisia tinctoria*	X			
Wisteria	*Wisteria frutescens*	X	X	X	X
Witchhazel	*Hamamelis virginiana*	X	X	X	X
Wild geranium	*Geranium maculatum*	X	X	X	X
Wild hydrangea	*Hydrangea arborescens*	X	X		X
Wild rose	*Rosa spp.*	X	X	X	X
Wild sage	*Salvia lyrata*	X	X	X	X
Wild sweet William	*Phlox maculata*	X	X	X	X
Winter cress	*Barbarea vulgaris*	X	X	X	X
Wood sorrel spp.	*Oxalis spp.*	X	X	X	X
Wood tickseed	*Coreopsis major*	X	X	X	X
Yarrow milfoil	*Achillea millefolium*	X	X	X	X
Yellow birch	*Betula alleghaniensis*	X	X	X	X

Appendix 1. Continued.

		Habitat			
Common Name	Scientific Name	G/F	G/FF	G/S	S/FF
Yellow corydalis	*Corydalis flavula*				X
Yellow foxtail	*Setaria glauca*		X	X	
Yellow oak	*Quercus muehlenbergii*	X	X		X
Yellow stargrass	*Hypoxis hirsuta*		X	X	X

Appendix 2. Orders, vernacular names, and scientific names of all bird species observed in this study or typically found in the region (Hall 1983, AOU 2000). Those with an asterisk were not observed on the MTRVF EIS study sites. Refer to Hall (1983) for status (i.e., breeding, migrant, rare visitant or hypothetical) for each species.

Order/Species	Scientific Name	Order/Species	Scientific Name
Order Gaviiformes		Great Blue Heron	*Ardea herodias*
Red-throated Loon *	*Gavia stellata*	Great Egret *	*Casmerodius albus*
Common Loon *	*Gavia immer*	Snowy Egret *	*Egretta thula*
Order Podicepediformes		Little Blue Heron *	*Egretta caerulea*
Pied-billed Grebe	*Podilymbus podiceps*	Cattle Egret *	*Bubulcus ibis*
Horned Grebe *	*Podiceps auritus*	Green Heron	*Butorides striatus*
Red-necked Grebe *	*Podiceps grisegena*	Black-crowned Night-Heron *	*Nycticorax nycticorax*
Eared Grebe *	*Podiceps nigricollis*	Yellow-crowned Night-Heron *	*Nyctanassa violacea*
Order Pelecaniformes		White Ibis *	*Eudocimus albus*
American White Pelican *	*Pelecanus erythrorhynchos*	Wood Stork *	*Mycteria americana*
Great Cormorant *	*Phalacrocorax carbo*	**Order Anseriformes**	
Double-crested Cormorant *	*Phalacrocorax auritus*	Tundra Swan *	*Cygnus columbianus*
Order Ciconiiformes		Trumpeter Swan *	*Cygnus buccinator*
American Bittern	*Botaurus lentiginosus*	Mute Swan *	*Cygnus olor*
Least Bittern *	*Ixobrychus exilis*	Greater White-fronted Goose *	*Anser albifrons*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
Snow Goose *	*Chen caerulescens*	Lesser Scaup *	*Aythya affinis*
Brant *	*Branta bernicla*	Common Goldeneye *	*Bucephala clangula*
Canada Goose	*Branta canadensis*	Bufflehead	*Bucephala albeola*
Wood Duck	*Aix sponsa*	Hooded Merganser	*Lophodytes cucullatus*
Green-winged Teal	*Anas crecca*	Common Merganser *	*Mergus merganser*
American Black Duck	*Anas rubripes*	Red-breasted Merganser *	*Mergus serrator*
Mallard	*Anas platyrhynchos*	Ruddy Duck *	*Oxyura jamaicensis*
Northern Pintail *	*Anas acuta*	King Eider *	*Somateria spectabilis*
Blue-winged Teal *	*Anas discors*	Harlequin Duck *	*Histrionicus histrionicus*
Northern Shoveler *	*Anas clypeata*	Long-tailed Duck *	*Clangula hyemalis*
Gadwall *	*Anas strepera*	Black Scoter *	*Melanitta nigra*
Eurasian Wigeon *	*Anas penelope*	Surf Scoter *	*Melanitta perspicillata*
American Wigeon *	*Anas americana*	White-winged Scoter *	*Melanitta fusca*
Canvasback *	*Aythya valisneria*	**Order Falconiformes**	
Redhead *	*Aythya americana*	Black Vulture *	*Coragyps atratus*
Ring-necked Duck *	*Aythya collaris*	Turkey Vulture	*Cathartes aura*
Greater Scaup *	*Aythya marila*	Osprey *	*Pandion haliaeetus*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
American Swallow-tailed Kite *	*Elanoides forficatus*	Ruffed Grouse	*Bonasa umbellus*
Bald Eagle *	*Haliaeetus leucocephalus*	Wild Turkey	*Meleagris gallopavo*
Golden Eagle	*Aquila chrysaetos*	Northern Bobwhite	*Colinus virginianus*
Northern Harrier	*Circus cyaneus*	**Order Gruiformes**	
Sharp-shinned Hawk	*Accipiter striatus*	Yellow Rail *	*Coturnicops noveboracensis*
Cooper s Hawk	*Accipiter cooperii*	Black Rail *	*Laterallus jamaicensis*
Northern Goshawk *	*Accipiter gentilis*	Clapper Rail *	*Rallus longirostris*
Red-shouldered hawk	*Buteo lineatus*	King Rail	*Rallus elegans*
Broad-winged Hawk	*Buteo platypterus*	Virginia Rail *	*Rallus limicola*
Red-tailed Hawk	*Buteo jamaicensis*	Sora *	*Porzana carolina*
Swanson s Hawk *	*Buteo swainsonii*	Purple Gallinule *	*Porphyrula martinica*
Rough-legged Hawk	*Buteo lagopus*	Common Moorhen *	*Gallinula chloropus*
American Kestrel	*Falco sparverius*	American Coot	*Fulica americana*
Merlin	*Falco columarius*	Sandhill Crane *	*Grus canadensis*
Peregrine Falcon	*Falco peregrinus*	**Order Charadriiformes**	
Order Galliformes		American Golden-plover *	*Pluvialis dominica*
Ring-necked Pheasant	*Phasianus colchicus*	Black-bellied Plover *	*Pluvialis squatarola*

Appendix 2. Continued.

Order/Species	**Scientific Name**	**Order/Species**	**Scientific Name**
Piping Plover *	*Charadrius melodus*	Baird s Sandpiper *	*Calidris bairdii*
Semipalmated Plover *	*Charadrius semipalmatus*	Pectoral Sandpiper *	*Calidris melanotos*
Killdeer	*Charadrius vociferus*	Dunlin *	*Calidris alpina*
American Avocet *	*Recurvirostra americana*	Stilt Sandpiper *	*Calidris himantopus*
Greater Yellowlegs	*Tringa melanoleuca*	Buff-breasted Sandpiper *	*Tryngites subruficollis*
Lesser Yellowlegs	*Tringa flavipes*	Short-billed Dowitcher *	*Limnodromus griseus*
Solitary Sandpiper	*Tringa solitaria*	Common Snipe	*Gallinago galliango*
Willet *	*Catoptrophorus semipalmatus*	American Woodcock	*Scolopax minor*
Spotted Sandpiper	*Actitis macularia*	Wilson s Phalarope *	*Phalaropus tricolor*
Upland Sandpiper *	*Bartramia longicauda*	Red-necked Phalarope *	*Phalaropus lobatus*
Whimbrel *	*Numenius phaeopus*	Red Phalarope *	*Phalaropus fulicaria*
Hudsonian Godwit *	*Limosa haemastica*	Parasitic Jaeger *	*Stercorarius parasticus*
Ruddy Turnstone *	*Arenia interpres*	Laughing Gull *	*Larus atricilla*
Sanderling *	*Calidrus alba*	Bonaparte s Gull *	*Larus philadelphia*
Semipalmated Sandpiper *	*Calidris pusilla*	Ring-billed Gull	*Larus delawarensis*
Western Sandpiper *	*Calidris mauri*	Herring Gull	*Larus argentatus*
Least Sandpiper *	*Calidris minutilla*	Greater Black-backed Gull *	*Larus marinus*
White-rumped Sandpiper *	*Calidris fuscicollis*	Black-legged Kittiwake *	*Rissa tridactyla*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
Caspian Tern *	*Sterna caspia*	Long-eared Owl *	*Asio otus*
Common Tern *	*Sterna hirundo*	Short-eared Owl *	*Asio flammeus*
Forster s Tern *	*Sterna forsteri*	Northern Saw-whet Owl *	*Aegolius acadicus*
Least Tern *	*Sterna albifrons*	**Order Caprimulgiformes**	
Sooty Tern *	*Sterna fuscata*	Common Nighthawk	*Chordeiles minor*
Black Tern *	*Chlidonias niger*	Chuck-will s-widow *	*Caprimulgus carolinensis*
Order Columbiformes		Whip-poor-will	*Caprimulgus vociferus*
Rock Dove	*Columba livia*	**Order Apodiformes**	
Mourning Dove	*Zenaida macroura*	Chimney Swift	*Chaetura pelagica*
Order Cuculiformes		Ruby-throated Hummingbird	*Archilocus colubris*
Black-billed Cuckoo	*Coccyzus erythropthalmus*	**Order Coraciiformes**	
Yellow-billed Cuckoo	*Coccyzus americanus*	Belted Kingfisher	*Ceryle torquata*
Order Strigiformes		**Order Piciformes**	
Barn Owl *	*Tyto alba*	Red-headed Woodpecker	*Melanerpes erythrocephalus*
Eastern Screech-Owl	*Otus asio*	Red-bellied Woodpecker	*Melanerpes carolinus*
Great Horned Owl	*Bubo virginianus*	Downy Woodpecker	*Picoides pubescens*
Snowy Owl *	*Nyctea scandiaca*	Hairy Woodpecker	*Picoides villosus*
Barred Owl	*Strix varia*	Yellow-bellied Sapsucker	*Sphyrapicus varius*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
Northern Flicker	*Colaptes auratus*	Purple Martin	*Progne subis*
Pileated Woodpecker	*Dryocopus pileatus*	Tree Swallow	*Tachycineta bicolor*
Black-backed Woodpecker *	*Picoides arcticus*	Northern Rough-winged Swallow	*Stelgidopteryx ruficollis*
Order Passeriformes		Bank Swallow	*Riparia riparia*
Olive-sided Flycatcher *	*Contopus borealis*	Cliff Swallow	*Petrochelidon pyrrhonota*
Eastern Wood-Pewee	*Contopus virens*	Barn Swallow	*Hirundo rustica*
Yellow-bellied Flycatcher *	*Empidonax flaviventris*	Blue Jay	*Cyanocitta cristata*
Acadian Flycatcher	*Empidonax virescens*	Black-billed Magpie *	*Pica pica*
Alder Flycatcher *	*Empidonax alnorum*	American Crow	*Corvus brachyrhynchos*
Willow Flycatcher	*Empidonax traillii*	Fish Crow *	*Corvus ossifragus*
Least Flycatcher	*Empidonax minimus*	Common Raven	*Corvus corax*
Eastern Phoebe	*Sayornis phoebe*	Black-capped Chickadee	*Poecile atricapillus*
Vermillion Flycatcher *	*Pyrocephalus rubinus*	Carolina Chickadee	*Poecile carolinensis*
Great Crested Flycatcher	*Myiarchus crinitus*	Boreal Chickadee *	*Poecile hudsonicus*
Western Kingbird *	*Tyrannus verticalis*	Tufted Titmouse	*Baeolophus bicolor*
Eastern Kingbird	*Tyrannus tyrannus*	Red-breasted Nuthatch *	*Sitta canadensis*
Scissor-tailed Flycatcher *	*Tyrannus forficatus*	White-breasted Nuthatch	*Sitta carolinensis*
Horned Lark	*Eremophila alpestris*	Brown Creeper	*Certhia americana*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
Carolina Wren	*Thryothorus ludovicianus*	Brown Thrasher	*Toxostoma rufum*
Bewick s Wren *	*Thryomanes bewickii*	American Pipit	*Anthus spinoletta*
House Wren	*Troglodytes aedon*	Bohemian Waxwing *	*Bombycilla garrulus*
Winter Wren	*Troglodytes troglodytes*	Cedar Waxwing	*Bombycilla cedrorum*
Sedge Wren *	*Cistothorus platensis*	Northern Shrike *	*Lanius excubitor*
Marsh Wren *	*Cistothorus palustris*	Loggerhead Shrike *	*Lanius ludovicianus*
Golden-crowned Kinglet	*Regulus satrapa*	European Starling	*Sturnus vulgaris*
Ruby-crowned Kinglet	*Regulus calendula*	White-eyed Vireo	*Vireo griseus*
Blue-gray Gnatcatcher	*Polioptila caerulea*	Blue-headed Vireo	*Vireo solitarius*
Eastern Bluebird	*Sialia sialis*	Warbling Vireo	*Vireo gilvus*
Veery *	*Catharus fuscescens*	Yellow-throated Vireo	*Vireo flavifrons*
Gray-cheeked Thrush *	*Catharus minimus*	Philadelphia Vireo *	*Vireo philadelphicus*
Swainson s Thrush	*Catharus ustulatus*	Red-eyed Vireo	*Vireo olivaceus*
Hermit Thrush	*Catharus guttatus*	Blue-winged Warbler	*Vermivora pinus*
Wood Thrush	*Hylocichla fuscescens*	Golden-winged Warbler	*Vermivora chrysoptera*
American Robin	*Turdus migratorius*	Tennessee Warbler	*Vermivora peregrina*
Gray Catbird	*Dumetella carolinensis*	Orange-crowned Warbler *	*Vermivora celata*
Northern Mockingbird	*Mimus polyglottos*	Nashville Warbler	*Vermivora ruficapilla*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
Northern Parula	*Parula americana*	Black-and-white Warbler	*Mniotilta varia*
Yellow Warbler	*Dendroica petechia*	American Redstart	*Setophaga ruticilla*
Chestnut-sided Warbler	*Dendroica pensylvanica*	Prothonotary Warbler *	*Protonotaria citrea*
Magnolia Warbler	*Dendroica magnolia*	Worm-eating Warbler	*Helmitheros vermivorus*
Cape May Warbler	*Dendroica tigrina*	Swainson s Warbler *	*Limnothlypis swainsonii*
Black-throated Blue Warbler	*Dendroica caerulescens*	Ovenbird	*Seiurus aurocapillus*
Yellow-rumped Warbler *	*Dendroica coronata*	Northern Waterthrush *	*Seiurus noveboracensis*
Black-throated Green Warbler	*Dendroica virens*	Louisiana Waterthrush	*Seiurus motacilla*
Blackburnian Warbler	*Dendroica fusca*	Kentucky Warbler	*Oporornis formosus*
Yellow-throated Warbler	*Dendroica dominica*	Connecticut Warbler *	*Oporornis agilis*
Sutton s Warbler *	*Dendroica potomac*	Mourning Warbler	*Oporornis philadelphia*
Pine Warbler	*Dendroica pinus*	Common Yellowthroat	*Geothlypis trichas*
Kirtland s Warbler *	*Dendroica kirtlandii*	Hooded Warbler	*Wilsonia citrina*
Prairie Warbler	*Dendroica discolor*	Wilson s Warbler *	*Wilsonia pusilla*
Palm Warbler	*Dendroica palmarum*	Canada Warbler	*Wilsonia canadensis*
Bay-breasted Warbler	*Dendroica castanea*	Yellow-breasted Chat	*Icteria virens*
Blackpoll Warbler	*Dendroica striata*	Summer Tanager	*Piranga rubra*
Cerulean Warbler	*Dendroica cerulea*	Scarlet Tanager	*Piranga olivacea*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
Western Tanager *	*Piranga ludoviciana*	Lark Bunting *	*Calamospiza melanocorys*
Northern Cardinal	*Cardinalis cardinalis*	Savannah Sparrow	*Passerculus sandwichensis*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Grasshopper Sparrow	*Ammodramus savannarum*
Blue-headed Grosbeak *	*Pheuticus melanocephalus*	Henslow s Sparrow *	*Ammodramus henslowii*
Blue Grosbeak	*Guiraca caerulea*	LeConte s Sparrow *	*Ammodramus leconteii*
Indigo Bunting	*Passerina cyanea*	Sharp-tailed Sparrow *	*Ammodramus caudacutus*
Painted Bunting *	*Passerina ciris*	Fox Sparrow *	*Passerella iliaca*
Dickcissel	*Spiza americana*	Song Sparrow	*Melospiza melodia*
Green-tailed Towhee *	*Pipilo chlorurus*	Lincoln s Sparrow	*Melospiza lincolnii*
Eastern Towhee	*Pipilo erythrophthalmus*	Swamp Sparrow	*Melospiza georgiana*
Brown Towhee *	*Pipilo fuscus*	White-throated Sparrow	*Zonotrichia albicollis*
Bachman s Sparrow *	*Aimophila aestivalis*	White-crowned Sparrow	*Zonotrichia leucophrys*
American Tree Sparrow	*Spizella arborea*	Harris Sparrow *	*Zonotrichia querula*
Chipping Sparrow	*Spizella passerina*	Dark-eyed Junco	*Junco hyemalis*
Clay-colored Sparrow *	*Spizella pallida*	Lapland Lonspur *	*Calcarius lapponicus*
Field Sparrow	*Spizella pusilla*	Snow Bunting *	*Plectrophenax nivalis*
Vesper Sparrow	*Pooecetes gramineus*	Bobolink	*Dolichonyx oryzivorus*
Lark Sparrow *	*Chondestes grammacus*	Red-winged Blackbird	*Agelaius phoeniceus*

Appendix 2. Continued.

Order/Species	Scientific Name	Order/Species	Scientific Name
Eastern Meadowlark	*Sturnella magna*	Purple Finch	*Carpodacus purpureus*
Western Meadowlark *	*Sturnella neglecta*	House Finch	*Carpodacus mexicanus*
Yellow-headed Blackbird *	*Xanthocephalus xanthocephalus*	Red Crossbill *	*Loxia curvirostra*
Rusty Blackbird *	*Euphagus carolinus*	White-winged Crossbill *	*Loxia leucoptera*
Brewer s Blackbird	*Euphagus cyanocephalus*	Common Redpoll *	*Carduelis flammea*
Common Grackle	*Quiscalus quiscula*	Pine Siskin *	*Carduelis pinus*
Brown-headed Cowbird	*Molothrus ater*	American Goldfinch	*Carduelis tristis*
Orchard Oriole	*Icterus spurius*	Evening Grosbeak *	*Coccothraustes vespertina*
Baltimore Oriole	*Icterus galbula*	House Sparrow	*Passer domesticus*
Pine Grosbeak *	*Pinicola enucleator*		

EIS REPORT

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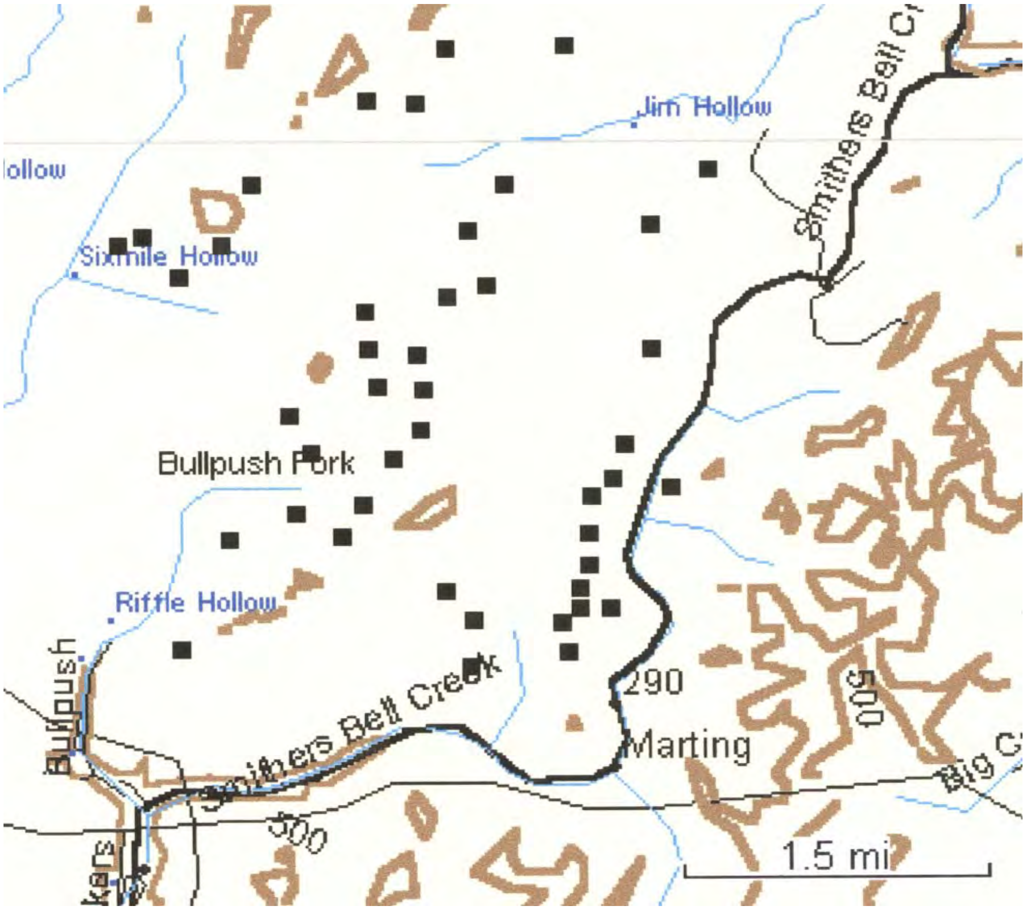


Figure 1. Location of edge points at the Cannelton mine.

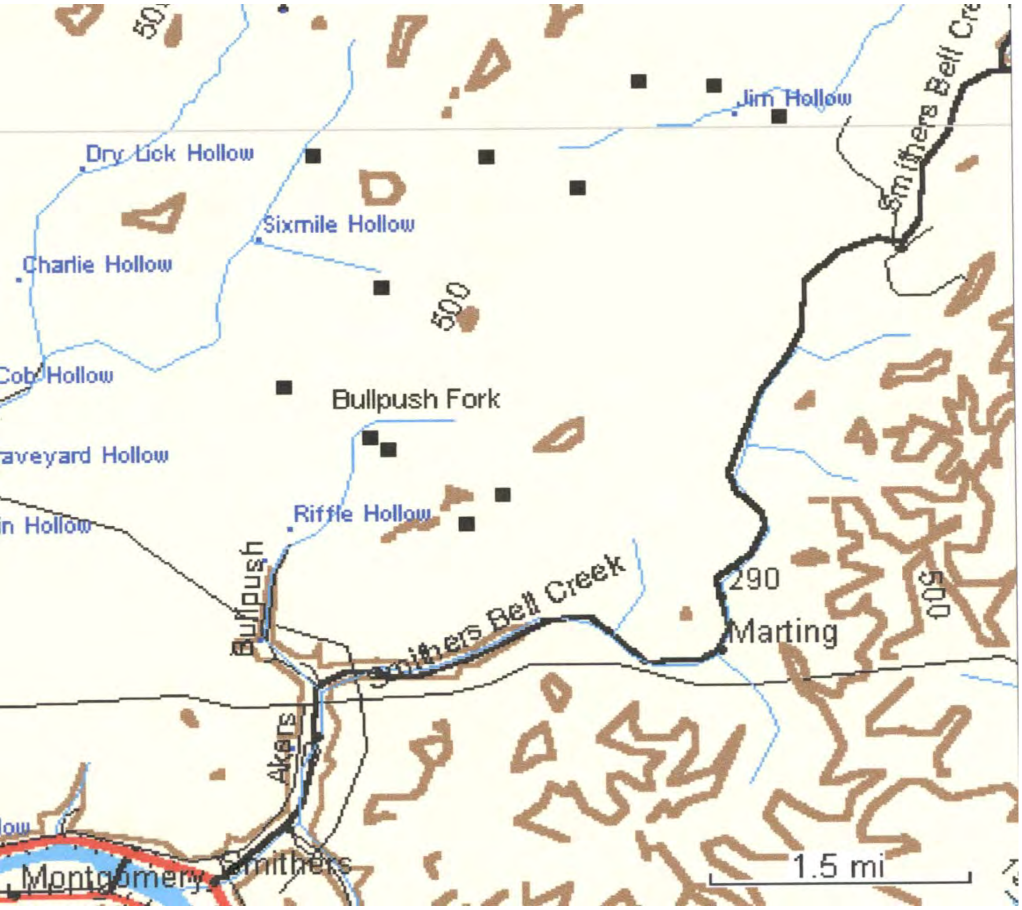


Figure 2. Location of line transects at the Cannelton mine.

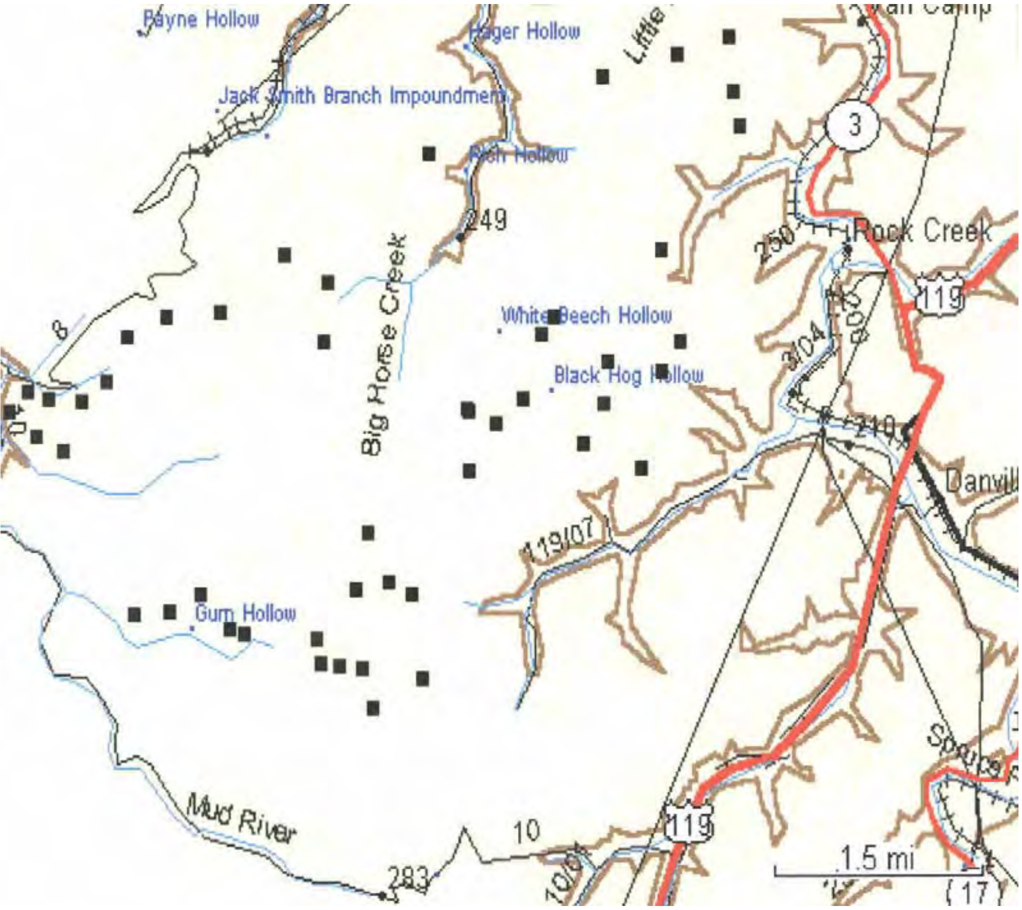


Figure 3. Location of edge points at the Hobet 21 mine.

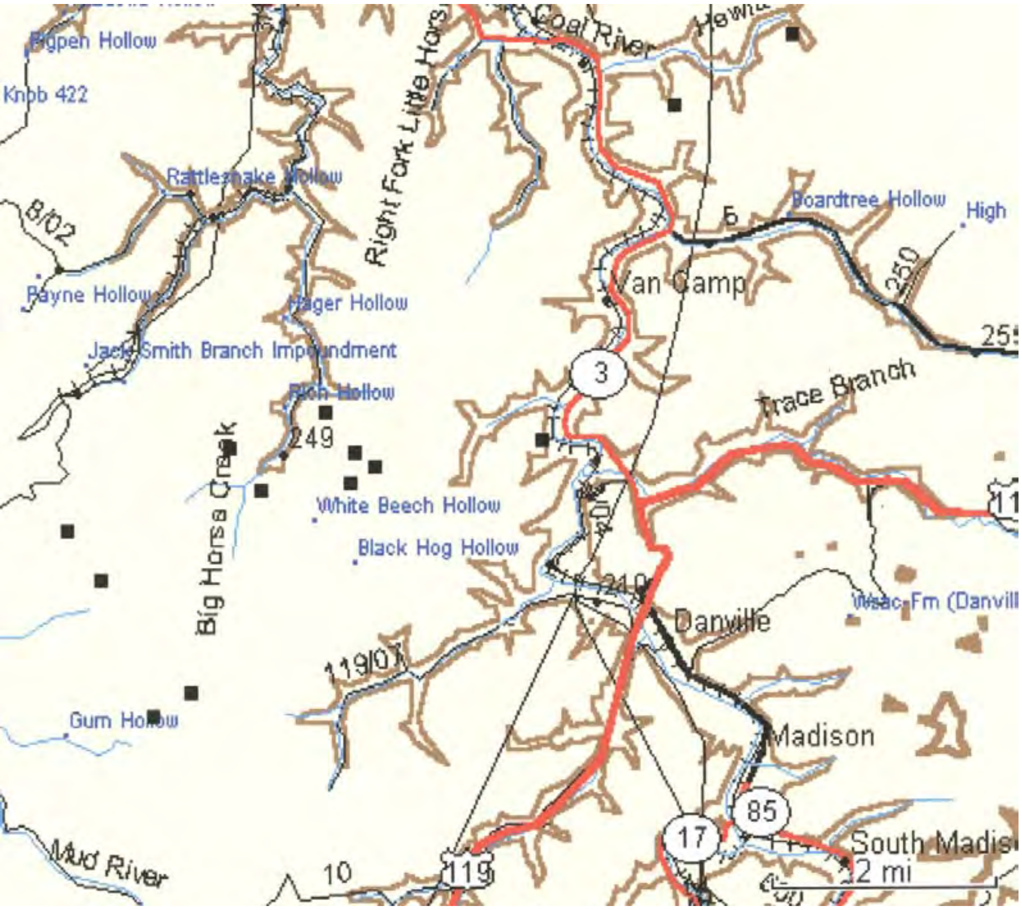


Figure 4. Location of line transects at the Hobet 21 mine.

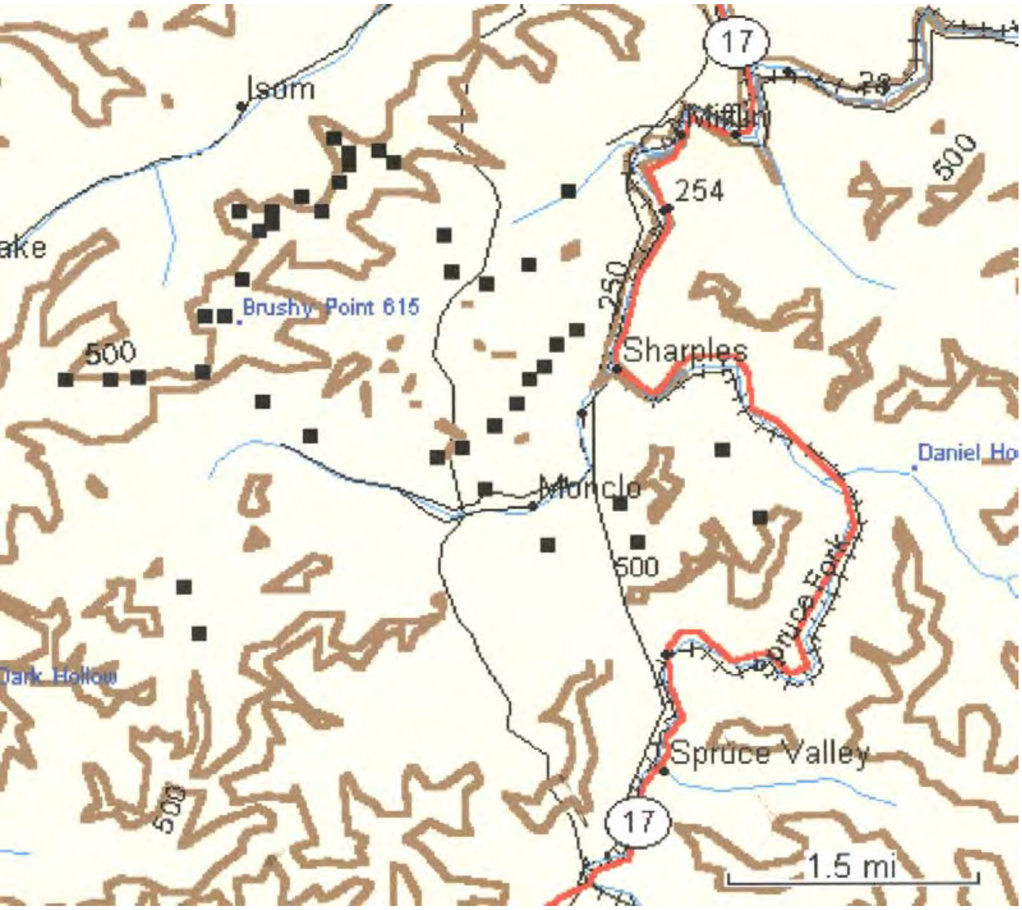


Figure 5. Location of point counts at the Daltex mine.

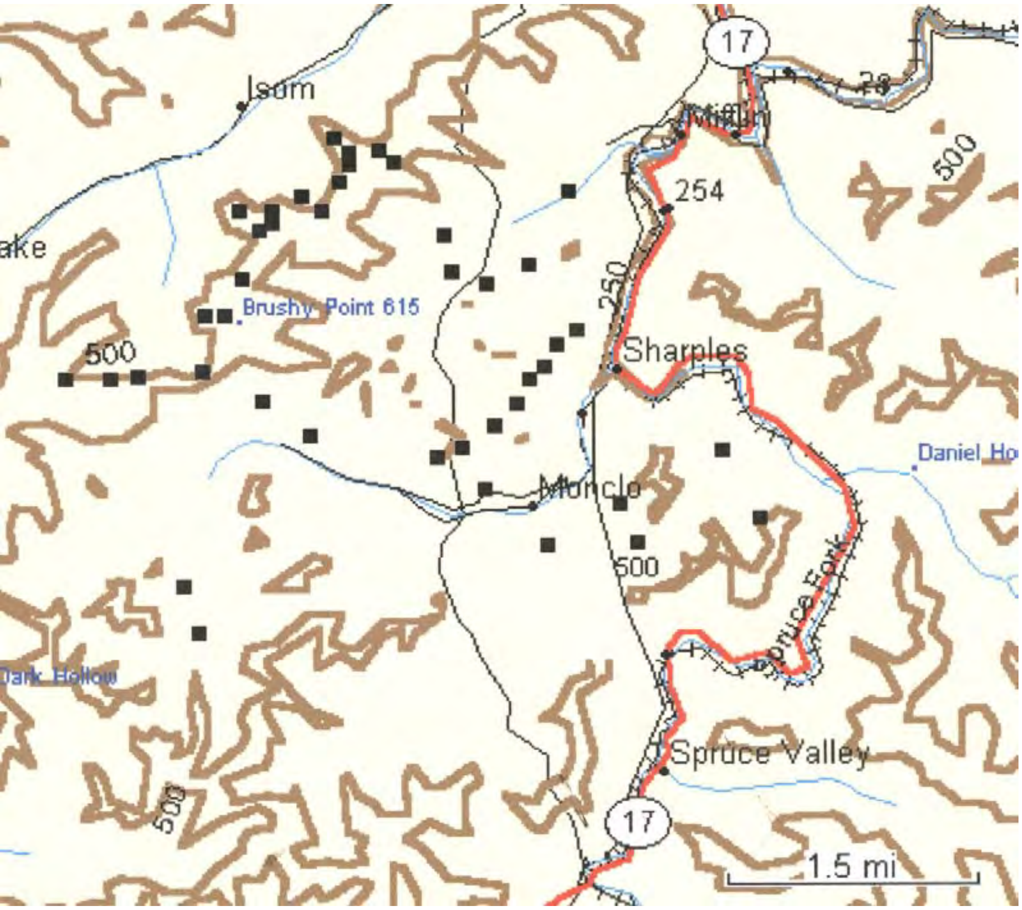


Figure 6. Location of line transects at the Daltex mine.

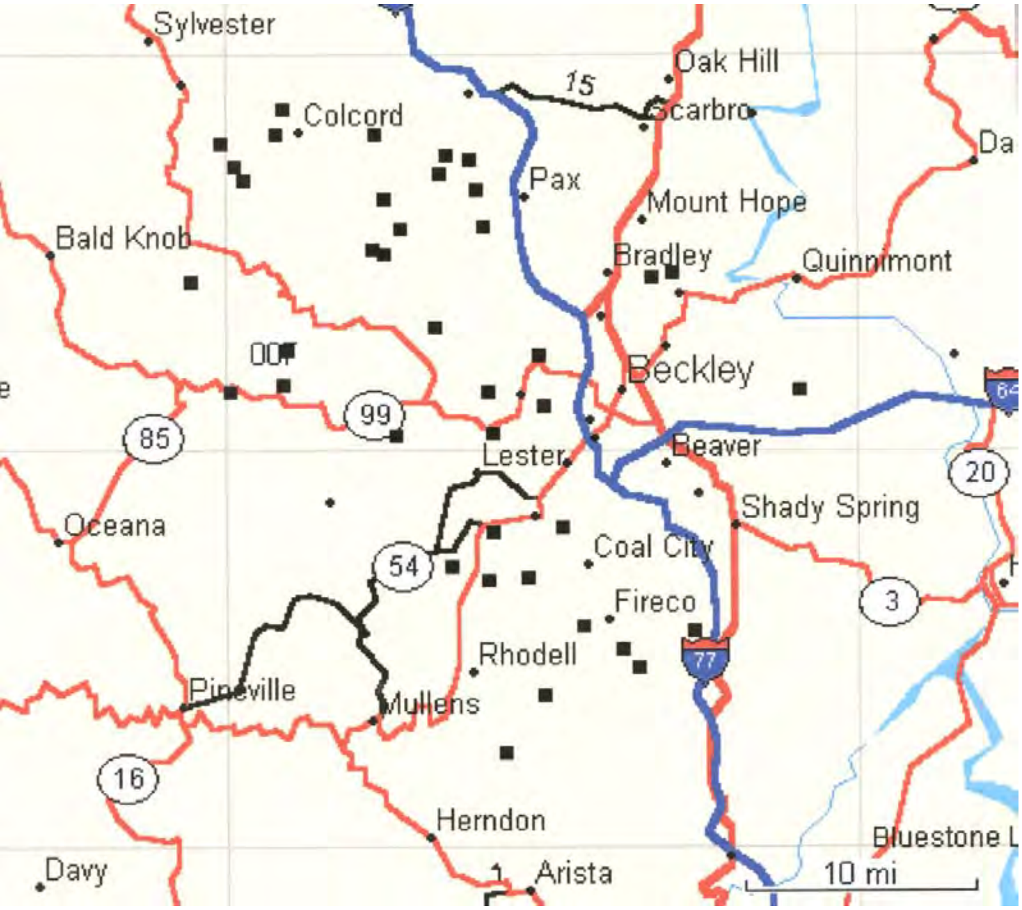
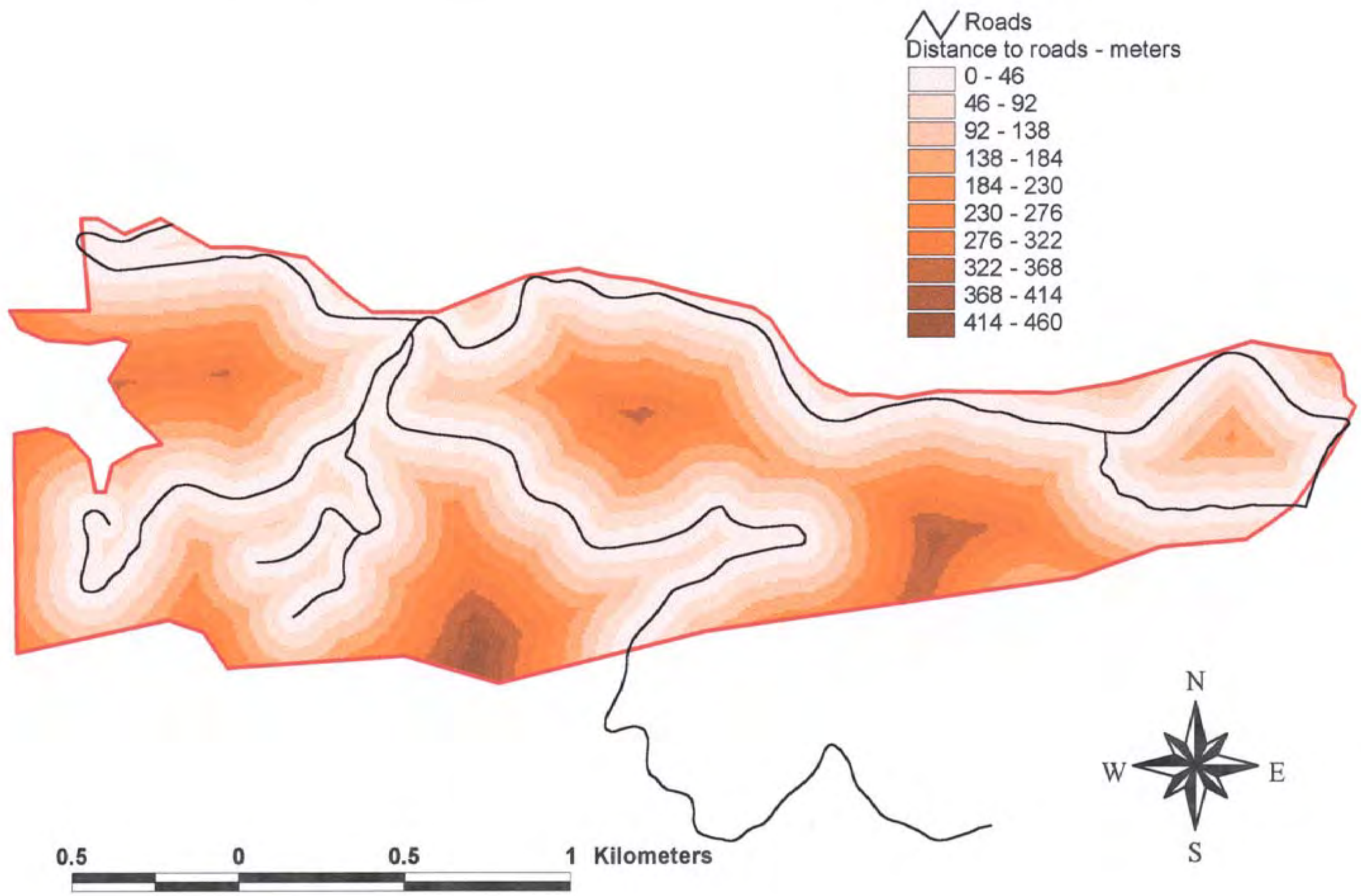


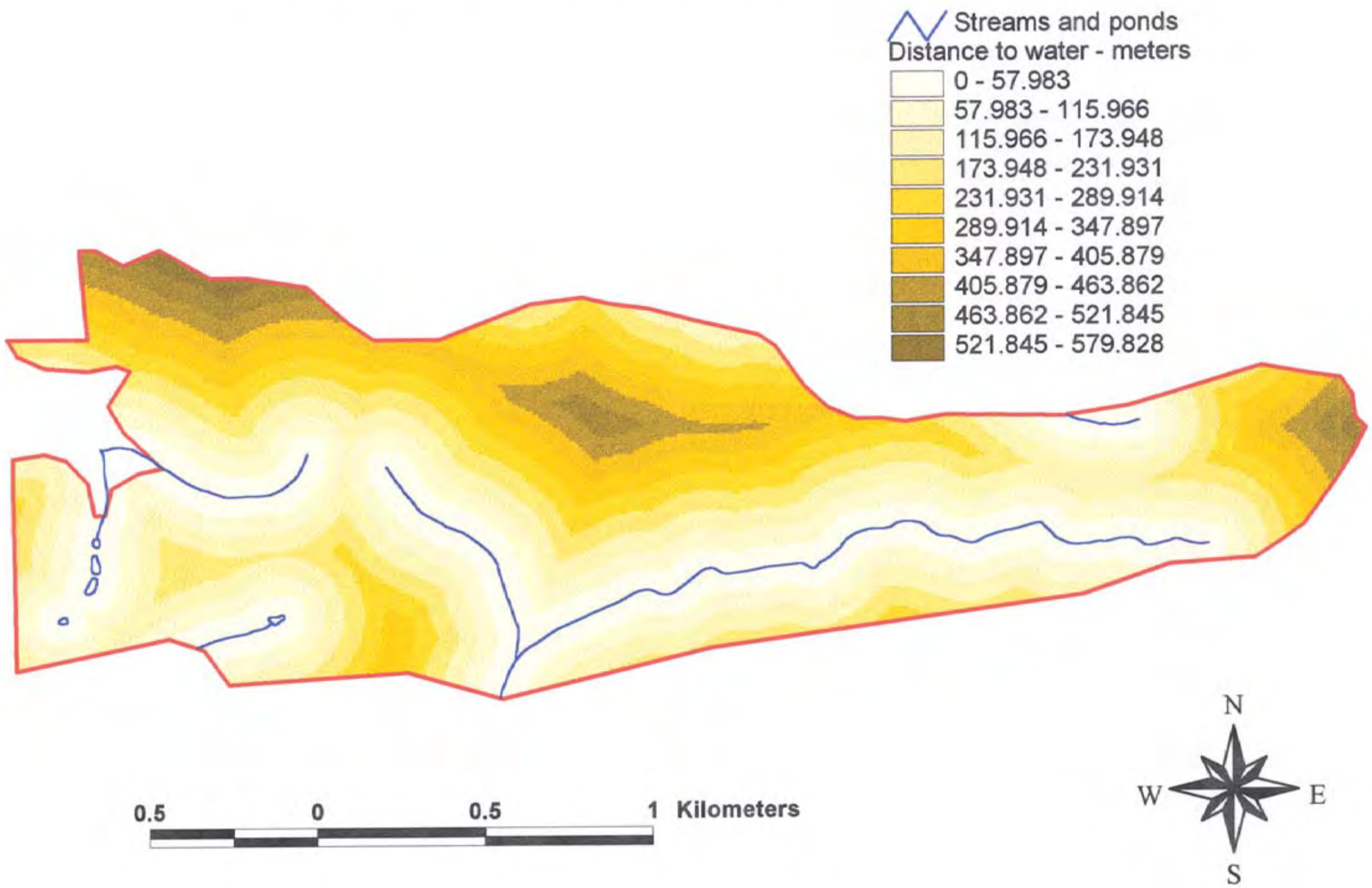
Figure 7. Location of Raleigh County historical mine sites.

Highland Mt. - Land cover

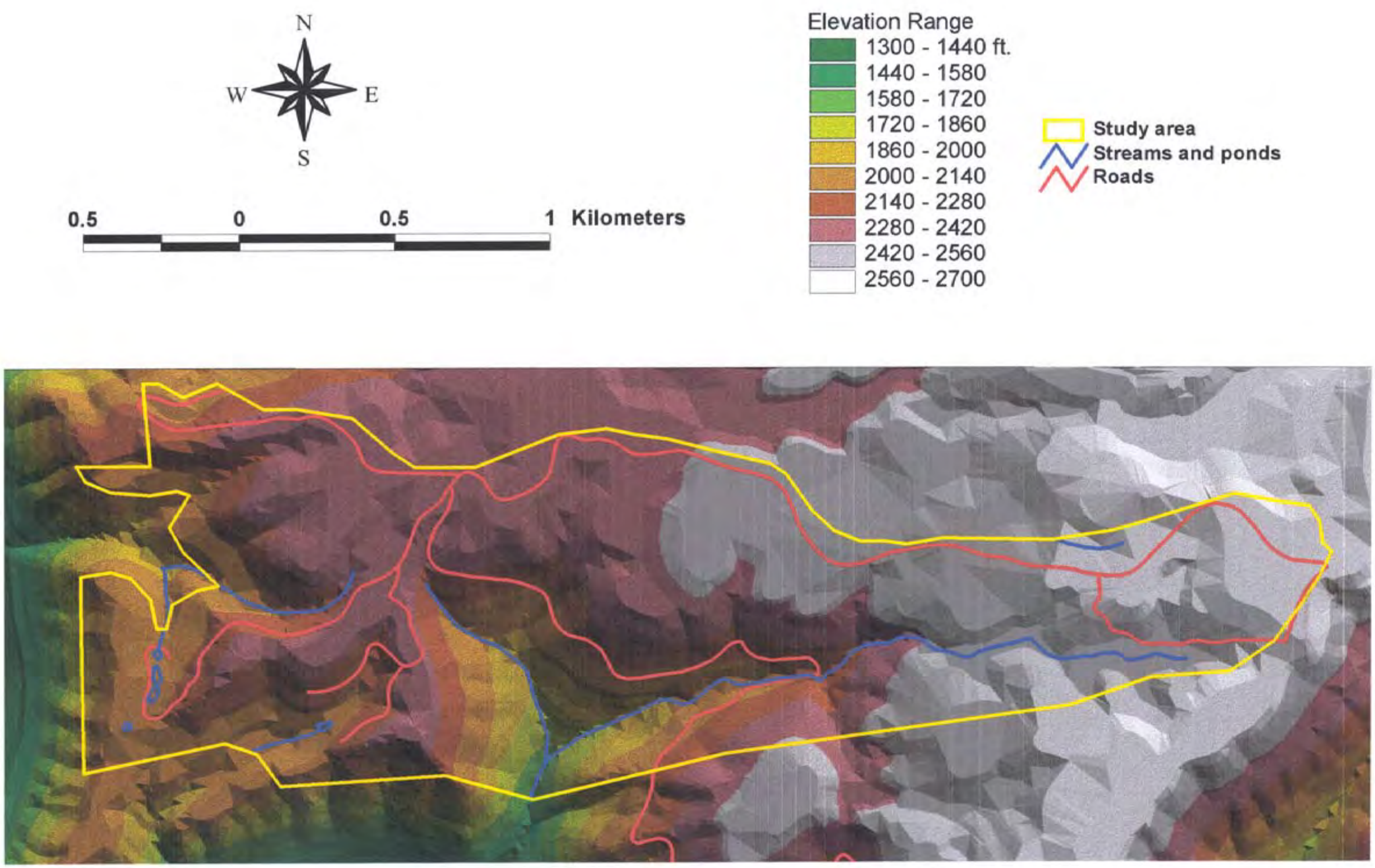
Highland Mt. - Roads



Highland Mt. - Water

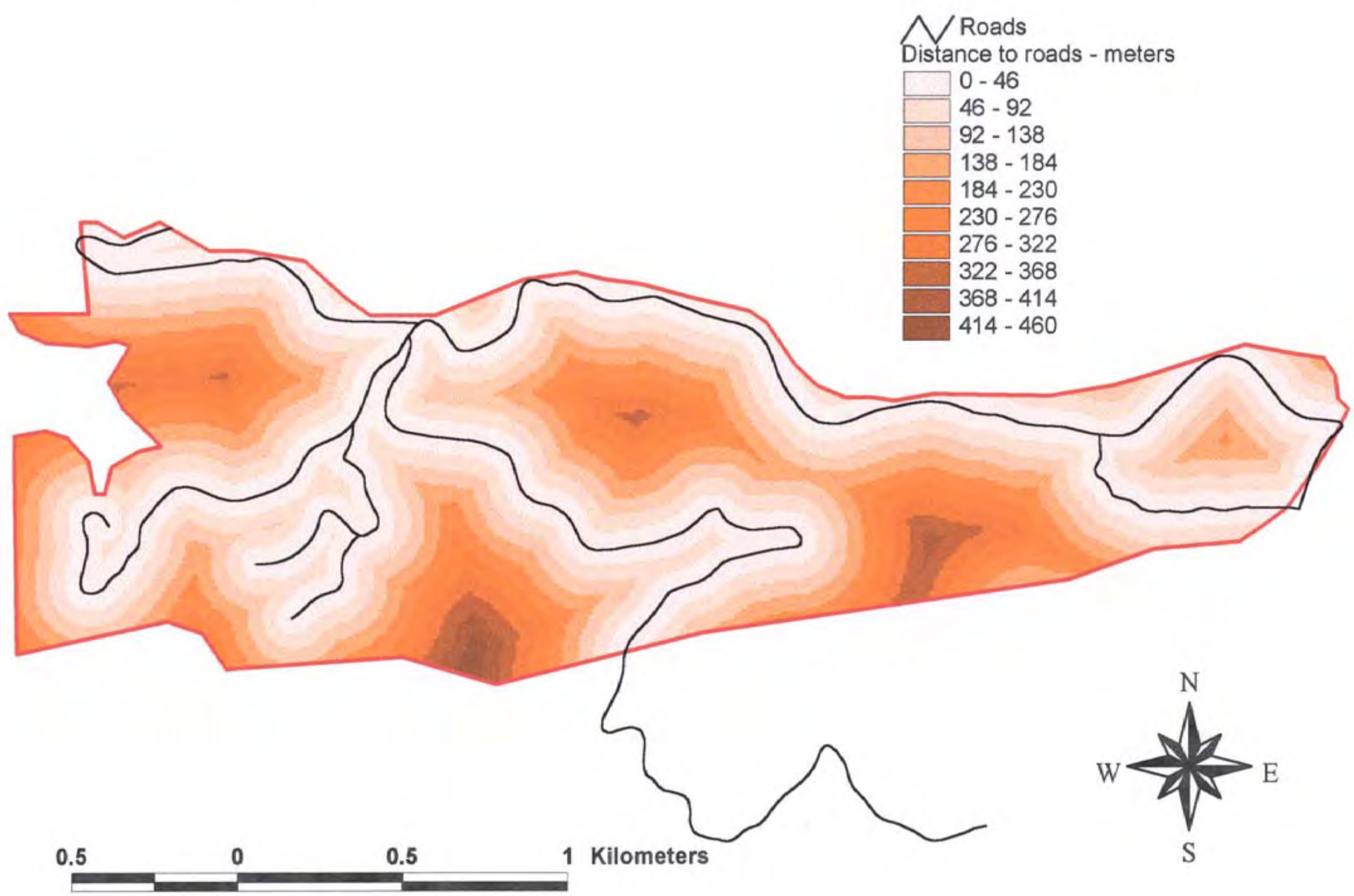


Highland Mt. - Elevation

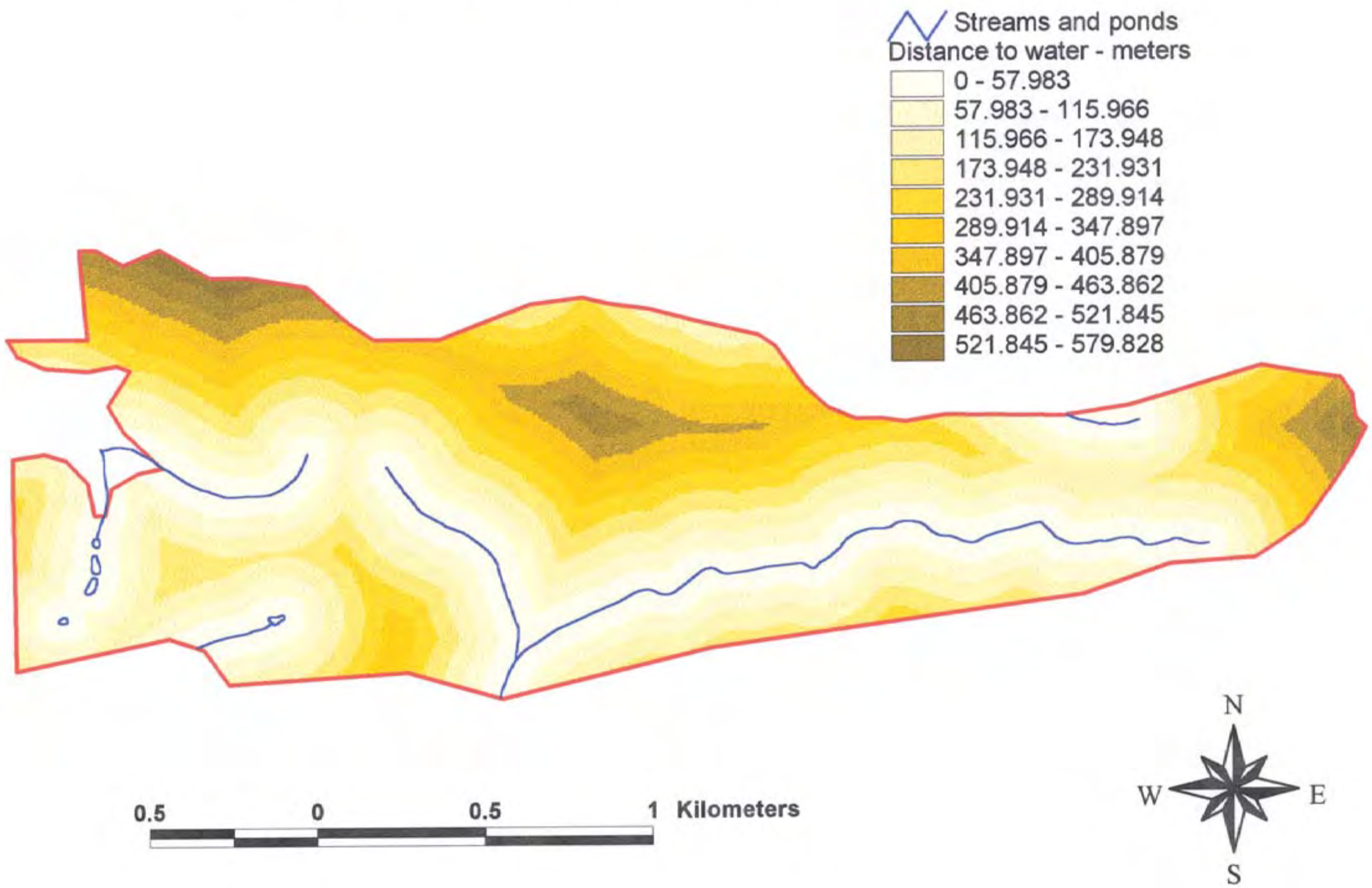


Highland Mt. - Land cover

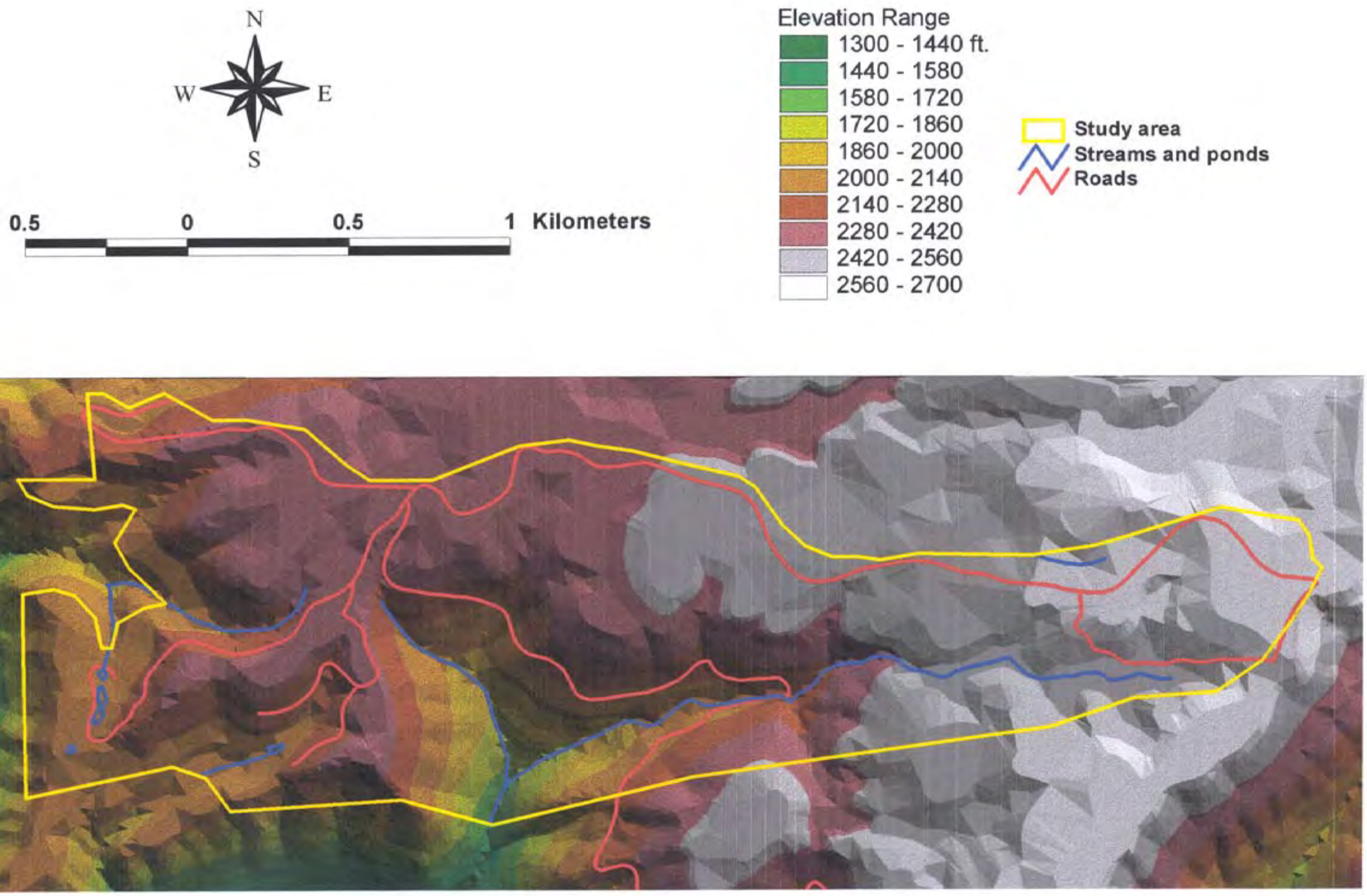
Highland Mt. - Roads



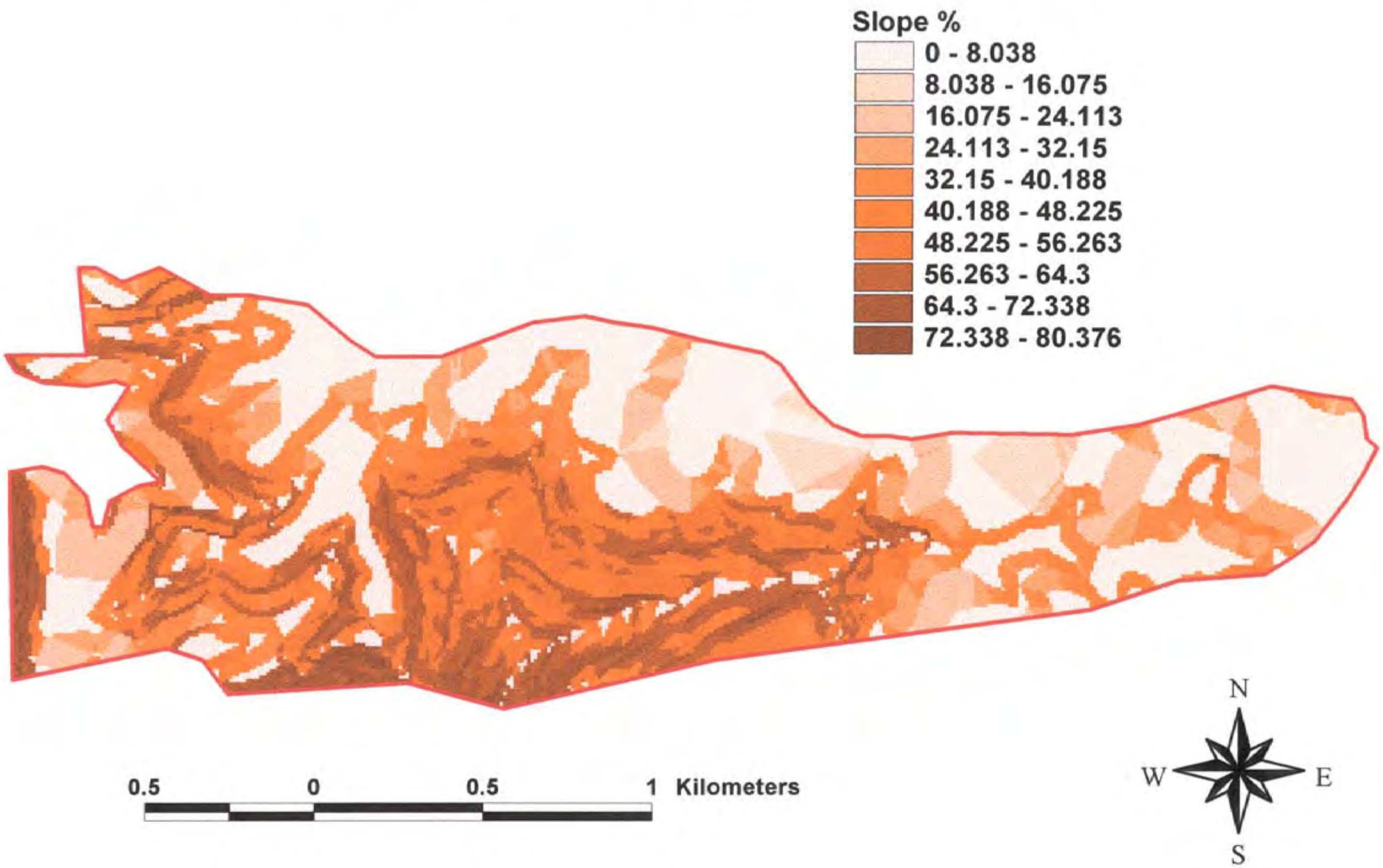
Highland Mt. - Water



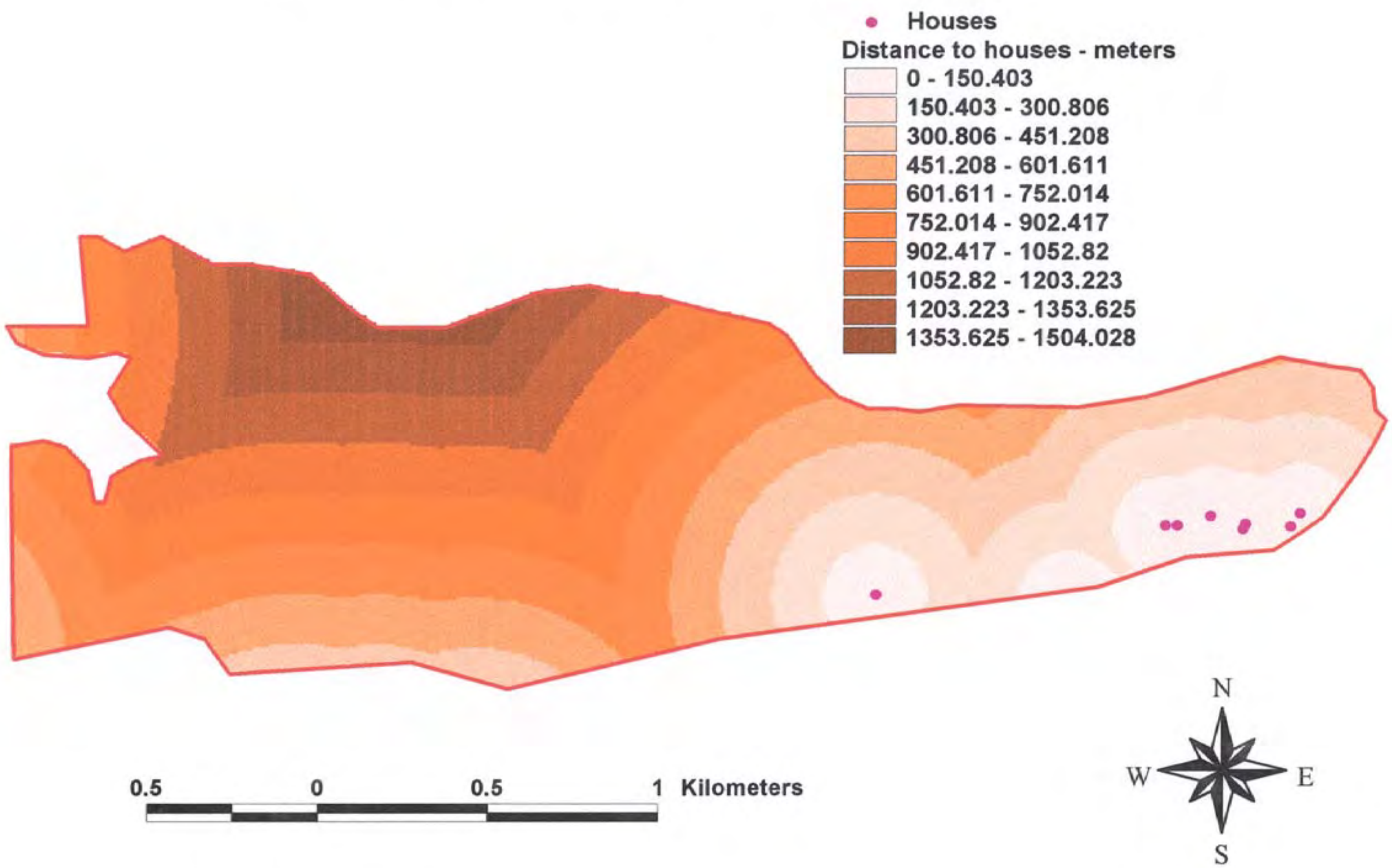
Highland Mt. - Elevation



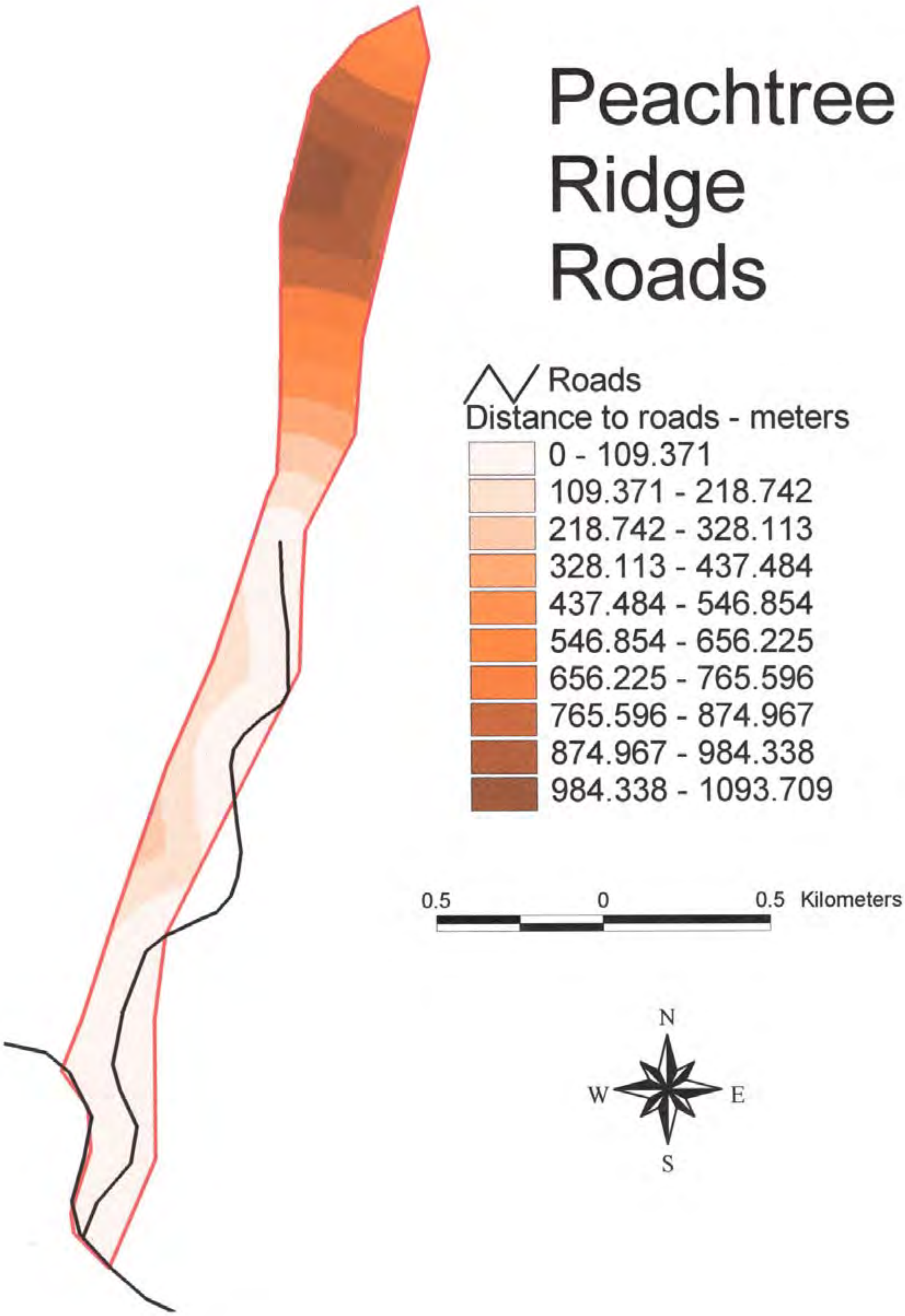
Highland Mt. - Slope



Highland Mt. - Houses




Peachtree
Ridge
Land cover
Strip mines
Cleared land
Wooded
0.5
0
0.5
Kilometers
N
W
E
S


Peachtree
Ridge
Roads
Roads
Distance to roads - meters
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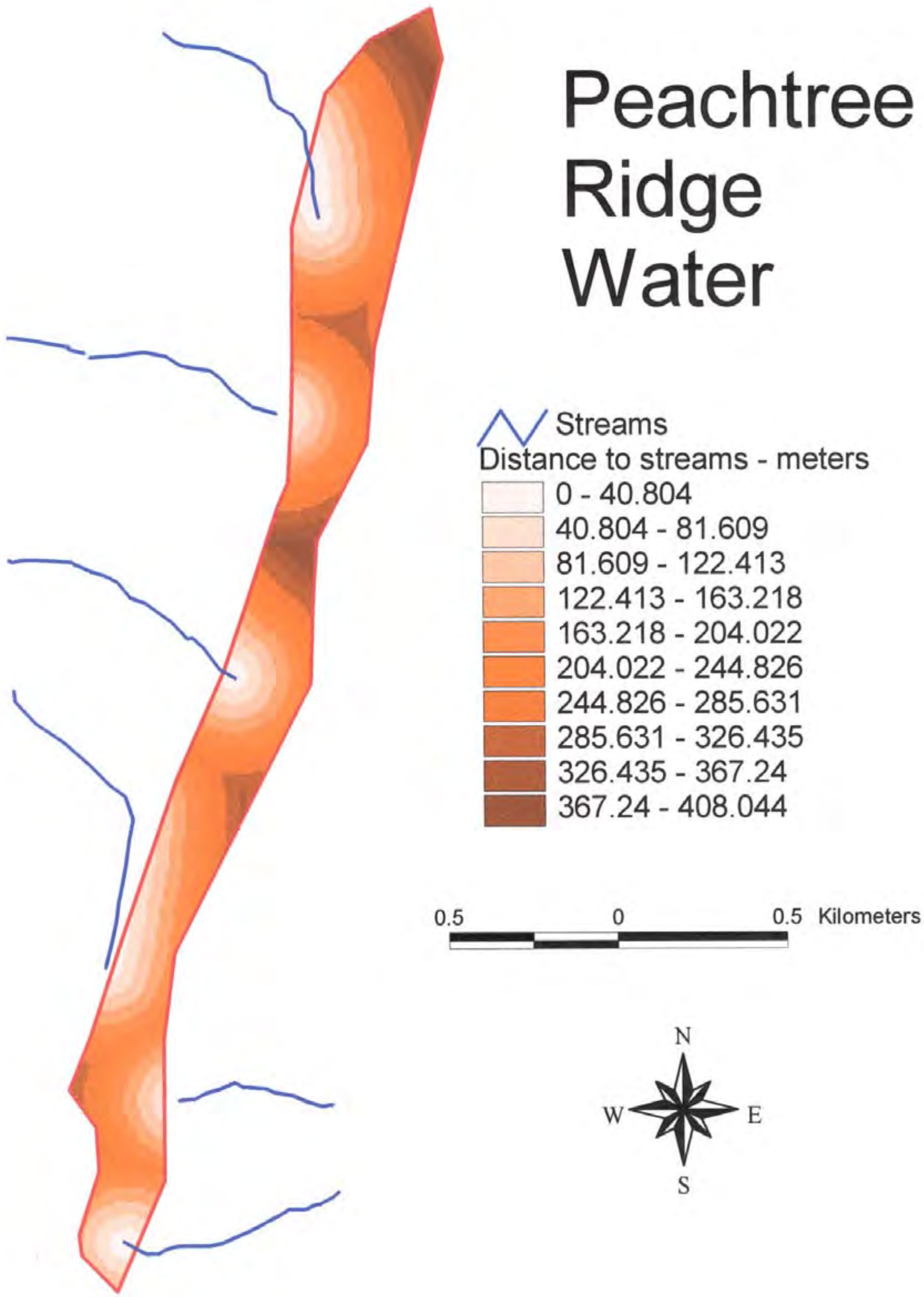
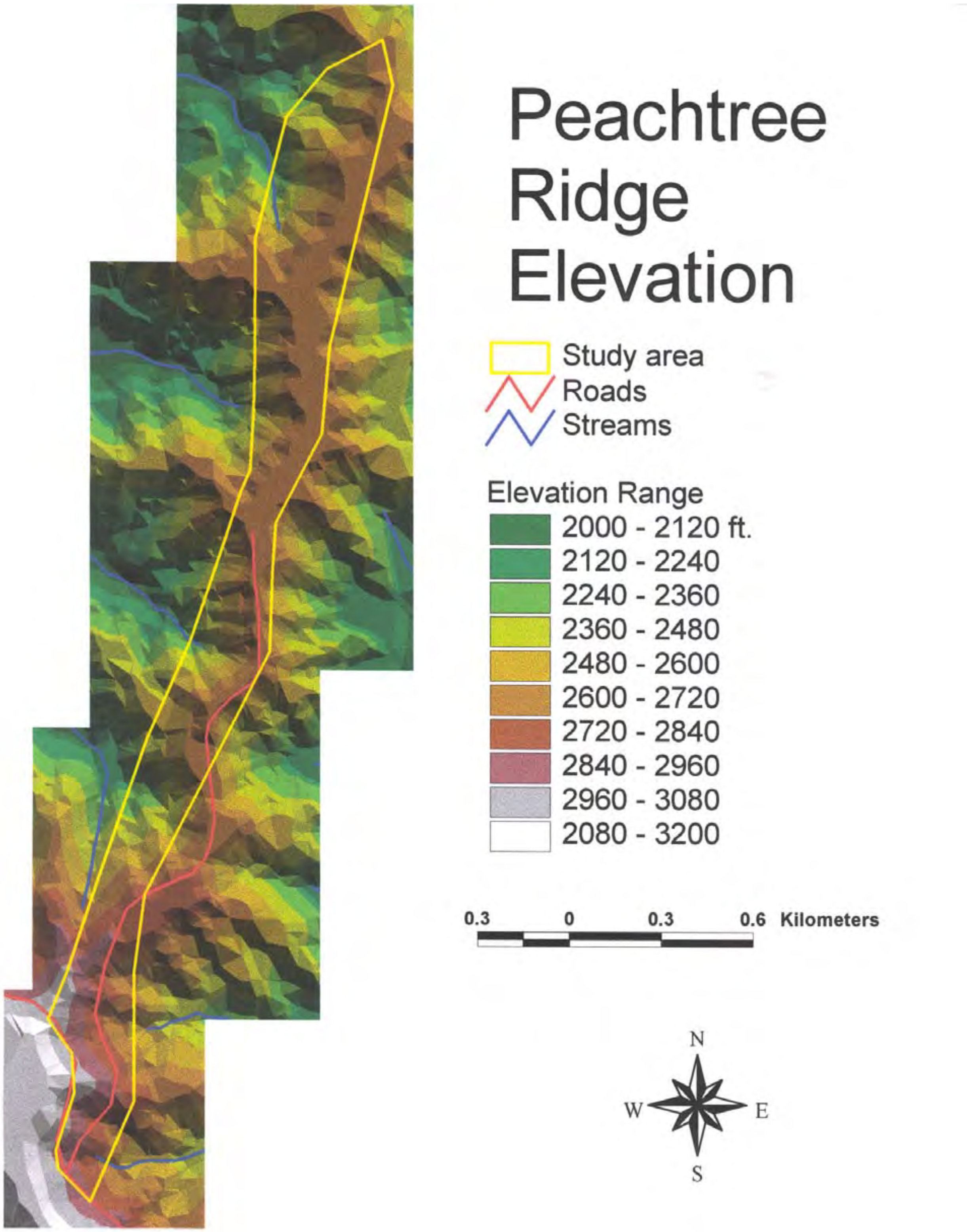
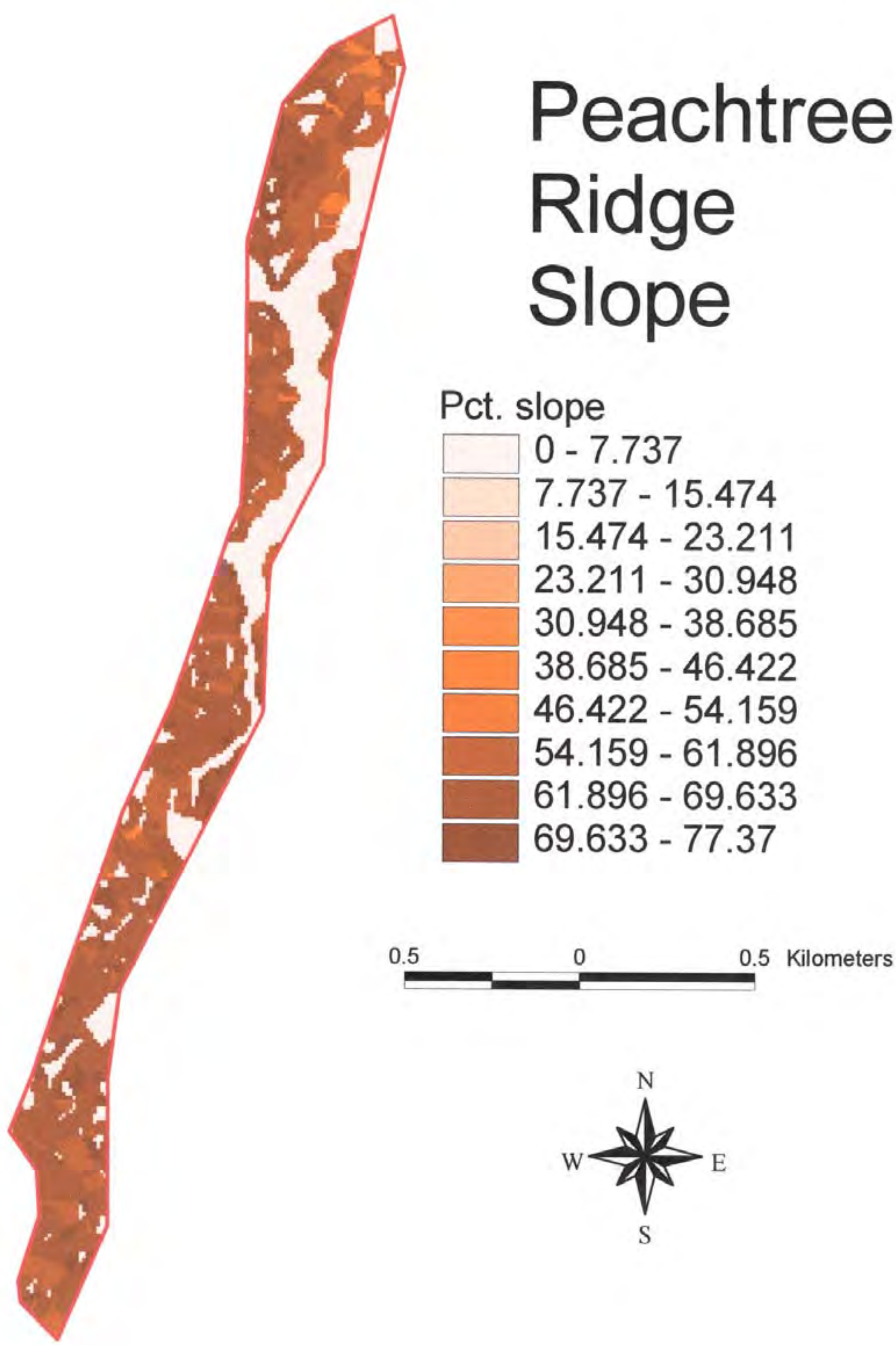
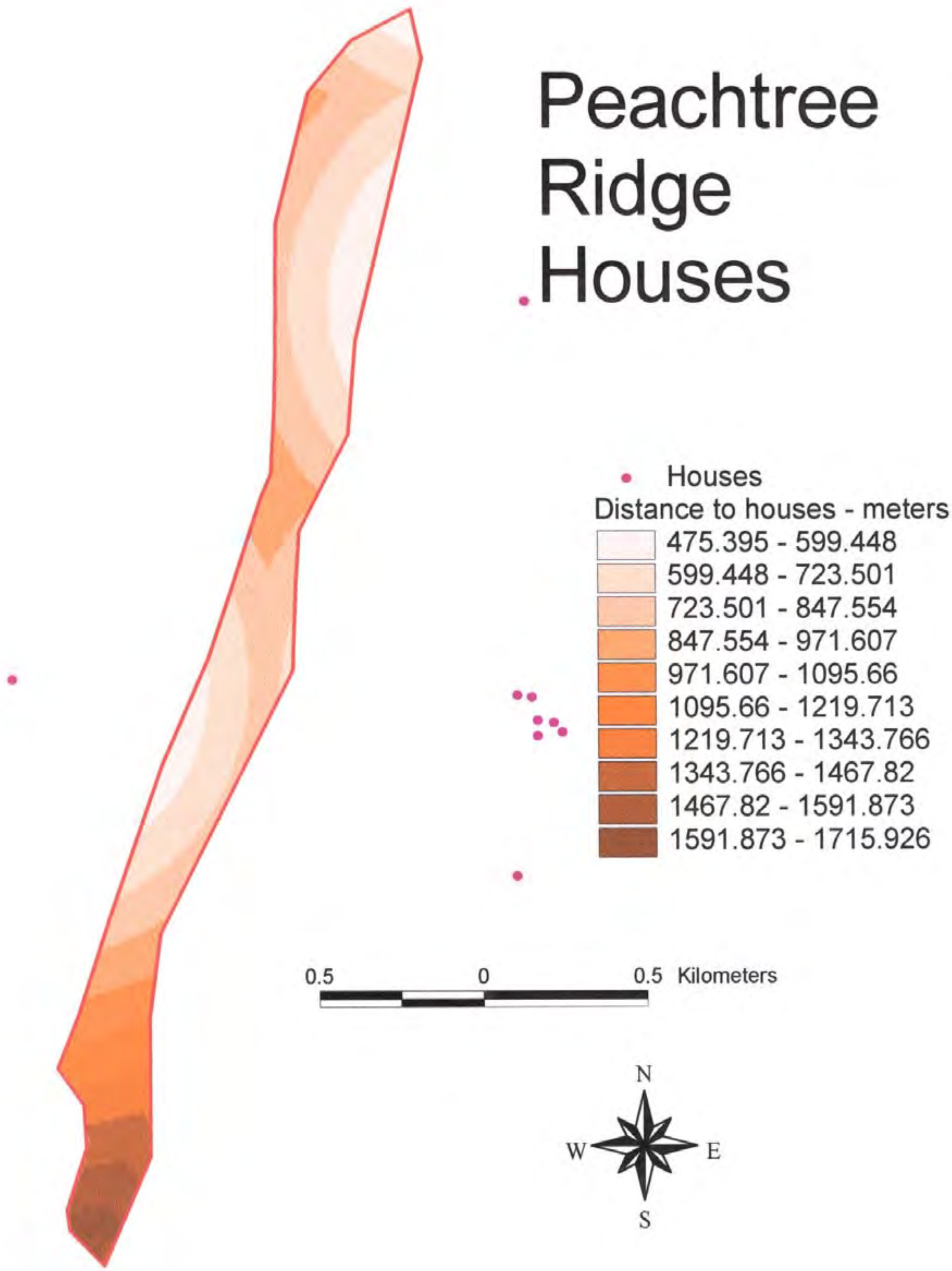
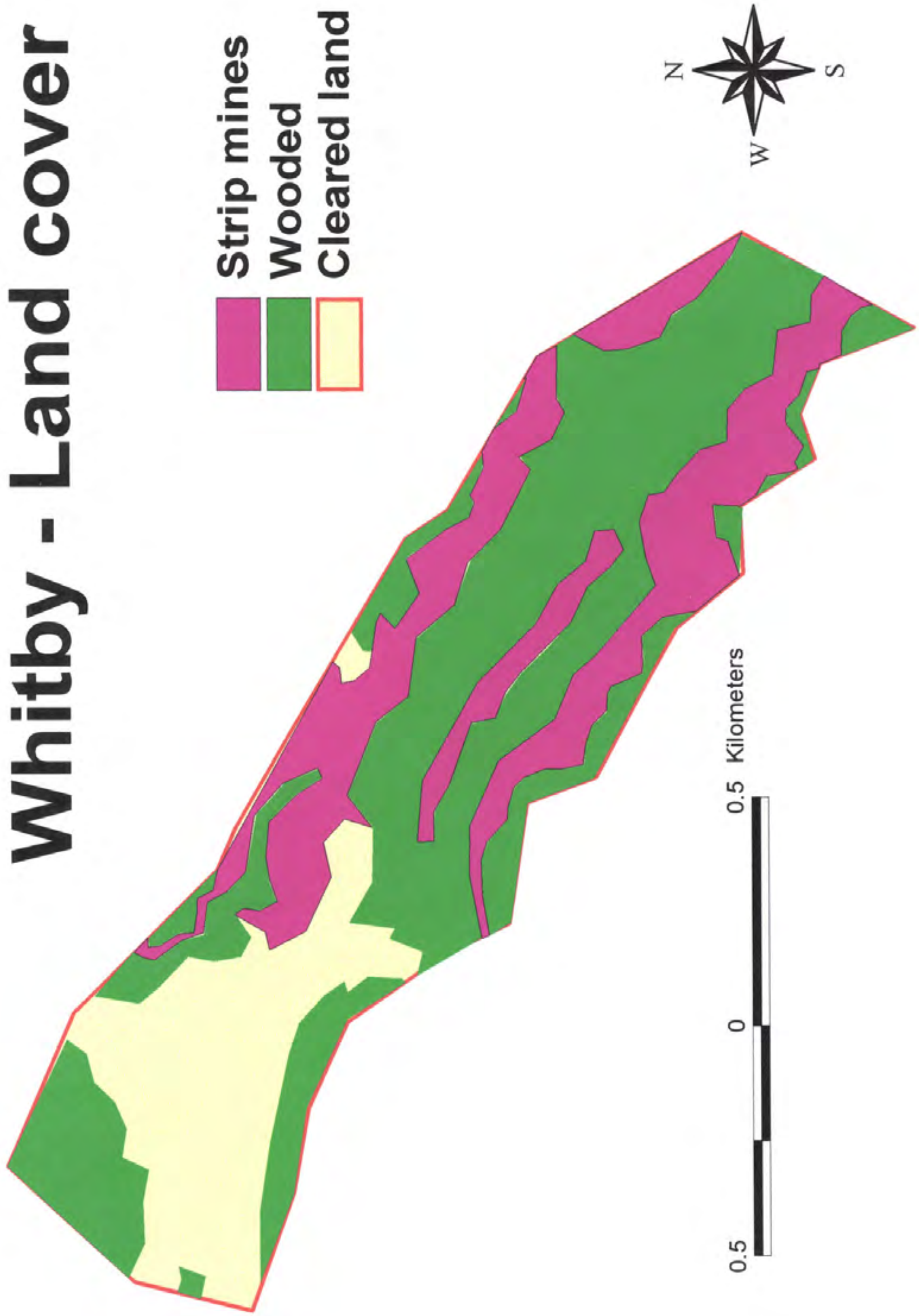
109.371 - 218.742
218.742 - 328.113
328.113 - 437.484
437.484 - 546.854
546.854 - 656.225
656.225 - 765.596
765.596 - 874.967
874.967 - 984.338
984.338 - 1093.709
0.5
0
0.5
Kilometers
N
W
E
S

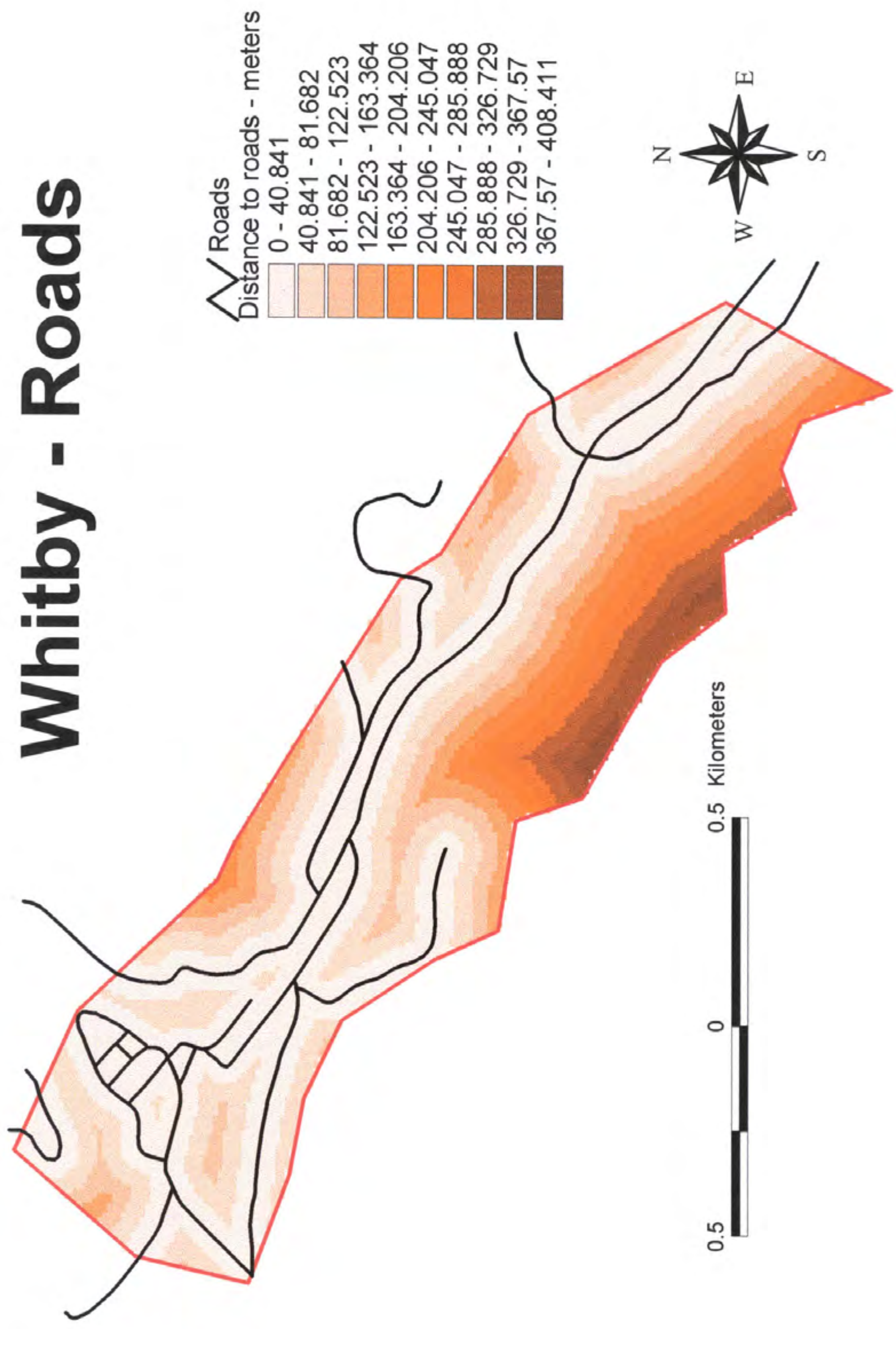

Peachtree
Ridge
Water
Streams
Distance to streams - meters
0 - 40.804
40.804 - 81.609
81.609 - 122.413
122.413 - 163.218
163.218 - 204.022
204.022 - 244.826
244.826 - 285.631
285.631 - 326.435
326.435 - 367.24
367.24 - 408.044
0.5
0
0.5 Kilometers
N
W
E
S

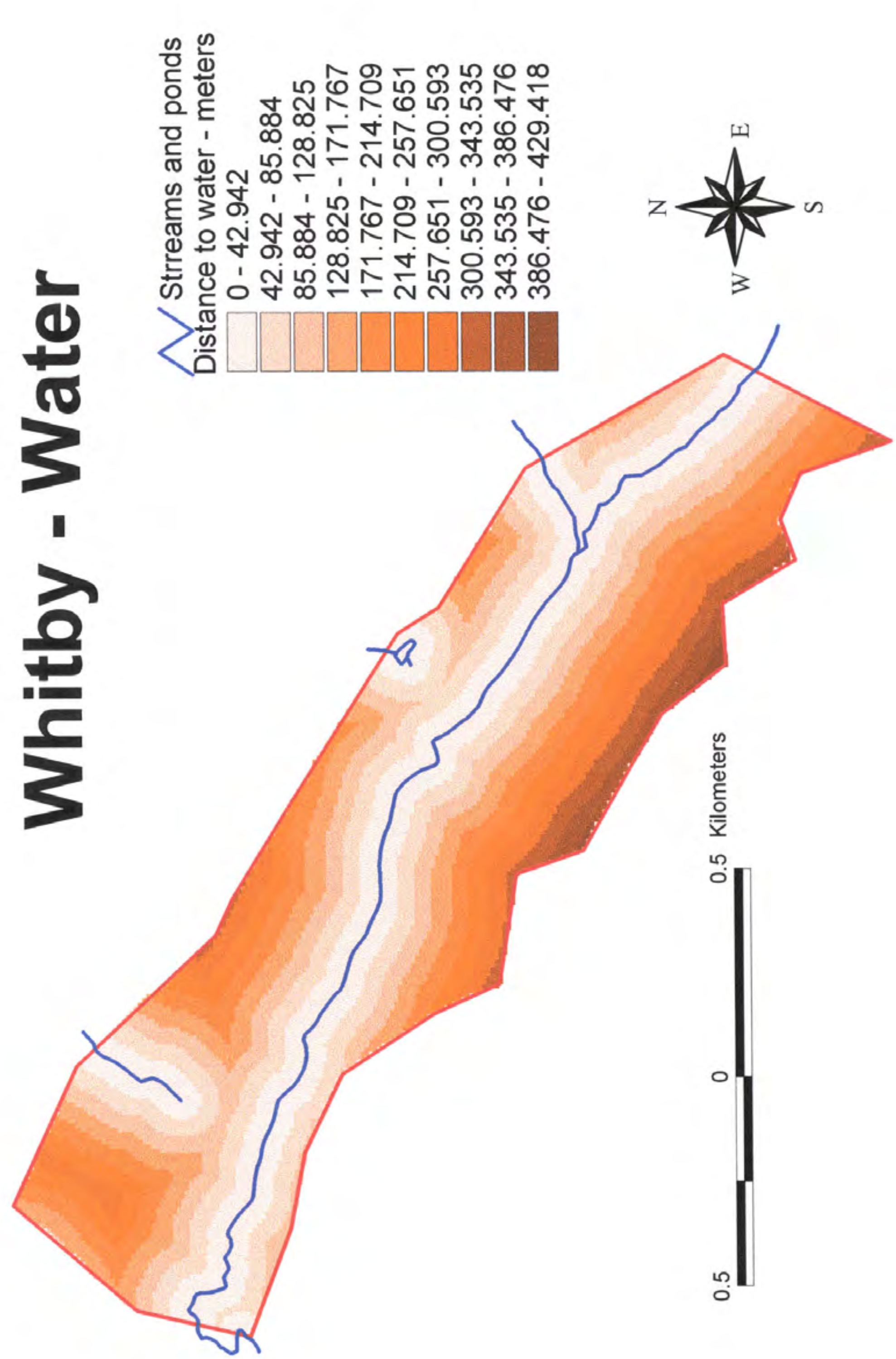

Peachtree Ridge Elevation
Study area
Roads
Streams
Elevation Range
2000 - 2120 ft.
2120 - 2240
2240 - 2360
2360 - 2480
2480 - 2600
2600 - 2720
2720 - 2840
2840 - 2960
2960 - 3080
2080 - 3200
0.3 0 0.3 0.6 Kilometers
N
W
E
S

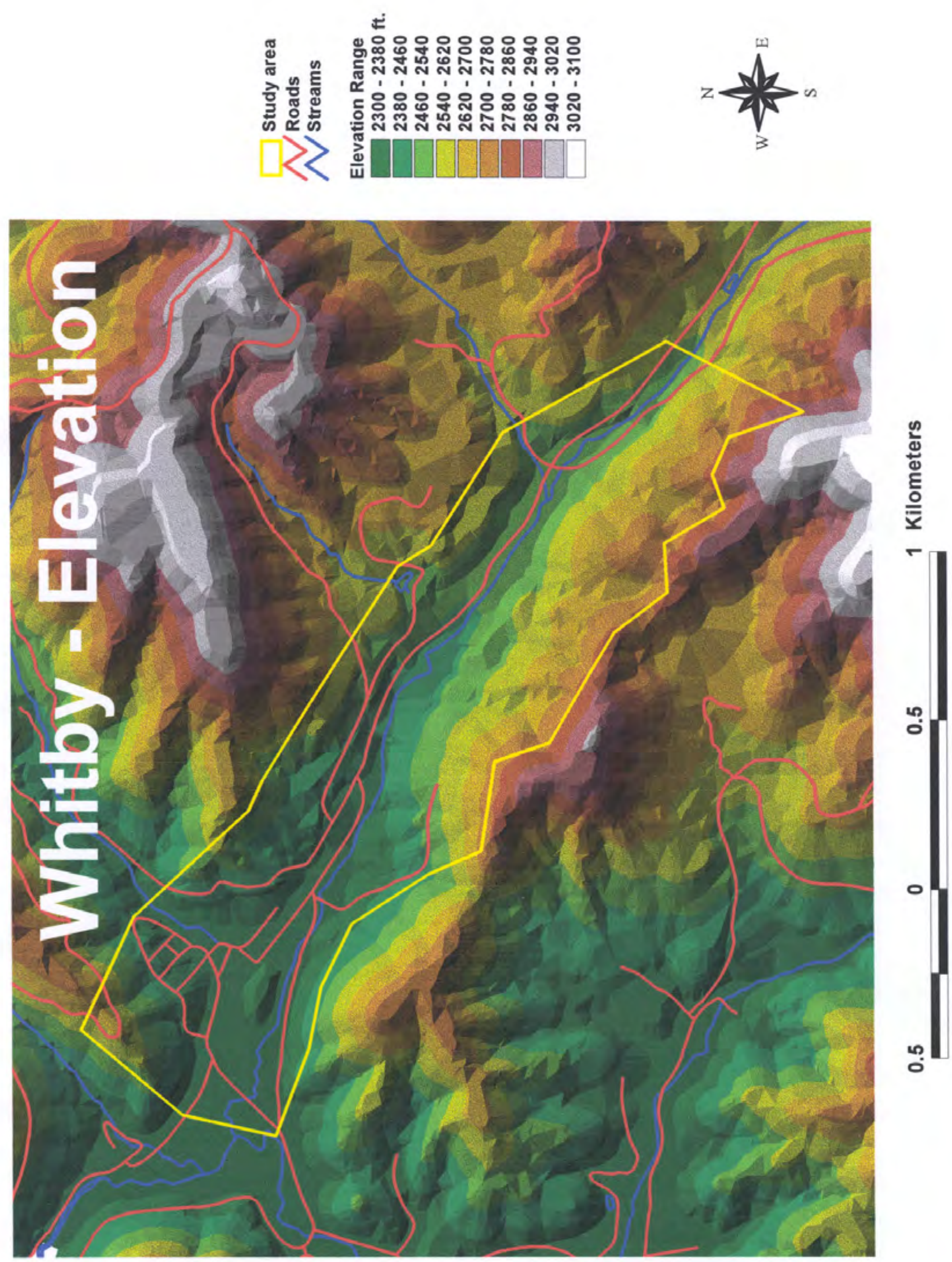

Peachtree
Ridge
Slope
Pct. slope
0 - 7.737
7.737 - 15.474
15.474 - 23.211
23.211 - 30.948
30.948 - 38.685
38.685 - 46.422
46.422 - 54.159
54.159 - 61.896
61.896 - 69.633
69.633 - 77.37
0.5
0
0.5 Kilometers
N
W
E
S

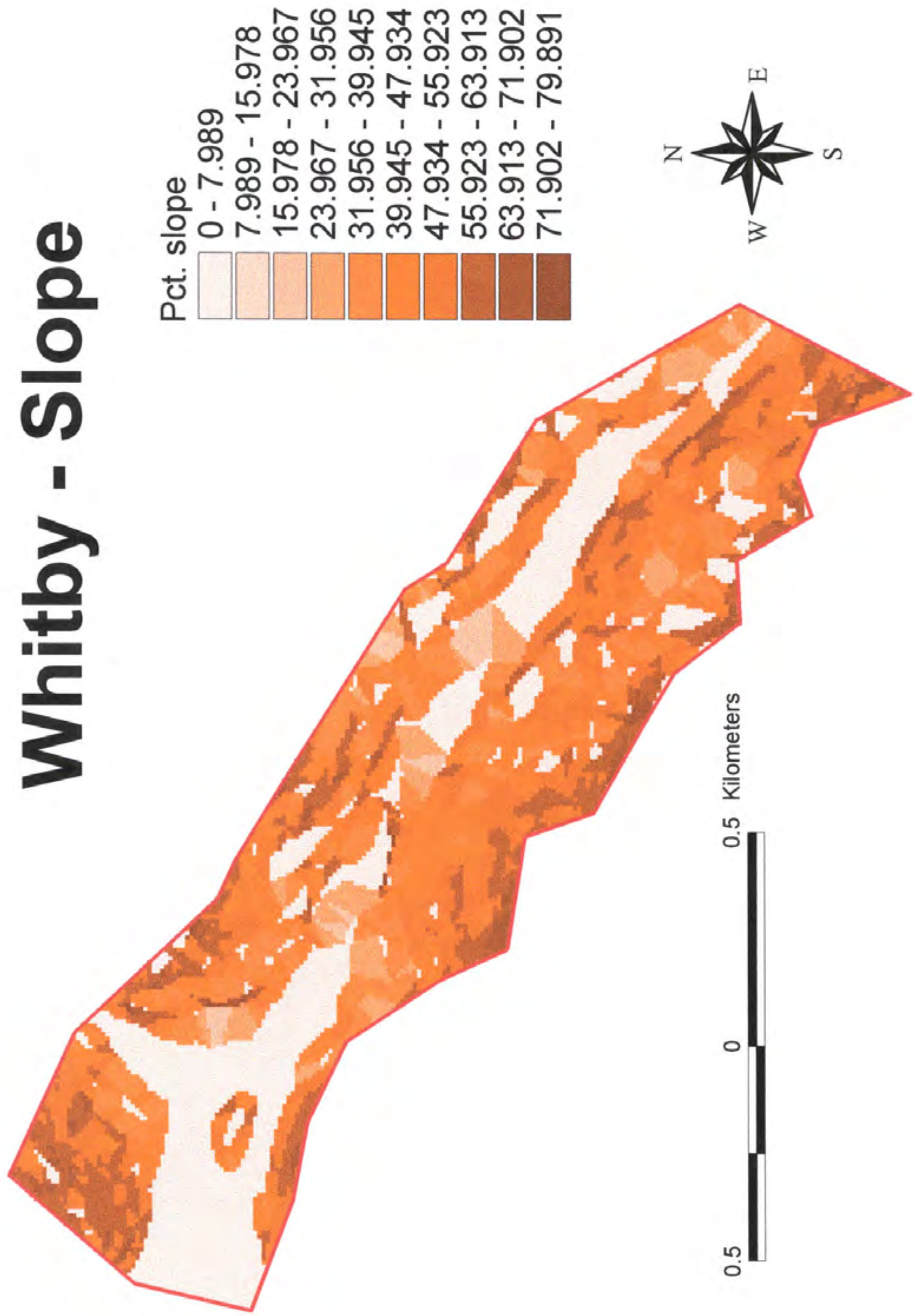

Peachtree
Ridge
Houses
Houses
Distance to houses - meters
475.395 - 599.448
599.448 - 723.501
723.501 - 847.554
847.554 - 971.607
971.607 - 1095.66
1095.66 - 1219.713
1219.713 - 1343.766
1343.766 - 1467.82
1467.82 - 1591.873
1591.873 - 1715.926
0.5
0
0.5 Kilometers
N
W
E
S


Whitby - Land cover
Strip mines
Wooded
Cleared land
N
E
S
W
0.5
0
0.5 Kilometers

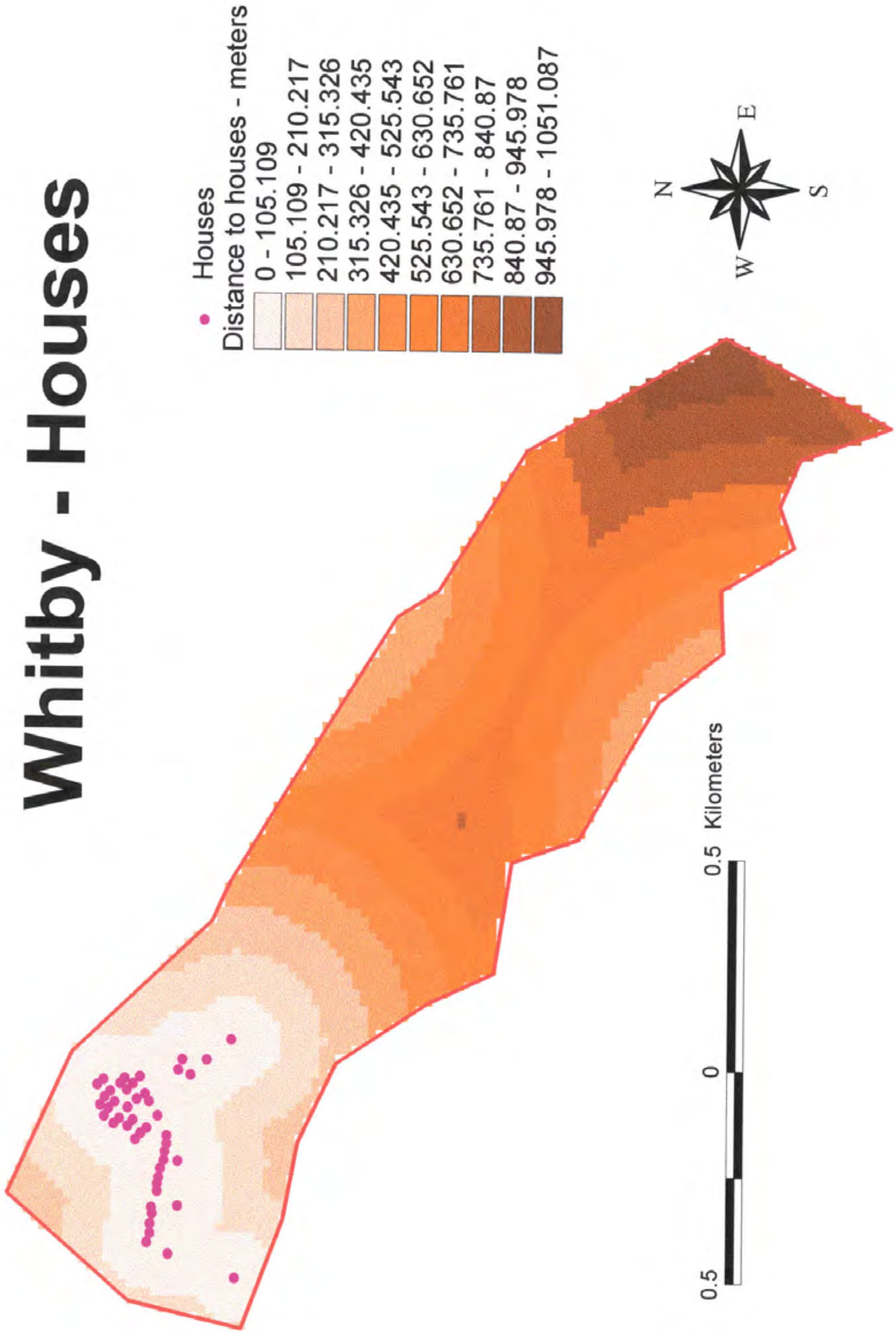

Whitby - Roads
Roads
Distance to roads - meters
0 - 40.841
40.841 - 81.682
81.682 - 122.523
122.523 - 163.364
163.364 - 204.206
204.206 - 245.047
245.047 - 285.888
285.888 - 326.729
326.729 - 367.57
367.57 - 408.411
N
E
S
W
0.5
0
0.5 Kilometers


Whitby - Water
Strreams and ponds
Distance to water - meters
0 - 42.942
42.942 - 85.884
85.884 - 128.825
128.825 - 171.767
171.767 - 214.709
214.709 - 257.651
257.651 - 300.593
300.593 - 343.535
343.535 - 386.476
386.476 - 429.418
N
E
S
W
0.5
0
0.5 Kilometers


Whitby - Elevation
Study area
Roads
Streams
Elevation Range
2300 - 2380 ft.
2380 - 2460
2460 - 2540
2540 - 2620
2620 - 2700
2700 - 2780
2780 - 2860
2860 - 2940
2940 - 3020
3020 - 3100
N
E
S
W
0.5
0
0.5
1 Kilometers



Whitby - Slope
Pct. slope
0 - 7.989
7.989 - 15.978
15.978 - 23.967
23.967 - 31.956
31.956 - 39.945
39.945 - 47.934
47.934 - 55.923
55.923 - 63.913
63.913 - 71.902
71.902 - 79.891
N
E
S
W
0.5
0
0.5 Kilometers


Whitby - Houses
Houses
Distance to houses - meters
0 - 105.109
105.109 - 210.217
210.217 - 315.326
315.326 - 420.435
420.435 - 525.543
525.543 - 630.652
630.652 - 735.761
735.761 - 840.87
840.87 - 945.978
945.978 - 1051.087
N
E
S
W
0.5
0
0.5 Kilometers

MOUNTAINTOP REMOVAL MINING/VALLEY FILL ENVIRONMENTAL IMPACT STATEMENT TECHNICAL STUDY

PROJECT REPORT FOR TERRESTRIAL STUDIES

October 2002

Terrestrial Plant (spring herbs, woody plants) Populations of Forested and Reclaimed Sites

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EXECUTIVE SUMMARY

The data presented in this report were collected in the spring and summer of 2000. They examine the pattern of revegetation of mountaintop removal and valley fill mining sites in southern West Virginia. The forests that are being removed by mountaintop removal and surface mining activities are located in the Mixed Mesophytic Forest Region. This region has very high biodiversity at the community level, and is among the most biologically rich temperate regions of the world (Figure 1. Hinkle et al. 1993). These forested mountaintops are predominantly being replaced by grasslands, although grasslands are not a naturally occurring habitat in this region (Figure 2. Hinkle et al. 1993). Blocks of young trees, some exotic, are often added to the final revegetation mix after grass establishment is successful. There is now great interest in developing and implementing mining practices that will have the least impact on future economic and ecosystem health.

Fifty-five transects on sites ranging in age from eight to twenty-six years since revegetation were visited in southern West Virginia by this investigation team. Plant species, sizes, and distribution were recorded across these sites for all woody species. Data from adjacent, unmined mature forests were also recorded. Invasion of native species onto reclaimed mined sites and valley fills was very low and restricted to the first several meters from the adjacent forest edge. Most of the plants found on mined sites were in the smallest (<1" diameter) size class, suggesting that the sites are stressful to plant growth and survival. Many of the species found in adjacent unmined forests are not present on the mined sites. Poor vegetation development with time was typical of the sites reclaimed after the 1977 SMCRA law. Diversity was significantly lower on the mined sites than in adjacent forests.

These data and other published studies support the conclusion that mining reclamation procedures limit the overall ecological health and plant invasion of the site. Plant invasion and success are dependent upon reclamation practices. Less soil compaction, smaller mining areas, healthy soil profiles, and native plant material all would support a healthier ecosystem return, although full premining biodiversity may be difficult to achieve. Sites that were reclaimed with pre-law protocols supported a richer flora than post-law sites, but this may be attributed to small scale, less compacted mining procedures. They also contained more native plants and represented all age classes unlike the post-law sites.

Herbaceous species were also studied on nineteen transects, in mature forests and on transects adjacent to mined sites. The loss of spring herbs on engineered sites was highly significant compared to forests away from mining activity. Information gathered from this aspect of the study shows that monitoring the forest herbs adjacent to mining activity is an additional useful indicator of environmental impact. The heavy compaction of the artificial slopes created during valley filling also contributes to these slow invasion rates. Additionally, the grassy vegetation mixes usually installed during revegetation are known to hinder the ability of the native plant species to establish. The poor invasion and growth of native vegetation across these study sites support the conclusion that these lands will take much longer than the natural time scale observed in old field succession to return to the pre-mining forest vegetation.

Objectives:

The objective of this study was to determine the patterns of terrestrial vegetation on areas affected by mountaintop removal mining and valley fills in the southern Appalachian region, and on adjacent, non-mined areas. Specific goals were to identify plant species present, determine the relative numbers of species present, record the size class distribution based on diameter at base or diameter at breast height of each species, and to document the pattern of vegetation from toe of slope to top of slope and from forested areas to mined areas. These data will enable investigators to understand the potential for re-establishment of native vegetation and document the actual change in vegetation since revegetation of the mined sites.

Importance of the objectives:

It is important to know the fate of the mined lands after reclamation, to determine the potential for re-establishment of surrounding native vegetation, and to see if a flora different from the vegetative mix installed upon reclamation can establish. The soils, seed pool, and local conditions on mined sites are quite different from the original conditions. It must be understood if mined areas will develop differently from the forested terrestrial communities surrounding the mined sites. These data are also needed to assess the quality of the habitat for animals of the region. If current reclamation methods are creating different habitat types, this must be known precisely, so that regulatory actions can be created to account for such changes.

METHODS:

Tree and shrub studies - site selection:

In order to assess the progress of invasion of woody species onto reclaimed mine lands, sites were selected that had a remnant forest adjacent to the mined area. A remnant forest is a forest that is directly bordering an active mining site or in this case, reclaimed sites. They are passively disturbed by mining activity through many ways including pollution, ground disturbance from blasting, hydrology changes and siltation, and increased edge area. These reclaimed areas were considered most relevant for this study because they included a seed source for the mined area, therefore offering an opportunity for woody species to invade the open, disturbed land. Study of mined lands adjacent to mature forests, of course, maximizes the potential for invasion of species, and potentially weighs the data sets towards higher invasion rates. However, it is necessary to see invasion, and the intensive sampling of edge areas gives the investigator a higher potential for determining invasion rates.

Sites across the mining region of southern West Virginia were selected to represent a wide variety of ages, conditions, and treatments. The sites in this study were recommended by EPA, WVDEP, FWS, and mining officials and engineers who worked for the mining companies that participated in the study. Knowing that the goal of this study was to record re-establishment of woody vegetation on mined lands, mining officials (list of personnel can be provided by investigators) directed our team towards the richest sites available. All of the recommended sites were studied and included in this report, in standing with the policy to visit every site recommended. At each specific locale, transects were positioned in a standardized location and vegetative cover and density were similar. The total number of forest transects surveyed and reported is 25 and the total number of mined land transects is 30. Ten different mine properties were surveyed, with ages ranging from eight to twenty-six years since revegetation. Emphasis was on surveys of sites that were older, but reclaimed after the 1977 surface mining law (SMCRA) was put into effect. Changes in reclamation protocols necessitated by that law caused important differences in reclamation practice (Vories and Throgmorton, 1999). A complete list of study sites is in the Appendix (Table 1).

Tree and shrub studies – data collection:

The first aspect of this study involves twelve transects that were run vertically down slope from a mined land (i.e. valley fill, mountain-top removal area, backfill, or contour mine) into an adjacent, mature, remnant forest apparently unaffected by mining activity (Figure 3a). (Many of these forested sites were once logged and showed vestiges of former rough logging roads. Consequently, these forests have been modified by human activity and are not considered intact or pristine forests. However, all forested areas contained large, diverse canopy trees with well-developed stands and unexcavated soil.) The transect line was continuous from mined area to the adjacent remnant forest, or in some instances started in the remnant forest above the reclaimed site and ran down into the mined land.

It is important to note the structure and nature of the *valley fills*. Transects were arrayed from top of slope to toe of slope (toe of slope in this study was defined as the bottom of the hill/fill where the ground leveled off, and/or the stream bank was reached), and ran the entire length of the fill. Because of the triangular geometry of valley fills (Figures 3a and 3b), areas at the toe (base) of the slope were surrounded on two sides by remnant forests. They were much moister areas than the top of the fill, due to storm water run-off and ground water. Because the toe of slope is wetter, much narrower, and much closer to remnant forests (on both sides), we see an increase in stem density that is indicative of an “edge effect.” Some of the valley fills had forest remnants at the top of the slope as well as at the bottom, therefore creating two zones of forest edges. Where this was the case, the top forest remnant was sampled and the bottom one was not.

There were an additional 43 transects studied where it was not possible to run continuous transects, as above. In these cases, the forest remnant transect was run perpendicular or adjacent to the mined area transect, as shown in Figure 3b.

Data were collected during the year 2000 growing season only. The presence of woody plants on these sites represents the reproductive performance of many years. The boundary, or edge, between forests and reclaimed mine land was recorded for each transect and is the “0” point on all data sets and graphs. The point-quarter sampling method was used to survey the woody plant community (Barbour, Burk, et al. 1999). This technique was used as it allowed the investigating team to cover the most ground, the most sites, and collect the most data points in the time frame given. There is a potential to underestimate rare species with this technique, as a census of all plants in an area is not done. However, a species effort curve performed on the data indicates that few, if any, rare species were missed given the large data set that covers thousands of individual plant records. Consequently, the field sampling technique is representative of the woody species on site.

At each sampling point, located at 20 meter intervals along the transect line, the area was divided into four quadrats. In each quadrat the distance was measured from the sample point on the transect line to the nearest woody plant and recorded for three different size classes, for a potential of twelve individuals per transect point. The size classes were defined as "small" (0-2.54cm), "medium" (2.54-7.62cm), and "large" (more than 7.62cm) based on diameter at base of stem. For each of these stems, the nearest neighbor's distance and species identification were recorded, as well as the distance to the nearest conspecific (individual of the same species). Trees that were obvious parts of an implemented planting program (determined by plantation spacing and diameter at breast height) were not included in the counts, as these did not naturally arrive on the sites and are not part of any invasion process. Any offspring produced by planted individuals were included in the data, however. We were not interested in survival of the planted trees, as all planted species we encountered are either forestry created hybrids or non-native and in fact illegal to plant in many states. Data were entered on computer databases for further study. Leaves and stems of questionable plants were collected and keyed out using herbarium specimens. Occasionally, specimens could not be keyed to species because they were barren of flowers or fruits; it was impossible, given the rapid time frame of the study, to return to each site at other seasonal times in the year 2000 to search for reproductive specimens.

Tree and shrub studies –data analysis:

Comparing the mined sites to the adjacent remnant forests is difficult at best. Mines are viewed by some as representatives of "primary successional soil/plant systems." Comparing them to the "native forest stands [as] largely secondary successional systems" is therefore like comparing apples and oranges. (W. Lee Daniels, personal communication). First, the mined lands are <u>not</u> primary successional landscapes. Primary succession is defined as "The development of an ecosystem in an area that has never had a living community….. Examples of areas in which a community has never lived before would be new lava or a rock from a volcano that makes a new island or a new landscape, or a sand bar that arises from shifting sands in the ocean" (University of North Carolina Wilmington). The question is not how the data were compared, but the task set before us was to document the invasion process from forest remnants to reclaimed land, to describe the vegetation and note patterns based on our knowledge and experience as restoration ecologists. We documented the successes and failures of natural recruitment onto these early successional landscapes, and analyzed our findings with statistics that allowed for such comparisons, which follow.

As previously mentioned, the objective of this terrestrial study was to determine the success of woody plant invasion onto the disturbed mining areas. The data were examined in several ways. Transects were categorized as one of six types: continuous forest (CF); remnant forest (RF); valley fill (VF); mountaintop removal area (MTR); backfill (BF); or contour mine (CM). Continuous forests are forests located away from mining activity and therefore not significantly impacted by mining activity, whereas remnant forests, as previously defined, are forests directly adjacent to and affected by mining activity. Remnant forests are typically smaller parcels than the continuous forests, but this is not a defining characteristic. Data were displayed within each of the six categories by the three size groupings of plants: small; medium; and large. The density of woody plants by size class was also determined. These densities were compared in order to evaluate the progress of the woody invasion. Species lists of forests and mined areas were developed and comparisons between native forests and mined lands were performed. Plant diversity was estimated using the Shannon-Weiner statistic, which includes measures of number of species and their relative abundances. For example, if you had two stands with the same number of plants and the same number of species, they can be distinguished from one another if one stand has these species in more or less equal proportions; a more diverse stand would have these species in more equal numbers.

Herb studies – site selection:

Nineteen forested sites, considered to be either "intact" forest (11) or "engineered" forest (8), were chosen to evaluate the herb community, adjacent to the EPA aquatic biology team's locations. The terms "intact" and "engineered" forests comply with EPA terminology and are equated to "continuous" and "remnant", respectively, as described in the paragraph previously. Sections of watersheds that had been mined (the engineered forest) and areas that were distant from mining activity (the intact forest) were selected. Sites are listed in the Appendix (Table 2). This protocol allows comparison and correlation of herb data with the aquatic study, for a more complete understanding of these sites.

Herb studies – data collection:

The study team visited all sites during April and May 2000, to sample the spring herbaceous vegetation. Early season sampling of the herb flora was necessary, as many spring herbs often complete their life history before the summer months, then persist underground until the following year (Schemske, et al., 1978; Bierzychudek, 1982). Transects were sampled every 10 meters, starting at the base of the slope, up hill for an additional 50 meters. It was determined by the investigating team that the herb cover significantly diminished around 40 or 50 meters from base of slope, and data from a broader geographical range could be collected if this was a decided end point. At each sample location, a 5x1m plot across the face of the slope was censused for all herbs. Species identity and stem count for each species were recorded for each 5x1m plot. Samples of species were collected for herbarium records and identification verification.

Herb studies – data analysis:

Data were summarized to determine relative distribution and number of species on undisturbed forest slopes compared to forest slopes adjacent to disturbed areas (i.e. mines and wide road cuts). These data were entered in a database for statistical analyses to determine vegetation distribution patterns. Shannon-Weiner Index of Diversity was performed to determine diversity values for both forest types using mean number of stems counted and mean number of species present in both forest types.

RESULTS:

TREE AND SHRUB STUDIES:

Presence of trees and shrubs on the study sites:

The 99 species listed in Table 3 were found collectively on the 25 forest transects and 30 mined transects. Table 4 shows the differences in species composition across these two types, ranked from most to least commonly present. The species did not have to be abundant at a particular site to be included, merely present on the site (i.e. whether the species has one or one thousand individuals, it is recorded as "present"). These numbers do not include data that were collected from contour mine sites or their associated remnant forests, which have been treated and reported separately, so the sample size here is 23 forest transects and 25 mined transects. Most of the species found in the majority of forest transects were found on only a few mine transects, with the exception of *Acer rubrum*, *Liriodendron tulipifera*, and *Rubus* sp., which are regularly found as small plants in disturbed areas. There are twenty species occurring on the mined lands that are not found in the forested lands and thirty forest species not found on the mined lands. Of the twenty unique mine species, many of these are typical early successional species *(Acer rubrum, Liriodendron tulipifera, Rubus* sp.*)* and many others (*Pinus* sp. and *Robinia pseudoacacia*) are offspring of the trees planted as part of reclamation efforts. Overall, there are ten more species found in the forest than on the reclaimed mined lands. This is not unusual given the very different stages of succession that these lands are in.

The data from Table 4 can also be summarized across sites by richness, defined as the number of species found regardless of abundance. Figure 4 shows that the forested category always contains more species than the sites in the reclaimed mine category, when listed from most to least rich site (i.e., the woody species are not growing in as much variety on the mined sites as in the forests.). In other words, the forests have higher plant species richness and more plant biodiversity than the mine sites (Figure 4).

Species-presence data can also be arrayed by individual species, in addition to the site values shown in Table 4 and Figure 4. Figures 5a and 5b illustrate the number and percent of transects studied where each species in the data set was found. Forested sites have a higher percent of transects represented for the majority of species. These data indicate that woody species occur across the entire forest transect, they are not just sequestered in a few unusually rich transects that happened to be included in the surveys.

There is special interest in the major tree species of the forest, as these are of possible commercial interest. Figures 6a and 6b display six of the most common hardwood tree species found by absolute number and percent of all woody stems found (total of 4,140 stems in the data sets, including all size classes). These trees are always more abundant as a proportion of stems on the forested sites. Five of the six are more common by absolute number on the forested sites; only *Acer rubrum* has more individuals on the mined sites, as many seedlings of this species were present. Further observations should be made on the reclaimed mine lands to see how well these economically viable species establish and grow.

Woody species found can also be displayed according to mine type (Table 5), to more clearly see if there are special determinants associated with species presence. Again, these numbers are based simply on being present at all, not abundance. Remnant forests have the most species, and mountaintop removal sites (MTR) have the fewest, when grouped in this way. However, only four MTR sites were examined as opposed to twenty remnant forest sites. If one examines the average number of species by site (see site table in appendix to see number of species per site), MTR's have 6.25 and remnant forests have 17.7 species on average. Table 5 also illustrates that some species (for example *Acer rubrum* and *Liriodendron tulipifera*) are more generalist (i.e. are found on all the site types). Others were found only on mined areas (*Lespedeza bicolor*) or only in forests (*Acer pensylvanicum, Lindera benzoin*). Once again, these species differences can be greatly attributed to varying successional stages.

The distribution of species can also be considered in terms of how abundant, or how frequently, the species appeared on the site (Table 6). Most species found in great number in the forests are not found in similar abundance on the mined sites. At the same time, common woody species on the mined sites, typical of earlier successional stages, are not found as abundantly in the forests. This is simply a matter of succession. The reclaimed mine lands are in a much earlier stage of succession or development than the forests, and one would expect to find different species compositions as a result of the various stages.

The forest community is comprised of a greater number of species. It is also a more diverse community than the mine land communities. More uncommon species occur in the forest and there is less dominance by a few common species. That is, the mine sites have a few dominant species making up most of their communities and few rare species present. Figures 7a and 7b illustrate the number of woody plants found during the point quarter sampling. The mine plot in Figure 7b is based on percentages, which allows a simpler comparison, as sampling effort was unequal between mine and forestlands. The mine species distribution starts quite low on the y-axis because there were many points, about 1600, where woody stems were not present at all (this very high point is not plotted on this graphic). Absence (not falling within sampling range) of a woody plant was rarely experienced on any of the forest sample points. Having more species that occur more evenly or frequently (i.e. not having a population dominated by only a few species) creates a more diverse environment. For many of the species found, the percent occurrence is high in forests. Having all the species occur only once or twice, such as on the mine lands, and being dominated by only a few species, creates a less diverse community.

There is growing concern over alien and invasive plants across all landscape types throughout the United States. This survey encountered very few invasive or alien plant species on mined-lands or in the forests (Tables 3, 7a and 7b note non-native species). Most of the non-native individuals observed were those that were planted as part of a reclamation effort (i.e. Autumn olive is both exotic and very invasive and every mine visited was using it for reclamation). There were several other exotic species that were observed, including Tree-of-heaven, Japanese honeysuckle, Princess-tree, and Multiflora rose that arrived on site naturally. Japanese Knotweed was also observed along the stream banks in developed areas.

Distribution of trees and shrubs across the study transects:

To spatially study the process of invasion, data were displayed across the x axis in figures 8-12, where "0" represents the edge, the sharp boundary between forest and reclaimed mine area. In these graphics, all alien species were removed from the data sets, as the interest in this study is the reappearance of the native West Virginia plant community. These data (in Figures 8-12) are from the twelve continuous transects described earlier (page 1). There are three Mountain-top Removal (MTR), three Valley

Fill (VF), three Backfill (BF), and three Contour Mine (CM) sites, all with paired forest remnants. The following figures graph the mean stem densities per 25m^2.

Figures 8a, 8b, and 8c illustrate the stem densities calculated for the small, medium, and large size-classes, for woody individuals on nine continuous mine to forest transects (contour mines not included in total density graphs). A “continuous transect” (Figure 3a) is a location where only one line was run, going from mine land directly into the remnant forest, or vice versa. Figure 8a shows that the small individuals (2.54cm and smaller diameter at base) are not regenerating on the mined lands as abundantly as they do in the forest. Figure 8b shows that establishment of the medium size class individuals (2.54-7.62cm diameter at base) is not as high on the mined lands as it is in the forests. (Figure 8c) Large individuals (7.62cm diameter at base) are barely present on the mining areas. There is little to no growth into this size class. This is not an unreasonable size class to reach given the age of these mines (range of 8 to 26 years old since revegetation).

The six most common forest tree species have the following age and size projections under optimum soil conditions: *Acer rubrum* can reproduce at an age as early as 4 years, with a size of 5-20cm diameter at breast height (DBH). *Quercus rubra* is 25 years at first reproduction with 60-90cm DBH. *Liriodendron tulipifera* is 15-20 years at first reproduction, with DBH of 17-25cm. *Acer saccharum* will reproduce as early as 22 years, with DBH equal to 20cm. *Fagus grandifolia* reaches substantial seed production at age 40 or with a DBH of 6cm. *Magnolia acuminata* starts reproducing at age 30, optimum at age 50, with DBH unreported (Burns and Honkala, 1990, for these data). These data should be carefully interpreted, as they are in optimum conditions, conditions that are not experienced on reclaimed mine lands. However, there are no age estimates published for such lands, with similar aspect, elevation, topography, etc. that we are aware of to compare our data to. The age and size estimates given above are at breast height, roughly 1.22m (4’) high, for the average adult. The size classes used in this report were determined at the *base* of the plants, as most of the individuals were no taller than 61cm. The reclamation age of many of the mine sites is nearing or has reached the reproductive age for several of these trees, but this study’s data indicates that trees in mine spoils have not approached the correlated sizes.

The woody data from reclaimed mine transects can also be divided into the four mining categories: Mountain-top Removal (MTR), Valley Fill (VF), Backfills (BF), and Contour Mine (CM). Figures 9a, 9b, and 9c illustrate the stem densities calculated for woody individuals in all three size-classes, on three MTR sites and the paired remnant forest transects. Figure 9a shows that the small individuals (2.54cm and smaller diameter at base) are not regenerating on the mine lands as they do in the forest, which is expected given the vast differences in soils. Of the three MTR’s surveyed, one was eight years old since revegetation and the other two were both 17 years since revegetation. It is expected to see small size-class individuals well before 17 years is reached. The medium individuals (2.54-7.62cm diameter at base) (Figure 9b) are not present on these mined lands, and there are only a few large individuals (7.62cm diameter at base) present on the surveyed, reclaimed mine lands (Figure 9c).

Figures 10a, 10b, and 10c illustrate the stem densities calculated for woody individuals in all three size-classes on three Valley Fill sites, that accompany MTR sites, and the paired remnant forest transects. The remnant forests of two of these transects were located above the fill (Colony Bay: Cazy fill; Hobet Mine: Bragg Fork fill) and the other was located at the bottom of the fill (Leckie Smokeless: Briery Knob). Due to the triangular geometry of Valley Fills (Figure 3a), which (a) allows closer proximity to forest edge, and (b) provides a moisture gradient created by the drainage ravines at the toe of the slope, there was an increase in stem densities with decreasing elevation in the Valley Fill sites. This has apparently increased the presence of the small size-class plants in this mining area. However, the data for the medium and large size classes shows a decrease in this trend over time. Valley fills remain stressful sites for these seedlings, and slow growth or lack of survival could underlie these low data points. As these sites are ages 16, 21, and 25 years, a higher representation in all three sizes would be expected during successional change, even without optimal soil conditions.

Figures 11a, 11b, and 11c illustrate the mean stem densities calculated for woody individuals in all three size-classes on three Backfill sites and the paired remnant forest transects. One Backfill is 14 and the other two are 16 years old since revegetation. Figure 11a shows that the small size-class individuals are regenerating along the forest edge as would be expected, but taper off rapidly beyond 60 meters and are not found further from the edge. An edge effect can also be observed in the medium size-class (Figure 11b) in the first 20 meters that quickly fades until there are no medium individuals found beyond that point in great number. Few large size-class individuals were found on the mined sites (Figure 11c).

Figures 12a, 12b, and 12c illustrate the stem densities calculated for woody individuals in all three size-classes, on three Contour Mine sites and their paired remnant forest transects. All three of these sites are 12 years since revegetation. The contour mines that our investigators visited were much shorter in length than the other mine lands and were typically less compacted upon completion than flat areas, because of less grading activity (Vories and Throgmorton, 1999). Bonferroni T tests (Proc GLM in SAS/STAT version 6.12; SAS 1990) were run on the mean densities of the four mine types, by size class. The Contour Mines' plant densities in the small and medium size classes were significantly greater than all three other mine types ($p_{small}=0.0011$ and $p_{medium}=0.0004$) (Figure 13). Because all four mine types included in this study had so few large individuals, there was no significant difference among any of the mine treatments.

Regeneration of the small size-class individuals on the CMs illustrates the edge effect of a forest (Figure 12a). The CM's trend of regeneration falls abruptly after 10 meters, and suggests that few woody stems would be present beyond 50 meters (the local limit of this site). Figure 12b shows a pattern similar to Figure 12a, the smaller individuals are surviving into the next size class. No large individuals occurred within our sampling efforts on these CMs (Figure 12c). However, it has only been 12 years since revegetation at these sites and not many tree species are expected in this size class from seed this quickly (see maturation information in previous text).

Finally, one transect studied represents a unique site where it is possible to compare three types of land engineering, all at the same age, to determine what woody plants have naturally recruited into the site. This site was at Peerless Eagle Mine, and its age is estimated between 12 and 17 years. The top third is mountaintop removal, the middle third is a clear-cut forest remnant (apparently cut in preparation for the fill, but never filled to that height, and has since revegetated), and the bottom third is valley fill (Figure 14a). Consequently, the soil in the clear-cut area was only minimally disturbed;

soil was removed or covered in the other areas. Figure 14b illustrates the lack of plant recruitment into the two engineered areas. During the same time, the central clear-cut area has fully revegetated, probably due to stump sprouts and germination from the undisturbed seed bank (Figure 14a). Soil quality is dramatically drawn into attention at this site. In the same amount of time, with the same external forces impacting the area, there is a remarkable lack of vegetation on the engineered sites.

Additional perspectives on trees and shrubs:

Once again, comparing these data between reclaimed lands and forests is difficult, in that we do not have a controlled environment or experiment. However, we must analyze the data to the best of our abilities and within the limits of statistical powers.

The Shannon-Weiner Index (H) is a measurement of community diversity, a function of both species number and relative abundance commonly used in vegetation analysis (Barbour, et al., 1999). For small, medium and large plant size classes, the diversity index is significantly higher (paired t test, df = 8, $p_{small} = 0.0191$, $p_{medium} = 0.0082$, $p_{large} = 0.0033$) on the forested parts of the transects (Figure 15), indicating greater species diversity than on the reclaimed mine lands.

Finally, figures 16a, 16b, and 16c compare mine age (since revegetation) and average total plant density on each transect site. Data from all remnant forest transects are shown as a mean of values, with standard deviation. These are displayed across the x-axis to allow a visual comparison with all of the values from the mine lands. However, this *does not represent* in any way the actual age of the forested sites; this acts as an approximate asymptote to which developing forests in this region might attain. The data for the forest were added to give a visual cue of where the average forest density is for each size class. Figures 16a, 16b, and 16c illustrate that mine age since revegetation does not positively correlate with increasing stem density. If the densities were increasing over time, one would see a positive regression line for the mines. However, for all three size classes there is no linear relationship, indicating no increase in number of individuals over time.

The last three data points along the x-axis (reclamation ages 23, 25, 26) of figures 16a-c are important to note. The two older mines were revegetated prior to the 1977 SMCRA laws, while the third was reclaimed just two years later, in 1979. The two older sites have revegetated much more quickly than the third site and all other sites visited. The medium and large size-class individuals were just within the remnant forest density mean (or very near the lower end of the range) at these two sites. What happened in two years to create such a change in reinvasion potential? Possible answers are scale of mining and reclamation practice (see Conclusions and Executive Summary).

General Conclusions for Trees and Shrubs:

There is a low number of species and an extremely low number of stems of woody plants on all mine types in this study compared to forests. The few native plants that do invade the mining areas are very close to the edge of the forest and are heavily concentrated in the smallest size class (less than 2.54cm diameter at base). The absence of significant numbers of stems larger than 2.54cm suggests that these are stressful sites, where very slow growth or high death rates for small plants are typical conditions. These are very low invasion rates compared to many sites adjacent to mature forests that do not have mining as a land use. As has been noted in many recent studies (e.g. Vories and Throgmorton, 1999), the combination of poor substrate quality and interference by inappropriate grass cover restricts the ability of native communities to return to these extensive land areas. Stands that have regenerated on pre-SMCRA sites often have diverse, productive forests (Rodrique and Burger, 2000), but newer protocols challenge this level of stand development, as is illustrated by these data.

A 1999 Greenlands article by Skousen et al. evaluated tree growth on surface mine lands in southern West Virginia. This study examined only three sites, two of which were pre-SMRCA law, and the third was reclaimed in 1980. Our team included all three of these sites in this study of 54 sites. Skousen's results clearly support our findings in that post-law sites are not regenerating as quickly as they could due to "[herb species suppressing woody seedling establishment], soil compaction and shallow soil depth." Similarly, in the pre-law sites that were not seeded with an herbaceous cover plant succession is rapid (Skousen 1999).

An in-press article by Holl (2002) shows the potential for reinvasion and recovery on reclaimed surface mined lands. It is extremely important to note that, like the Skousen article, her study was comprised of pre-law sites dating back to 1962 reclamations. She does not report how many of the 15 sites were post-law (post 1977), but her three age classes for the mines are 1962-1967, 1972-1977, and 1980-1987. Also, the mines in that report are small ¼ hectare parcels, not comparable to the large mountaintop removal areas subject to this study. The Holl study sites, only 62.5 x 40m in size, examined areas very close to seed sources, within "5-50 m from unmined forests." It becomes obvious that invasion is possible for many species if the landscape setting is different from current large-scale practice. We have yet to see evidence that the original community has or will return to these seriously degraded landscapes.

Recently, a new series of West Virginia State regulations was passed to detail better procedures for re-establishing forest lands on AOC mine sites. These regulations include detailed requirements in soil, cover, and landscape requirements to begin getting productive habitats returning to the land. These new active regulations could be the starting point to address the poor stand development seen on the sites recorded in this study. However, full return of the rich biodiversity of the historical forests of the region would require more intervention than the addition of several dominant species, as is required in the new West Virginia regulations.

Attempts to encourage woody establishment are being made by some industry participants. One of the current practices is to plant rows or blocks of a tree species (Autumn olive, Black locust, Black alder, pine) in an effort to create corridors – areas that seed dispersers (birds, mammals) might find inviting for perching, foraging, and protection, which then introduces seed into the area. Our study found that blocks of olives and pines had little to no plants establishing underneath them. These trees were usually planted very close together and both species tend to grow dense and bush-like. Seed was either excluded from the area or could not establish due to poorer soil quality or not enough light and rain penetration. The alder and locust blocks had more success. These trees grow much straighter and do not shade out seed-rain, light, or other resources as much as the other two species. Other attempts have been made as well, like experimenting with different crop trees.

HERB STUDIES:

Presence of herbs on the study sites:

The herb communities on the forested sites were generally dense and species-rich, as is typical of this region (Hinkle et al., 1993). Eighty-five herbaceous species have been identified (Table 7a), and more were found on site, which required flowering structures for complete species identification. The presence and composition of the forest herb stratum is critical for forest health, as these herbs maintain soil structure and add nutrients, and offer habitat and nutrients to many animal species.

Three of the nineteen transects were on valley fills, the rest in forests. Presence-absence of the woodland herbs was recorded at these three valley fill sites, so these data are analyzed separately from the remaining data, which follow. Woodland herbs were not expected to be observed in open, sunny fields, as most of the herbs on Table 7a require the shade and moisture of the forest floor. The species that were recorded on the mine sites are on Table 7b.

Of the remaining sixteen sites, eleven were in mature intact forests and five were on lands directly adjacent to mining activities, such as the mine itself, a railroad, or a busy vehicular haul road. These are the "engineered" forests. Table 8 lists herbaceous species found on study sites, ranked from most to least present. The engineered forest sites are contrasted with the intact forest sites to determine the effects of mining activity on adjacent forest herbs. There might not be direct physical destruction of these adjacent forest remnants, but the disturbance caused by high activity levels (i.e. mining equipment, blasting, fumes and exhaust from train engines and hauling vehicles), as well as sun shafts cutting through to the forest floor from adjacent human-dominated areas, may disrupt the forest community starting with the herbaceous stratum. Seventeen fewer species are found in engineered forests than on intact forested sites.

In analyzing species distribution on the slopes, intact sites have more species at any point than engineered sites (Figure 17a). This can be seen with a two-way analysis of variance (ANOVA) (Proc GLM in SAS/STAT version 6.12; SAS 1990) to test for the effects of treatment type, distance from toe of slope, and the interaction of treatment and distance on mean number of species. Significant results were found for treatment type and distance from toe of slope on the species mean (both had a p value = 0.0001), indicating that both the distance up the hill and the type of site affected the number of species. There was no significant interaction between environment and distance.

The herb stratum in the intact sites also contained more stems in study areas than in the engineered sites along the entire slope (Figure 17b). A two-way ANOVA was performed, testing treatment and distance on mean number of herb stems (treatment $p = 0.0016$ and distance $p = 0.125$). Treatment type was found to be significant for number of plants found. There was no significant interaction found for distance from toe of slope on number of stems. There was no significant effect of treatment and distance collectively on number of herb stems counted.

The diversity of the herb stratum follows a similar pattern as described above. Figure 17c shows that the engineered sites had less diversity than the intact sites at all but one point along the slope. ANOVAs show a significant value ($p = 0.003$) for treatment type, and a marginally significant result ($p = .0989$), at a lower level, for distance on diversity. Once again, there was no significant relation between treatment and distance.

Tables 9a and 9b record the herbaceous species found at study sites, ranked from most to least abundant (number of stems counted) in engineered and intact sites and by percent abundance, respectively. (The two tables record absolute number and percent of stems on these sites.) Several of the species, which are found most abundantly on the intact forest sites, were not present, or were present in very low numbers, on the disturbed engineered sites. This indicates that human activity is affecting the forest ecosystem and changing the community composition. Four of the top ten intact forest herbs are in the top ten of the engineered sites, however, three of the top ten were not present at all on the engineered sites. This might indicate that although some of the heartier species are persisting, some of the more sensitive species are disappearing.

Table 10 records herbaceous species found, ranked by abundance (number of stems counted) in engineered and intact sites. In this table, values have been standardized by multiplying engineered numbers by 11/5 to even out differences in the number of sites sampled. By equalizing the numbers, one can see the abundance of the species from a level starting point. (The total number of stems for the engineered and intact forests is 3978 and 8817 respectively.) The totals indicate, even when the differing number of sites is compensated for, that the density of herbaceous stems at the engineered sites was less than half that of the intact forest sites.

General Conclusions for Herbs:

When mine disturbance is adjacent to a forest (engineered forest), we found the herb community, important for nutrient status and wildlife values, to be much less dense and species-rich. Part of the reason for the difference in spring herb abundance and diversity can be attributed to mining activity. Mining activity (i.e. filling and contour mining) often results in covering up the toe of the slope, eliminating the most diverse and rich community habitats. In our study, the engineered sites we visited *may have been* the higher slope regions depicted in Figure 18. Therefore, the habitat may have been drier and less diverse than the intact forest sites due to the fact that it was the naturally drier, higher slope community. Also, because the engineered sites suffer more intense and frequent disturbance, the quantity of light penetrating the canopy may be increased. This increase in light energy reaching the ground can dry out the soil and make conditions less favorable for the spring herb population. These herbs rarely invade mining lands on the areas studied, so data sets used for woody plants did not include forest herbs because they were seldom, if ever, observed. (Dispersal limits and the need for shady, moist microhabitat are obvious limits to regeneration.) A return to full forest biodiversity of plants is apparently even more challenged on mining areas when herb species are added to a concern.

CLOSING STATEMENT:

OSM reviewers pointed out that the unstated goal in mine reclamation in the Appalachians is to render the land green and stable. Traditionally, attempts are not made to reclaim the ecology or even the land use capability required by law. This report addresses what was accomplished, not what could be. What we see is only what is politically feasible, not technologically possible.

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Table 1: West Virginia woody plant study sites (2000).
Gives transect number, name, county, site type, age (if mined), number of species found, planted or not, date visited, and brief description of site.

Diagram 1: Diagram of valley fill sampling technique.

Table 2: West Virginia spring herbaceous study sites (2000).
Gives site number, name, county, site type (engineered or not), number of species found, number of stems counted, date visited, and brief description of site.

Table 3: List of West Virginia woody species found on study transects.
The species listed were found on the 25 forest transects and 30 mined transects that were studied. Scientific and common names given.

Table 4: Woody species found on study sites ranked from most to least present.
The transects studied can be lumped into two categories- forest sites and mined sites. This table shows the differences in species composition across these two types. The species did not have to be abundant at a particular site to be counted, merely present. These numbers do not include data that were collected from contour mine sites or their associated remnant forests. Most of the species that were found on the most forest transects were found on only a few mine transects, with the exception of *Acer rubrum*, *Liriodendron tulipifera*, and *Rubus* sp., which are often found in disturbed areas.

Figure 1: Woody species richness on all study sites. Sites are ranked not in pairs, but in decreasing species richness.
Overall, there were more species present on the forested transects than on the mined transects. The woody species are just not growing in as much variety on the mined sites as in the forests. (There were a total of 25 mined transects and 23 forest transects).

Figure 2a: Frequency of occurrence (by number of transects) of woody species on 23 forest and 25 mined sites.
Forest species occurred on more transects when they were present than mine species. A few species were found on many mine transects, but most of the species were only found on a few mine sites.

Figure 2b: Frequency of occurrence (by percent of transects) of woody species on 23 forest and 25 mined sites.
This shows the same information as the previous graph, but in proportion to the total number of transects.

Figure 3a: The presence of six major forest tree species on forest and mined areas (of total 1332 forest data points and 2808 mine data points, all size classes included).
Counting individual data points, the listed species were the most abundant on the forested transects. This graph compares the abundance of these six major species on forest transects to their abundance on mine transects.

Figure 3b: Percent occurrence of six dominant forest tree species (of total 1332 forest data points and 2808 mine data points).

This illustrates the same comparison as the previous graph, but adjusts the values so they are in proportion to the total data points collected. The major species of the forests were not present in such numbers on the mines.

Table 5: Woody species found at study sites by category.

The data can also be broken down into more specific categories, to see more clearly where the species are growing. Again, these numbers are based on presence, not abundance. Remnant forests have the most different species, and mountain top removal sites seemed to have the fewest, when grouped as such. Also, this chart illustrates that some species (for example *Acer rubrum* and *Liriodendron tulipifera*) are more generalist, and are found on all the site types. Others were found only on mined areas (*Lespedeza bicolor*) or only in forests (*Acer pensylvanicum, Lindera benzoin*)

Table 6: Woody species found, ranked by abundance in forested and mined sites. (There were 33 forest transect points and 1601 mined points where no individual was found in range.)

The distribution of species can also be considered in terms of how often the species was found as the data point in the survey. Some species that are found in great number in the forests, are not found in the same abundance on the mined sites. At the same time, common woody species on the mine sites are not found as abundantly in the forests.

Figure 4a: Species abundance distribution (total data points: 1332 forest, 2808 mined).

The raw numbers of the graph 4b(see below for description).

Figure 4b. Percent species abundance based on 1332 forest points and 2808 mined points.

The forest has more species that comprise of its community- the mines have a few species that are abundant, and many that are found only a few times. (The difference in the mine plot in this second graph is due to the large number of study points on the mine on which there were no individuals to be counted.)

Figure 5a: Stem density vs. distance from forest edge. Small woody plant [1" (2.54cm) and smaller in diameter at base] densities of mined lands compared to paired forest remnants.

Figure 5b: Stem density vs. distance from forest edge. Medium woody plant [1-3" (2.54-7.62cm) diameter at base] densities of mined lands compared to paired forest remnants.

Figure 5c: Stem density vs. distance from forest edge. Large woody plant [3" (7.62cm) and larger diameter at base] densities of mined lands compared to paired forest remnants.

Figure 6a. Small size-class mean stem density vs. distance from forest edge for three Mountain-top Removal sites (ages 6, 15, 15) compared to their three remnant forests. Small woody plants are defined as 1" (2.54cm) and smaller in diameter at base.

Figure 6b. Medium size-class mean stem density vs. distance from forest edge for three Mountain-top Removal sites (ages 6, 15, 15) compared to their three remnant forests. Medium woody plants are defined as 1-3" (2.54-7.62cm) diameter at base.

Figure 6c. Large size-class mean stem density vs. distance from forest edge for three Mountain-top Removal sites (ages 6, 15, 15) compared to their three remnant forests. Large woody plants are defined as 3" (7.62cm) and larger diameter at base.

Figure 7a. Small size-class mean stem density vs. distance from forest edge for three Valley Fill sites (ages 14, 17, 19) compared to their three remnant forests. Small woody plants are defined as 1" (2.54cm) and smaller in diameter at base.

Figure 7b. Medium size-class mean stem density vs. distance from forest edge for three Valley Fill sites (ages 14, 17, 19) compared to their three remnant forests. Medium woody plants are defined as 1-3" (2.54-7.62cm) diameter at base.

Figure 7c. Large size-class mean stem density vs. distance from forest edge for three Valley Fill sites (ages 14, 17, 19) compared to their three remnant forests. Large woody plants are defined as 3" (7.62cm) and larger diameter at base.

Figure 8a. Small size-class mean stem density vs. distance from forest edge for three Backfills (ages 12, 14, 14) compared to their three remnant forests. Small woody plants are defined as 1" (2.54cm) and smaller in diameter at base.

Figure 8b. Medium size-class mean stem density vs. distance from forest edge for three Backfills (ages 12, 14, 14) compared to their three remnant forests. Medium woody plants are defined as 1-3" (2.54-7.62cm) diameter at base.

Figure 8c. Large size-class mean stem density vs. distance from forest edge for three Backfills (ages 12, 14, 14) compared to their three remnant forests. Large woody plants are defined as 3" (7.62cm) and larger diameter at base.

Figure 9a. Small size-class mean stem density vs. distance from forest edge for three Contour Mines (all age 10) compared to their three remnant forests. Small woody plants are defined as 1" (2.54cm) and smaller in diameter at base.

Figure 9b. Medium size-class mean stem density vs. distance from forest edge for three Contour Mines (all age 10) compared to their three remnant forests. Medium woody plants are defined as 1-3" (2.54-7.62cm) diameter at base.

Figure 9c. Large size-class mean stem density vs. distance from forest edge for three Contour Mines (all age 10) compared to their three remnant forests. Large woody plants are defined as 3” (7.62cm) and larger diameter at base.

Figure 10: Mean stem density, by size-class, by mine type.
We tested if mine type differed in density with an analysis of variance for each size class, and compared mean density within size-class with Bonferroni adjusted multiple comparisons. (Proc GLM in SAS/STAT version 6.12; SAS 1990). Contour mines were significantly different than all other mine types in small and medium classes.

Figure 11a: Peerless Eagle transect site. A photo of the site illustrating the three areas of the continuous, downhill transect. Taken by Amy E.K. Long, 2000.

Figure 11b: Peerless Eagle Transect: Stem density vs. distance.
This transect represents a unique case where one can compare three types of land engineering, all at the same age, and see what woody plants might naturally recruit into the site. This site was at Peerless Eagle Mine. The site age is estimated between 12 and 15 years. It is a downhill site, where the top third is mountain-top removal, middle third is a clear-cut forest remnant (apparently cut in preparation for the fill, but never filled to that height, which has since revegetated), and the bottom third is valley fill. The soil of the clear-cut was not disturbed, except for minor components during logging. Figure 11a illustrates the lack of plant recruitment into the two engineered area, whereas the natural area, of the same age, has revegetated to a high density of stems.

Figure 12: Shannon-Weiner diversity index (H). Comparison of mined lands to forest remnants. A paired t test was performed with df = 8, t (small) = 2.92, t (medium) = 3.49, t (large) = 4.13.

Figure 13a. Site age vs. mean small stem density of 30 mined sites compared to the average of 25 forest remnants. Forested sites are displayed along x-axis, age is not implied for forests by position along x axis.

Figure 13b. Site age vs. mean medium stem density of 30 mined sites compared to the average of 25 forest remnants. Forested sites are displayed along x-axis, age is not implied for forests by position along x axis.

Figure 13c. Site age vs. mean large stem density of 30 mined sites compared to the average of 25 forest remnants. Forested sites are displayed along x-axis, age is not implied for forests by position along x axis.

Figures 13a, b, and c compare mine age and mean total density per transect site. The forest transects’ means are randomly distributed across the x-axis, however, this does not indicate or represent in any way the age of those forested sites.

All three figures (a,b,c) indicate that age does not matter. Densities are not increasing over time, which is what we would expect to see in the medium and large size classes. The lines for the forest were added to give the viewer a visual cue of where the average forest density is for each size class.

Table 7a: List of West Virginia herbaceous species found on transects sampled for the EIS terrestrial analysis.
It is important to consider the presence and composition of the forest herb stratum when assessing the health of the forests. Species listed were found on sites sampled from late April to early May. Nine of the fourteen sites were considered intact forests. The remaining sites were lands that were directly adjacent to a mine, railroad, or a busy vehicular road.

Table 7b: List of West Virginia spring herbaceous species observed on three Valley fills.
During the spring herb census, three mined sites were examined. This is a list of observed herbs noted by the investigating team.

Table 8: Herbaceous species found on study sites ranked from most to least present.
Herbs are excellent indicators of forest and soil health. The engineered sites are contrasted with the intact forest sites in order to determine the effects of mining activity on adjacent forests. There might not be direct physical destruction of these adjacent forest remnants, but the disturbance of high activity levels surrounding a forest remnant may disrupt the forest, starting with the herbaceous stratum.

Table 9a: Herbaceous species found at study sites, ranked from most to least abundant (number of stems counted) in engineered and intact forests.
Several of the species which are found most abundantly on the intact forest sites were not present, or present in low numbers, on the disturbed (engineered) sites. This would indicate that the disturbance is indeed affecting the forest ecosystem, and changing the community composition. Four of the top ten intact forest herbs are also in the top ten of the engineered sites. Three of the top ten, however, were not present at all on the engineered sites. This might indicate that although some of the heartier species are persisting, some more sensitive species are disappearing.

Table 9b: Herbaceous species found at study sites, ranked by percent abundance (number of stems counted) in engineered and intact forests.
This illustrates the same as the above table, but in proportion to the total number of stems counted.

Table 10: Herbaceous species found at study sites, ranked by abundance (number of stems counted) in engineered and intact sites. (Values have been standardized by multiplying engineered numbers by 11/5 to even out difference in number of sites sampled.)
By equalizing the numbers, we can see the abundance of the species from a more level starting point. (The total number of stems for the engineered and intact forests respectively are 3254 and 6669.) The totals indicate that, even when compensated for the

different number of sites studied, the density of herbaceous stems at the engineered sites was approximately half that of the intact forest sites.

Figure 14a: Mean number of spring herb species vs. distance from toe of slope, in engineered forested site and intact forested site understories. Two-way ANOVA results: treatment effect $p = 0.0001$(*), distance effect $p = 0.0001$(*), treatment and distance effect $p = 0.26$. The treatment (engineered or control/intact) gave significantly different results, as did distance.

Figure 14b: Number of spring herb stems counted vs. distance from toe of slope, in engineered forested site and intact forested site understories. ANOVA results: treatment effect $p = 0.0016$(*), distance effect $p = 0.125$, treatment and distance effect $p = 0.9$. The treatment (engineered or control/intact) gave significantly different results.

Figure 14c: Estimate of biodiversity (H) for spring understory herbs, in engineered forested sites and intact forested sites. Two-way ANOVA results: treatment effect $p = 0.003$(*), distance effect $p = 0.099$, treatment and distance effect $p = 0.368$. The treatment (engineered or control/intact) gave significantly different results.

Table 11: Soil depth and moisture recordings from ten mines and their paired remnant forest.
Holes were dug until large rock was hit, impeding further digging, or 60cm was reached. The forest soil was consistently deeper, moister, and darker in color. The mine soil consisted mostly of small rocks and solid, impenetrable rock was hit at shorter depths.

Figure 15: Microbial activity (indicated by Formazan production) in soil samples at different land types. A comparison of land treatments at individual sites. Average bars are drawn in for each land type.
Backfills did as well as the remnant forests we looked at. And MTR's were not that far behind. VF's had less than half the production as all other site types.

Table 12: Rutgers' Soil Testing Laboratory results. Macronutrients (P, K, Mg, Ca) are in pounds per acre, and micronutrients (Cu, Mn, Zn, B) are in ppm. Nutrient levels vary greatly and are more favorable for forest plant species in the native soil samples. No trends are found with age suggesting improvement in soil pH.

Table 10. Herbaceous species found at study sites, ranked by abundance (number of stems) in engineered and intact sites. (Values have been standardized by multiplying engineered numbers by 11/5 to even out difference in number of sites sampled.)
* indicates alien/non-native species

Ranked by abundance on intact sites.

Species	intact	engineered
Sedum ternatum	1043	396
Tiarella cordifolia	872	180
Dicentra cucullaria	702	0
Aster sp.	377	202
Urtica dioica	305	2
Fragaria virginiana	292	37
Osmorhiza claytonii	292	20
Erythronium americanum	279	15
Dentaria maxima	270	0
Viola sp.	256	154
Meehania cordata	245	0
*Stellaria pubera**	241	207
Botrychium sp.	236	15
Asarum canadense	215	156
Polygonum sp.	192	249
Podophyllum peltatum	182	132
Arisaema triphyllum	179	90
Polystichum acrostichoides	172	55
Anemonella thalictroides	171	77
*Glechoma hederaea**	149	42
Claytonia caroliniana	143	2
Geranium maculatum	139	112
Trillium grandiflorum	136	40
Lactuca sp.	107	141
Smilacina racemosa	99	2
Delphinium tricorne	94	156
Impatiens capensis	92	22
Viola blanda	89	0
Galium aparine	85	77
Dentaria multifida	77	2
Hydrophyllum macrophyllum	76	22
Medeola virginiana	75	29
Caulophyllum thalictroides	73	0
Hepatica acutiloba	65	0
Polygonatum biflorum	57	13
Viola rostrata	52	132
Lycopus virginicus	50	0
low 3-leaves	50	0
Galium sp.	47	64
Mitchella repens	38	13
3-3 leaf	38	0
Panax trifolium	36	0
Sanguinaria canadensis	35	13
Galium triflorum	27	11
Actaea pachypoda	26	2
Phlox stolonifera	26	0
Dioscoria quaternata	24	20
Galium circaezans	23	121
Viola papilionacea	23	62
Disporum languinosum	23	31
Allium tricoccum	21	0
Polemonium reptans	18	200
Carex plantaginea	17	0
Carex, narrow	17	0
Potentilla canadensis	16	79
Viola canadensis	16	26
Pedicularis canadensis	12	57
Unk composite	12	2
Chimaphila maculata	12	0
Viola macloskeyi (V. pallens)	11	0

Ranked by abundance on engineered sites.

intact	engineered	Species
1043	396	*Sedum ternatum*
872	249	*Polygonum sp.*
702	207	*Stellaria pubera**
377	202	*Aster sp.*
305	200	*Polemonium reptans*
292	180	*Tiarella cordifolia*
292	161	*Senecio aureus*
279	156	*Asarum canadense*
270	156	*Delphinium tricorne*
256	154	*Viola sp.*
245	141	*Lactuca sp.*
241	132	*Podophyllum peltatum*
236	132	*Viola rostrata*
215	121	*Galium circaezans*
192	112	*Geranium maculatum*
182	90	*Arisaema triphyllum*
179	84	*Phlox sp.*
172	79	*Potentilla canadensis*
171	77	*Anemonella thalictroides*
149	77	*Galium aparine*
143	64	*Galium sp.*
139	62	*Viola papilionacea*
136	57	*Pedicularis canadensis*
107	55	*Polystichum acrostichoides*
99	42	*Glechoma hederaea**
94	40	*Trillium grandiflorum*
92	37	*Fragaria virginiana*
89	33	*Carex sp.*
85	31	*Disporum languinosum*
77	29	*Medeola virginiana*
76	29	*Smilax sp.*
75	29	*Viola pedata*
73	26	*Viola canadensis*
65	24	*Viola rotundifolia*
57	24	*Agrimonia striata*
52	22	*Impatiens capensis*
50	22	*Hydrophyllum macrophyllum*
50	22	*Goodyera repens*
47	22	Unk ground cover, purple
38	20	*Osmorhiza claytonii*
38	20	*Dioscoria quaternata*
36	15	*Erythronium americanum*
35	15	*Botrychium sp.*
27	13	*Polygonatum biflorum*
26	13	*Mitchella repens*
26	13	*Sanguinaria canadensis*
24	13	heart leaf herb
23	11	*Galium triflorum*
23	11	*Antennaria plantaginifolia*
23	11	*Carex blanda*
21	11	*Senecio obovatus*
18	7	6 thin-leaved galium
17	4	*Viola striata*
17	2	*Urtica dioica*
16	2	*Claytonia caroliniana*
16	2	*Smilacina racemosa*
12	2	*Dentaria multifida*
12	2	*Actaea pachypoda*
12	2	Unk composite
11	2	*Zizia aurea*

Table 10 (con't)

Ranked by abundance on intact sites.

Species	intact	engineered
Viola pennsylvanica	11	0
Viola rotundifolia	8	24
Sedge 2 (pale, broad)	6	0
Carex sp.	5	33
Adiantum pedatum	5	0
Unk -geranium like	4	0
Phlox sp.	3	84
Smilax sp.	3	29
Potentilla sp.	3	0
Unk- 3 mitten leaf	3	0
Unk fern	3	0
Unk - purple flower "rue"	3	0
Goodyera repens	2	22
Zizia aurea	2	2
Epifagus virginiana	2	0
Waldsteinia fragarioides	2	0
Solidago sp.	1	2
*Asparagus officinalis**	1	0
Unk -- very hirsute	1	0
Unk -- round leaf	1	0
Unk ground cover	1	0
Senecio aureus	0	161
Viola pedata	0	29
Agrimonia striata	0	24
Unk ground cover, purple	0	22
heart leaf herb	0	13
Antennaria plantaginifolia	0	11
Carex blanda	0	11
Senecio obovatus	0	11
Unk 6 thin-leaved galium	0	7
Viola striata	0	4
Ranunculus sp.	0	2
Stellaria media	0	2
Unk - tomentose	0	2

Ranked by abundance on engineered sites.

intact	engineered	Species
11	2	*Solidago sp.*
8	2	*Ranunculus sp.*
6	2	*Stellaria media*
5	2	Unk - tomentose
5	0	*Dicentra cucullaria*
4	0	*Dentaria maxima*
3	0	*Meehania cordata*
3	0	*Viola blanda*
3	0	*Caulophyllum thalictroides*
3	0	*Hepatica acutiloba*
3	0	*Lycopus virginicus*
3	0	low 3-leave
2	0	3-3 leaf
2	0	*Panax trifolium*
2	0	*Phlox stolonifera*
2	0	*Allium tricoccum*
1	0	*Carex plantaginea*
1	0	*Carex* , narrow
1	0	*Chimaphila maculata*
1	0	*Viola macloskeyi (V. pallens)*
1	0	*Viola pennsylvanica*
0	0	Sedge 2 (pale, broad)
0	0	*Adiantum pedatum*
0	0	Unk -geranium like
0	0	*Potentilla sp.*
0	0	Unk- 3 mitten leaf
0	0	Unk fern
0	0	Unk- purple flower "rue"
0	0	*Epifagus virginiana*
0	0	*Waldsteinia fragarioides*
0	0	*Asparagus officinalis**
0	0	Unk -- very hirsute
0	0	Unk -- round leaf
0	0	Unk ground cover

Diagram 1. Diagram of valley fill sampling technique. Arrows indicate relative location and direction of transect lines on the valley fill and into the adjacent forest remnant.

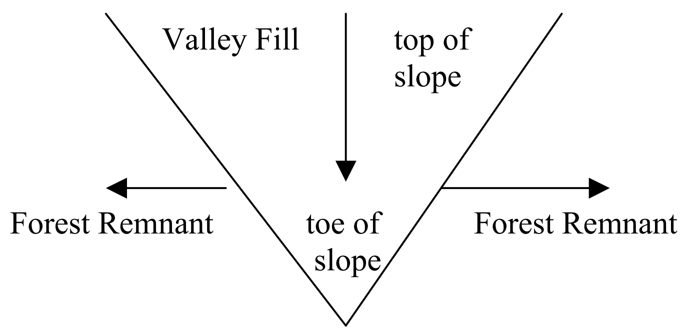

Figure 14a. Peerless Eagle site. MTR on top, then clear-cut, then VF. Taken summer 2000.

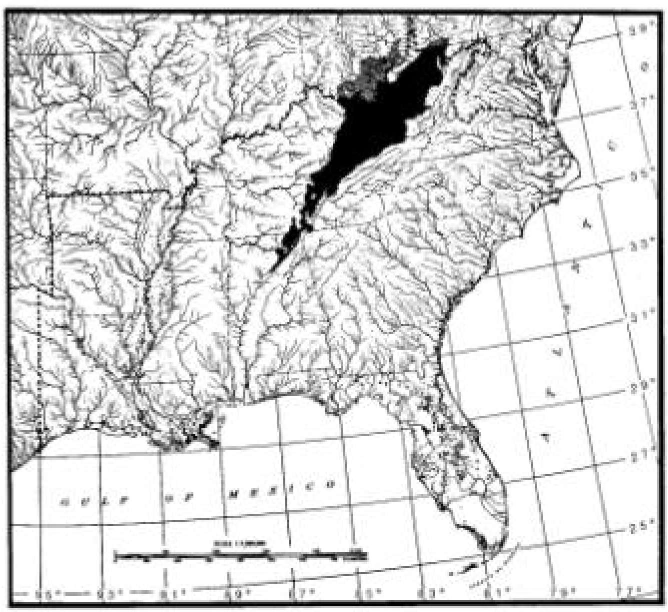

Figure 1. The blackened area illustrates the Mixed Mesophytic Forest Region of the southeastern United States. Taken from Hinkle et. al in Biodiversity of the southeastern United States, upland terrestrial communities.

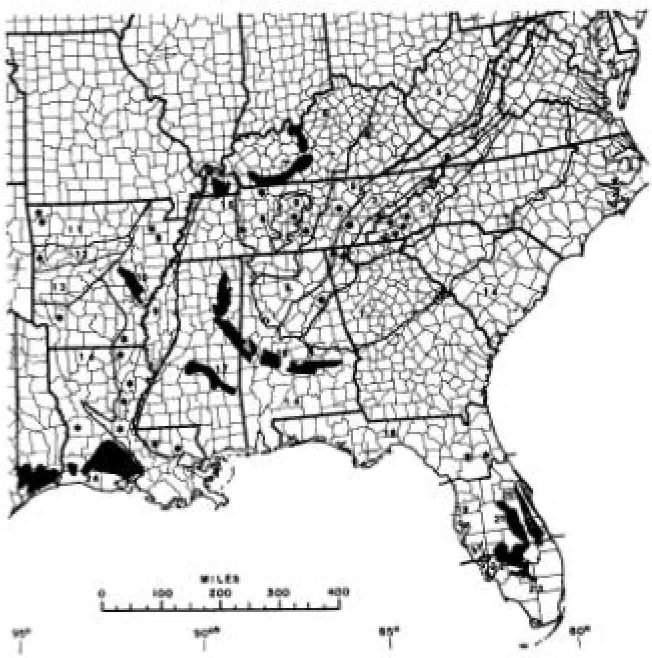

Figure 2. The naturally occurring grasslands of the southeastern United States. Taken from Hinkle et. al in Biodiversity of the southeastern United States, upland terrestrial communities.

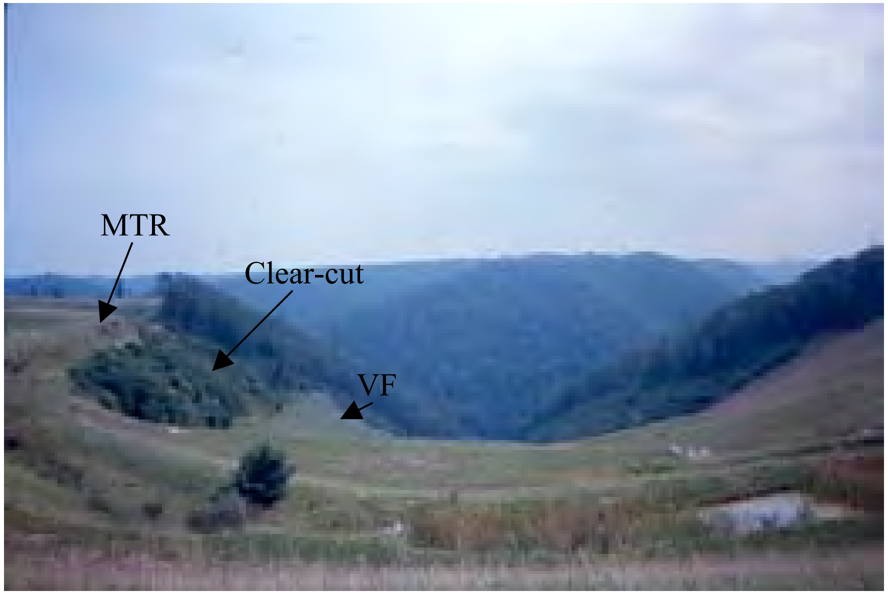

Figure 11a. Peerless Eagle site. MTR on top, then clear-cut, then VF. Taken summer 2000.

Figure 3a. Diagram of valley fill geometry. Arrows indicate relative location and direction of transect lines on the valley fill and into the adjacent forest remnant. Darker line indicates how the 12 *continuous* transects were run from mined land to remnant forest.

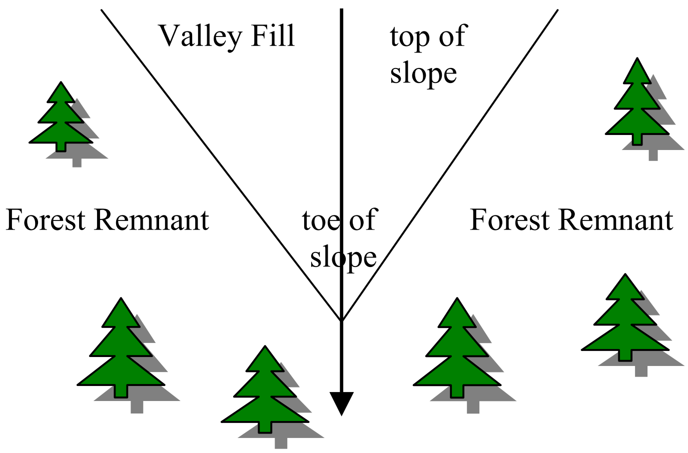

Figure 3b. Diagram of valley fill geometry when continuous line could not be run. Arrows indicate relative location and direction of transect lines on the valley fill and into the adjacent forest remnant. Darker lines indicates how the mined transect and forest transect were run. Only one forest transect was run, either on the left or the right, not both.

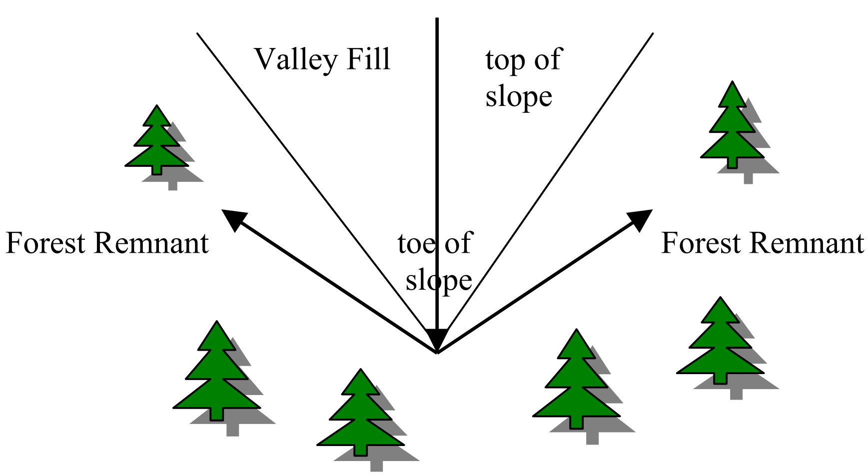

Figure 18. Diagram of mining activity eliminating toe of slope, compared to an intact forest's position of toe. This situation is hypothetical. All values are arbitrary. Dashed line indicates valley fill. Brackets indicate area sampled.

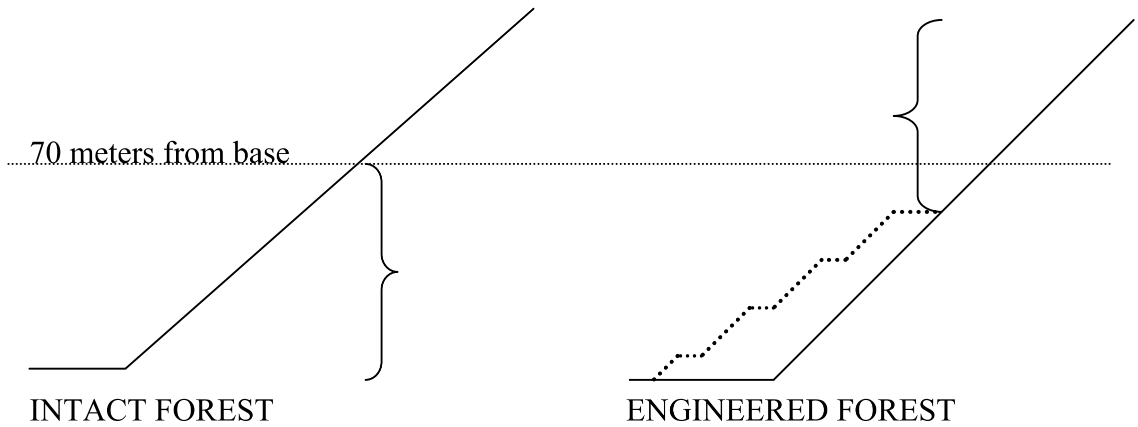

Table 7b. List of West Virginia spring herbaceous species observed on three valley fills. * indicates alien/non-native species.

*Alliaria petiolata**	Garlic mustard
Asarum canadense	Wild ginger
Aster sp.	Aster species
Brassicaceae	Mustard species
*Coronilla varia**	Crown vetch
Galium aparine	Cleavers
Galium tinctorum	Clayton's bedstraw
Grass sp.	Grass species
*Lamium purpureum**	Purple dead nettle
*Lespedeza bicolor**	Bush clover
Phlox sp.	Phlox species
Polygonum sp.	Polygonum species
Polystichum acrostichoides	Christmas fern
Potentilla canadensis	Dwarf cinquefoil
Ranunculus sp.	Buttercup species
Silene virginica	Fire pink
Stellaria pubera	Star chickweed
*Trifolium sp.**	Clover species
*Tussilago farfara**	Coltsfoot
Unk.	Dandelion-like milky weed
Vicia caroliniana	Wood vetch
Viola sp.	Violet species
Waldsteinia fragarioides	Barren strawberry
Zizia aurea	Golden Alexanders

Table 7b. List of West Virginia spring herbaceous species observed on three valley fills.

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Stellaria pubera	Star chickweed
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MOUNTAINTOP REMOVAL MINING/VALLEY FILL
ENVIRONMENTAL IMPACT STATEMENT TECHNICAL STUDY

DRAFT PROJECT REPORT FOR TERRESTRIAL STUDIES

DECEMBER 2000

Terrestrial Plant (spring herbs, woody plants) Populations of Forested and Reclaimed Sites

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Objectives:

The objective of this study was to determine the patterns of terrestrial vegetation on areas affected by mountaintop removal mining and valley fills in the southern Appalachian region, and watersheds closely adjacent to areas that have used this mining technique. Specifically, we wish to know the plant species present, the relative numbers and size of species present, and the pattern of vegetation along transects from toe of slope towards the top of slope or from forest to mined areas. These data will enable us to understand the potential for re-establishment of native vegetation, and the actual change of vegetation since closure of the sites. Together, this will assist in developing potential improvements in the habitat condition of post-mining land.

Importance of the objectives:

It is urgent to know the fate of the mined lands after closure, to determine the potential for re-establishment of surrounding native vegetation, and to see if a different flora becomes established. The soils, seed pool, and local conditions on mined sites may be quite different from the original conditions, and we must understand if mined areas will develop differently from the forested terrestrial communities surrounding the mined sites. These data are also needed to assess the quality of the habitat for animals of the region. If current closure methods are creating different habitat types, this must be known precisely, to be the foundation for regulatory action.

Methods:

Tree and shrub studies - site selection:

In order to assess the progress of invasion of woody species onto disturbed mine lands, sites were selected which had a remnant forest adjacent to the mined area. These areas were considered most relevant because they included a seed source for the mined area, and therefore offered an opportunity for woody species to invade the more open disturbed land. Study of mined lands adjacent to mature forests, of course, maximizes the potential for invasion of species, and potentially weighs the data sets towards higher invasion rates. However, it is necessary to see invasion, and the over-sampling of edge areas gives the investigator a higher potential for determining invasion rates.

Sites across the mining region of southern West Virginia were selected, to represent a wide variety of ages, conditions, and treatments. We visited sites recommended by EPA, WVDEP, FWS, and mining officials and engineers from the mines studied. Knowing that we wished to record re-establishment of woody vegetation on mined lands, mining officials derected us towards the richest sites they knew were available, and our policy was to visit every site recommended. At each specific locale, we picked transect locations typical in density and degree of vegetative cover for this summary. The total number of forested site transects surveyed and reported is 25 and the total number of mined land transects is 30. Ten different mine properties were surveyed, with ages ranging from six to twenty-four years since beginning of reclamation. Emphasis was on surveys of sites that were older, but closed after the 1977 surface mining law (SMCRA) was put in effect. Changes in protocols necessitated bythat law caused important differences in reclamation practise (Vories and Throgmorton, 1999). A complete list of study sites is in the Appendix (Table 1).

Tree and shrub studies – data collection:

First, twelve transects were run, each on a continuous line from types of mined land (i.e. valley fill, mountain-top removal area, backfill, or contour mine) into an adjacent mature remnant forest, apparently unaffected by mining activity. (Many of these forested sites once were logged, and showed vestiges of former rough logging roads. Consequently, these forests, themselves, have been modfied by human activity, and may be expectd to be lower in biodiversity than historic stands [Martin, etal. 1993, chaps. 5, 8]. However, all forested areas contained large, diverse canopy trees with well-developed stands, and unexcavated soil.) The transect line was continuous from mined area to the adjacent remnant forest.

There were an additional 43 transects studied where it was not possible to run continuous transects, as above. In these cases, the forest remnant transect was run perpendicular or adjacent to the mined area transect, as shown in Diagram 1. On valley fill areas, transects were arrayed from top of slope to toe of slope, for the length of the fill. Because of the typically triangular geometry of these fills, fill areas at the toe of slope were usually much closer to surrounding forests. Also, some valley fills have plantings on flat terraces, usually black locust.

Data were collected during the year 2000 growing season only. The presence of woody plants, even small ones, on these sites can represent the reproductive performance of many years. The location of the boundary or edge between forested and mining activity land was recorded for each transect, and is the "0" point on data sets. The point-quarter sampling method was used to survey the woody plant community (Barbour, Burk, et al. 1999). This technique was used as it allowed the investigating team to cover the most ground, the most sites, and collect the most data points in the time frame given. There is a potential to underestimate rare species with this technique, as a census of all plants in an area is not done. However, a species effort curve performed in this lab on the data indicates that minimal, if any, rare species were missed given our large data set that covers thousands of individual plant records. Consequently, the field sampling technique is representative of the woody species on site.

At each sampling point, located at 20 meter intervals along the transect line, the area was divided into four quadrats. In each quadrat the distance from the sample point on the transect line to the nearest woody species was measured and recorded for three different size classes, for a potential of twelve individuals per transect point. The size classes were defined as 0-1 inch ("small"), 1-3 inch ("medium"), and more than 3-inch ("large") diameter, as measured at the base of each stem. For each of these stems the nearest neighbor's distance and species identification were recorded, as well as the distance to the nearest conspecific (individual of the same species). Trees that were obviously part of an implemented planting program were not included in the counts, as these did not naturally arrive on these sites, and are not part of an invasion process. Any offspring produced by planted individuals were included in the data, however. Data were entered on computer databases for further study. Leaves and stems of questionable plants were collected and keyed out using herbarium specimens. Occasionally, specimens could not be keyed to species, because they were barren of flowers or fruits; it was impossible, given the rapid time frame of the study, to return to each site at other times of the year 2000 season to search for reproductive specimens.

Tree and shrub studies –data analysis:

The main objective of this study was to determine the success of woody species in invading the disturbed mining areas. The data were examined in several ways. Transects were categorized as one of six types: continuous forest; forest remnant; valley fill; mountain-top removal area; backfill; or contour mine. Data were displayed within each of these categories, by the three size groupings of plants: small; medium; and large. The density of woody plants of the different size classes was also determined. These densities can be compared in order to evaluate the progress of the woody invasion. Species lists of continuous and mined areas were developed, and comparisons between native forests and mined lands performed. Plant diversity was also estimated using the Shannon-Weiner statistic, which includes measures of number of species and their relative abundances. For example, stands with the same number of plants and the same number of species can be distinguished if one stand has these species is more or less equal proportions; a more diverse stand with this statistic would have these species in more equal numbers.

Herb studies – site selection:

Nineteen forested sites, considered to be either intact forest (11) or engineered forest (8), were chosen to evaluate the herb community, adjacent to the locations where the EPA aquatic biology team was collecting data for this EIS. Sections of watersheds that had been mined (the engineered forest) as well as areas that were distant from mining activity (the intact forest) were selected. Sites are listed in the Appendix (Table 2). This protocol allows comparison and correlation of herb data with the aquatic study, for a more complete understanding of these sites. No sites on the continuous transects used for the tree survey were used for these forest herb data, because these are plants of shady habitats, that were by-and-large missing from these mined sites.

Herb studies – data collection:

The study team visited all sites during April - May, 2000, to map the study sites and sample the herbaceous vegetation. Early season sampling of the herb flora was necessary, as many spring herbs often complete their life history before the summer months, then persist underground until the following year (Schemske, et al., 1978; Bierzychudek, 1982). Transects were sampled every 10 meters, starting at the base of the slope, up hill for an additional 50 meters. It was determined by the investigating team that the herb cover significantly diminished around 40 or 50 meters from base of slope, and data from a broader geographical range could be collected if this was a decided end point. At each sample location, a 5x1m plot across the face of the slope was censused for all herbs. Species identity and stem count for each species were recorded for each 5x1 plot. Samples of species were collected for herbarium records and identification verification.

Herb studies – data analysis:

Data were summarized to determine relative distribution and number of species along the slope, on undisturbed forest slopes compared to forest slopes adjacent to disturbed areas (i.e. mines and wide road cuts). These data were entered in a database for statistical analyses to determine vegetation distribution patterns. Shannon-Weiner Index of Diversity was performed as well as calculations to determine the mean number of stems counted and the mean number of species present in both forest types.

Soil studies:

Nineteen soil samples were collected, nine remnant forest samples and ten mined soil samples. Two points along the point-quarter transect line were randomly selected, one in the mined area and one in the paired remnant forest. The contour mine transects (7 of 30 mine sites, as well as 4 remnant forests that were paired with the contour mines) were omitted because soil treatment was quite different and these data are atypical of the remaining sites of prime interest. At each of these points the area was divided into a grid ten by ten meters, numbered 0 through 9 with each number one meter apart from the next along both axes. Random numbers were used to determine grid location at which a sample of approximately 8 inches^3 at the soil surface was taken. Five samples were collected at each site, placed into plastic bags, and brought back to the Rutgers' lab for dehydrogenase activity analysis and for further mechanical analysis by the Rutgers' Soil Testing Laboratory.

DHA analysis is an assessment of the microbial activity in the soil. When triphenyl tetrazolium chloride (TTC) is added to soil, it reacts with dehydrogenases (enzymes) that have been produced by soil microbes. This reaction creates formazan, which is red in color. The concentration of formazan can then be measured using a spectrophotometer. The amount of formazan produced indicates the amount of dehydrogenase enzymes present in the soil. Two ml of 1% TTC and 0.35ml $CaCO_3$ buffer were added to 2.00g soil samples. The samples were mixed, capped, and incubated at 37° for 24 hours. Three replicates of each soil sample were run. After incubation, the contents of each test tube were extracted with 50ml methanol and centrifuged. The supernatant was collected and absorbance was measured in a spectrophotometer (set to 485nm). Results were compared to TPF (triphenyl formazan) standards. By weighing out a sample, drying it at 65˚C for 24 hours, and reweighing it, the moisture content of the samples was also determined. Dehydrogenase activity was calculated using the following equation (Harris and Steer, 1997):

$$\text{Formazan formation } (\mu g/g/24h) = \frac{29.54 \text{ x absorbance x volume}}{\text{Dry weight of sample}}$$

Soil samples brought back to Rutgers' Soil Testing Laboratory were tested for pH, salt content, macro- and micronutrient content, gravel content, inorganic nitrogen, soil organic matter, and mechanical analysis. The elements chosen for analysis are those considered critical for plant health, and are also amendable aspects of soil specifications in the reclamation of mined lands.

To assess soil depth, a hole was dug at the center point of the designated grid. Using a standard shovel, soil was removed until digging was no longer exposing soil (i.e. hitting rock too large or solid to dig through) or a depth of 60 centimeters was reached. All depths were recorded and reported.

Results:

Tree and shrub studies:

Presence of trees and shrubs on the study sites:

The 99 species listed in Table 3 were found on the 25 forest transects and 30 mined transects. Table 4 shows the differences in species composition across these two types, ranked from most to least commonly present. The species did not have to be abundant at a particular site to be included, merely present on the site (i.e. whether the species has one or one thousand individuals, it is recorded as "present"). These numbers do not include data that were collected from contour mine sites or their associated remnant forests, which have been treated and reported separately, so the sample size here is 23 forest transects and 25 mined transects. Most of the species found in the majority of forest transects were found on only a few mine transects, with the exception of *Acer rubrum*, *Liriodendron tulipifera*, and *Rubus* spp., which are regularly found as small plants in disturbed areas. There are twenty species occurring on the mined lands that are not found in the forested lands and thirty forest species not found on the mined lands. Of the twenty unique mine species, many of these are typical early successional species *(Acer rubrum, Liriodendron tulipifera, Rubus sp.)* and many others (pines and black locust) are offspring of the trees planted as part of reclamation efforts. Overall, there are ten more species found in the forest than on the reclaimed mined lands.

These data from Table 4 can also be summarized across sites by richness, defined as the number of species found, regardless of abundance. Figure 1 shows that the forested category always contains more species than the sites in the mined category, when listed from most to least rich site. (I.e., the woody species are not growing in as much variety on the mined sites as in the forests.) In other words, the forests have a higher species richness and more biodiversity than the mine sites (Figure1 and Figure 11).

Species-presence data can also be arrayed by individual species, in addition to the site values shown in Table 4 and Figure 1. Tables 2a and 2b illustrate the number and percent of transects studied where each species in the data set was found. Forested sites have a higher percent of transects represented for the large majority of species. These data show that woody species are more generally occurring across the sample universe, not just sequestered in a few unusually rich transects that happened to be included within individual site surveys.

There is special interest in the major tree species of the forest, as these are of possible commercial interest. Figures 3a and 3b display six of the most common hardwood tree species found, by absolute number and percent of all woody stems found (total of 4,140 stems in the data sets, including all size classes). These trees are always more abundant as a proportion of stems on the forested sites. Five of the six are more common by absolute number on the forested sites; only red maple has more individuals on the mined sites, as many seedlings of this species were present.

Woody species found at study sites can also be displayed by type of mining site (Table 5), to see more clearly if there are special determinants associated with species presence. Again, these numbers are based simply on being present at all, not abundance.

Remnant forests have the most species, and mountain top removal sites have the fewest, when grouped in this way. However, only four MTR sites were examined and twenty remnant forests were. If one examines the average number of species by site (see site table in appendix to see number of species per site), MTR's have 6.25 and remnant forests have 17.7 species on average. Table 5 also illustrates that some species (for example *Acer rubrum* and *Liriodendron tulipifera*) are more generalist (i.e. are found on all the site types). Others were found only on mined areas (*Lespedeza bicolor*) or only in forests (*Acer pensylvanicum, Lindera benzoin*).

The distribution of species can also be considered in terms of how abundant, or how frequently the species appeared on the site (Table 6). Most species found in great number in the forests are not found in similar abundance on the mined sites. At the same time, common woody species on the mined sites, typical of early successional stages, are not found as abundantly in the forests.

The forest community is comprised of a greater number of species. It is also a more diverse community than the mine land communities. More uncommon species occur in the forest and there is less dominance by a few common species. That is, the mine sites have a few dominant species making up more of their communities and fewer rare species present (Figures 4a and 4b). These data are the number of woody plants found during the point quarter sampling. The mine plot in Figure 4b is based on percentages, which allows a simpler comparison, as sampling effort was unequal between mine and forest lands. The mine species distribution starts quite low on the y-axis because there were many points, about 1600, where woody stems were not present at all (this very high point is not plotted on this graphic). An absence of any woody plants was rarely found on any of the forest sample points. Having more species that occur more evenly or frequently (i.e. not having a population dominated by only a few species) creates a more diverse environment. For many of the species found, the percent occurrence is high on forest land. Having all the species occur only once or twice, such as on the mine lands, and being dominated by only a few species, creates a less diverse community.

Distribution of trees and shrubs across the study transects:

To spatially study the process of invasion, data are displayed across the transects, where, on figures 5-9, "0" represents the "edge", the sharp boundary between forest and mining area. In these graphics, all alien species were removed from the data sets, as the interest in this study is the reappearance of the native West Virginia plant community. These data (in Figures 5-9) are from the twelve continuous transects described earlier (page 1). There are three MTR, three VF, three BF, and three CM, all with paired forest remnants. The following figures graph the mean stem densities per $25m^2$.

Figures 5a, 5b, and 5c illustrate the stem densities calculated for the small size class, medium size-class, and large size-class, for woody individuals on nine continuous mine and forest transects. A "continuous transect" is a location where only one line was run, going from mine land directly into the remnant forest. Figure 5a shows that the small individuals (1" and smaller diameter at base) are not regenerating on the mined lands as abundantly as they do in the forest. Figure 5b shows that survival of the medium size class individuals (1-3" diameter at base) is decreasing on the mined lands, compared to the small class' performance. (Figure 5c) Large individuals (3" diameter at base) are not present on the mining areas. There is little to no growth into this size class. This is not an unreasonable size class to reach given the age of these mines (range of 6 to 23 years old since reclamation).

The six most common forest tree species have the following age and size projections (under favorable soil conditions): *Acer rubrum* can reproduce as early as 4 years with size at first reproduction of 5-20cm (2-8") diameter at breast height (DBH). *Quercus rubra* is 25 years at first reproduction with size of 60-90cm (23.6-35.4") DBH. *Liriodendron tulipifera* is 15-20 years at first reproduction, DBH of 17-25cm (6.7-9.8"). *Acer saccharum* as early as 22 years, DBH equal to 20 (8")cm. *Fagus grandifolia* reaches substantial seed production at age 40 or with a DBH of 6cm (2.4"). *Magnolia acuminata* starts reproducing at age 30, optimum at age 50, with DBH unreported (Burns and Honkala, 1990, for these data). These age and size estimates are given at breast height, roughly 4' high, for the average adult. The size classes used in this report were determined at the base of the plants, as most of the individuals were not taller than two feet, so tend to overestimate plant performance when compared to the USDA correlations. The reclamation age of many of the mine sites is nearing, or has reached, the reproductive age for several of these trees, but this study's data indicates that the trees have not approached the correlated sizes.

The woody data from mined transects can also be divided into the four mining area categories of interest: Mountain-top Removal, Valley Fill, Backfills, and Contour Mine. Figures 6a, 6b, and 6c illustrate the stem densities calculated for woody individuals in all three size-classes, on three Mountain-top Removal (MTR) sites and the paired remnant forest transects. Figure 6a shows that the small individuals (1" and smaller diameter at base) are not regenerating on the mine lands as they do in the forest. Of the three MTR's surveyed, one was six years old since reclamation and the other two were both 15 years since reclamation. It is expected to see small size-class individuals well before 15 years is reached. The medium individuals (1-3" diameter at base, Figure 6b) are not present on these mined lands, and there are only a few large individuals (3" diameter at base) present on the surveyed, reclaimed mine land (Figure 6c).

Figures 7a, 7b, and 7c illustrate the stem densities calculated for woody individuals in all three size-classes on three Valley Fill (VF) sites, that accompany MTR sites, and the paired remnant forest transects. The remnant forests of two of these transects were located above the fill (Colony Bay: Cazy fill; Hobet Mine: Bragg Fork fill) and the other was located at the bottom of the fill (Leckie Smokeless: Briery Knob). Due to the triangular geometry of Valley Fills (Diagram 1), which (a) allows closer proximity to forest edge, and (b) provides a moisture gradient created by the drainage ravines at the toe of the slope, there was in increase in stem densities with decreasing elevation in the Valley Fill sites. This apparently has increased the presence in this mining area of the small size-class plants. However, the data for the medium and large size classes shows that this trend is decreasing over time. Valley fills remain stressful sites for these seedlings, and slow growth or lack of survival could underlie these low data points. As these sites are ages 14, 17, and 19 years, a higher representation in all three sizes would be expected during successional change.

Figures 8a, 8b, and 8c illustrate the mean stem densities calculated for woody individuals in all three size-classes on three Backfill (BF) sites and the paired remnant forest transects. One Backfill is 12 and the other two are 14 years old since reclamation. Figure 8a shows that the small size-class individuals are regenerating along the forest edge as would be expected, but taper off rapidly beyond 60 meters and are not found further from the edge. An edge effect can also be observed in the medium size-class (Figure 8b) in the first 20 meters that quickly fades until there are no medium individuals found beyond that point in great number. Few large size-class individuals were found on the mined site (Figure 8c).

Figures 9a, 9b, and 9c illustrate the stem densities calculated for woody individuals in all three size-classes, on three Contour Mine (CM) sites and their three paired remnant forest transects. All three of these sites are 10 years since reclamation. The contour mines we visited are much shorter than the other types of mine lands and typically are less compacted upon completion than flat areas, because of less grading activity (Vories and Throgmorton, 1999). Bonferroni T tests ("proc glm" statistical test of SAS version 6.0) were run on the mean densities of the four mine types, by size class. The Contour Mines' plant densities in the small and medium size classes were significantly greater than all three other mine types (Figure 10). Because all four mine types included in this study had so few large individuals, there was no significant difference among any of the mine treatments.

Regeneration of the small size-class individuals on the CM illustrates the edge effect of a forest (Figure 9a). The CM trend of regeneration falls abruptly after 10 meters, and suggests that few woody stems would be present beyond 50 meters (the local limit of this site type). Figure 9b shows a pattern similar to Figure 9a, the smaller individuals are surviving into the next size class. No large individuals occurred within our sampling efforts on these CMs (Figure 9c). However, these sites are only 10 years since reclamation and not many tree species are expected in this size class from seed this quickly (see maturation information in text above).

Finally, one transect studied represents a unique site where it is possible to compare three types of land engineering, all at the same age, to determine what woody plants have naturally recruited into the site. This site was at Peerless Eagle Mine, and its age is estimated between 10 and 15 years. The top third is mountain-top removal, the middle third is a clear-cut forest remnant (apparently cut in preparation for the fill, but never filled to that height, and has since revegetated), and the bottom third is valley fill Figure 11a). Consequently, the soil in the clear-cut area was only minimally disturbed; soil was removed or covered in the other areas. Figure 11b illustrates the lack of plant recruitment into the two engineered areas. During the same time, the central clear-cut area has fully revegetated, probably due to stump sprouts and germination from the undisturbed seed bank (Figure 11a).

Additional perspectives on trees and shrubs:

The Shannon-Weiner Index (H) is a measurement of community diversity, a function of both species number and relative abundance commonly used in vegetation analysis (Barbour, et al., 1999). For small, medium and large plant size classes, the diversity index is significantly higher (paired t test, df = 8, p_{small} = 0.0191, p_{medium} = .0082, p_{large} = .0033) on the forested parts of the transects (Figure 12), indicating greater species diversity than on the mine lands.

Finally, figures 13a, 13b, and 13c compare mine age and average total plant density on each transect site. Data from all remnant forest transects are shown as a mean of values, with standard deviation. These are displayed across the x-axis to allow a visual comparison with the values from the mine lands. However, this does not represent in any way the actual age of the forested sites; this acts as an approximate asymptote to which developing forests in this region might attain. These figures illustrate that mine area age does not positively correlate with increasing stem density (linear regression, r2 = 1, 95% conf. interval). If the densities were increasing over time, we would see an increase in the slope of the regression line for the mines. However, for all three size classes there is no linear relationship, indicating no increase in number of individuals over time. The data for the forest were added to give a visual cue of where the average forest density is for each size class.

General Conclusions for Trees and Shrubs:

There is a lowering of tree and shrub species and an extremely low number of stems of woody plants on all but contour mine sites in this study compared to forests. The few native plants that do invade the mining areas are very close to the edge of the forest and are heavily concentrated in the smallest size class, less than 1 inch diameter at base. The absence of significant numbers of stems larger than even 1 inch suggests that these are very stressful sites and very slow growth or high death rates for small plants are typical conditions. These are very low invasion rates compared to many sites adjacent to mature forests that do not have mining as a land use. As has been noted in many recent studies (e.g. Vories and Throgmorton, 1999), the combination of poor substrate quality and interference by inappropriate grass cover restricts the ability of native communities to return to these extensive land areas. Stands that have regenerated on pre-SMCRA sites often have diverse, productive forests (Rodrique and Burger, 2000), but newer protocols challenge this level of stand development, as is illustrated by these data. Recently, a series of new State of West Virginia regulations have been passed to detail better procedures for re-establishing forest lands on AOC mine sites. These regulations include detailed requirements in soil, cover, and landscape requirements to begin getting productive habitats returning to the land. These new active regulations could be the starting point to address the poor stand development seen on the sites recorded in this study. However, full return of the rich biodiversity of the historical forests of the region would require more intervention than the addition of several dominant species, as is required in the new West Virginia regulations.

Herb studies:

Presence of herbs on the study sites:

The herb communities on the forested sites were generally dense and species-rich, as is typical of this region (Hinkle et al., 1993). Eighty-five herbaceous species have been identified (Table 7a), and more were found on site, which required flowering structures for complete species identification. The presence and composition of the forest herb stratum is critical for forest health, as these herbs maintain soil structure and nutrients, and offer habitat to many animal species.

Three of the nineteen transects were on valley fills, the rest in forests. Presence-absence only of the woodland herbs was recorded at these three sites, so these data are analyzed separately from the remaining data, which follow. Woodland herbs were not expected to be observed in open, sunny fields, as most of the herbs on Table 7a require the shade and moisture of the forest floor. The species that were recorded on the mine sites are on Table 7b.

Of the remaining the sixteen sites, eleven were in mature, intact forests. The remaining five sites were lands that were directly adjacent to mining activities, such as the mine itself, a railroad, or a busy vehicular (haul) road. Table 8 lists herbaceous species found on study sites, ranked by presence from most to least number of sites. The engineered forest sites are contrasted with the intact forest sites to determine the effects of mining activity on adjacent forest herbs. There might not be direct physical destruction of these adjacent forest remnants, but the disturbance of high activity levels (i.e. mining equipment, blasting, fumes and exhaust from train engines and hauling vehicles) as well as sun shafts cutting through to the forest floor from adjacent human-dominated areas surrounding a forest remnant may disrupt the forest community, starting with the herbaceous stratum. Seventeen fewer species are found on sites adjacent to engineered areas than on intact forest sites.

In analyzing species distribution on the slopes, intact sites have more species at any point than engineered sites (Figure 14a). this can be seen with a two-way analysis of variance (ANOVA) (proc GLM, SAS version 6.0) to test for the effects of treatment type, distance from toe of slope, and the interaction of treatment and distance on mean number of species. Significant results were found for treatment type and distance from toe of slope on the species mean (both had a p value = 0.0001), indicating that the number of species were effected by both the distance up the hill and the type of site. There was no significant interaction between environment and distance.

The herb stratum in intact sites also contained more stems in study areas than in engineered sites, along the entire slope (Figure 14b). A two-way ANOVA was performed, testing treatment and distance on mean number of herb stems (treatment p = 0.0016 and distance p = 0.125). Treatment type was found to be significant for number of plants found. There was no significant interaction found for distance from toe of slope on number of stems. There was no significant effect of treatment and distance collectively on number of herb stems counted.

The diversity of the herb stratum follows a similar pattern as described above. Figure 14c shows that the engineered sites had less diversity than the intact sites at all but one point along the slope. ANOVAs show a significant value (p = 0.003) for treatment type, and a marginally significant result (p = .0989) for distance on diversity. Once again, there was no significant relation between treatment and distance.

Tables 9a and 9b record the herbaceous species found at study sites, ranked from most to least abundant (number of stems counted) in engineered and intact sites and by percent abundance, respectively. (The two tables record absolute number and percent of stems on these sites.) Several of the species, which are found most abundantly on the intact forest sites, were not present, or are present in very low numbers, on the disturbed engineered sites. This would indicate that the human activity is effecting the forest ecosystem and changing the community composition. Four of the top ten intact forest herbs are in the top ten of the engineered sites, however, three of the top ten were not present at all on the engineered sites. This might indicate that although some of the heartier species are persisting, some of the more sensitive species are disappearing.

Table 10 records herbaceous species found at study sites, ranked by abundance (number of stems counted) in engineered and intact sites. In this table, values have been standardized by multiplying engineered numbers by 11/5 to even out difference in the number of sites sampled. By equalizing the numbers, we can see the abundance of the species from a more level starting point. (The total number of stems for the engineered and intact forests respectively are 3978 and 8817.) The totals indicate, even when the different number of sites studied is compensated for, that the density of herbaceous stems at the engineered sites was less than half that of the intact forest sites.

General Conclusions for Herbs:

The herb community, important for nutrient status and wildlife values, is much less dense and species-rich when disturbance is adjacent to an intact forest. Part of the reason for the difference in spring herb abundance and diversity could be attributed to mining activity. When mining activity results in covering up the toe of the slope, the most diverse and rich communities are eliminated. The engineered sites studied could have been higher up the original slope than at the intact sites. Also, since the engineered sites have been more disturbed, the quantity of light penetrating the canopy may be increased. This increase in light energy reaching the ground can dry out the soil and make conditions less favorable for the spring herb population. These herbs rarely invade mining lands on the areas studied, so data sets used for woody plants did not include forest herbs because they were seldom, if ever, observed. (Dispersal limits and the need for shady, moist microhabitat are obvious limits to regeneration.) A return to full forest biodiversity of plants is apparently even more challenged on mining areas when herb species are added to a concern.

Soil Sampling:

Table 11 lists the soil depth and percent moisture content recordings from ten mines and their paired remnant forest. Depths were determined by digging holes until either large rock was hit, impeding further digging, or 60cm was reached. The forest is often described as having a very thin layer of soil (e.g. Torbert and Burger, 1996), difficult to be collected before mining operations begin. However, this study's sampling encountered, three times in the forest, 60 cm loose soil depth, with additional soil below that was not sampled. Overall, the forest soils were consistently found to be deeper, moister, and darker in color than the mine soils (Table 11). The mine soil consisted mostly of small rocks, and solid impenetrable rock was hit at generally shallower depths.

Moisture content (Table 11) can account for some of the observed color variation. The darker soils, such as those found in the forest, were much higher in moisture content than the valley fills and backfills. Only two MTR soil samples were collected and they came from the same MTR site (Leckie Smokeless: Briery Knob). This site was very unusual compared to other MTRs visited during this study. The forests to either side of the mined area were flat, like the MTR, and level to the "prairie" site. It appeared that the mining activity was carried out very close to the surface of the ground, therefore disturbing very little of the natural processes. However, the representative showing us the property was not sure of those particulars of the mine's history and the mining company was no longer in business. These two MTR sites had higher moisture content and microbial activity (Figure 15) than expected by the investigators.

The microbial activity is displayed in Figure 15 by land type, with bars marking average values drawn across each group of columns. Overall there was not much difference between remnant forests and back fills. This is consistent with earlier vegetation findings that Back Fills are more promising habitats than the other two mine types. But when comparing the microbial data to the stem density data (Figures 6-8), there seems to be no correlation between the two. Once again, further and more in-depth soil analyses must be performed before any conclusions can be drawn. It is important to analyze the soil column by horizon and time did not permit that type of collection for our team this year.

Table 12 summarizes the Rutgers University Soil Testing Laboratory's findings on the same soil samples used for the DHA analysis. Sample size was small, and it is difficult to observe any trends in the data. The pH values range from 3.6 (a BF and RF) to 7.7 (a VF). There is no observed trend of pH decreasing with age. This should be monitored over time, to see how quickly the rock is breaking down and creating the needed soil layers. Gravel content was not unusual apart from one remnant forest with 53.45% gravel. This was a very thin section of woods, 37m wide, located above the VF and subsequent BF of Briery Knob. Much of the West Virginia woods contained rock outcrops, so this should not be too uncommon. There are large ranges discovered in the soil analysis within the macro- and micronutrients, but it is notable that the N content in the remnant forests (RF) are significantly higher than in the mine lands. This is a critical nutrient whose pool must be enhanced for long-term forest productivity.

Conclusions:

The soil collections from the vegetation analysis sites are too few at present (due to small sampling size) to firmly state an overview of the current conditions of the mine-land soil. Further sampling would be required to complete a detailed analysis. More mine types, greater range of soil age since reclamation, more reclamation schemes, and more in-depth sampling techniques such as soil cores to identify the soil horizons and assess the horizon development need to be examined. Some of this information is in the soil study section of the EIS. Our small scale soil study shows that there is a moisture differs between land types, which must contribute to seedling development and survival, but we cannot say if this is an overriding.

The surface microbial activity does not appear to be unevenly distributed. Backfills did almost as well as the remnant forests. Further testing would be conducted to test the activity level throughout the first few soil horizons. Studies expect to find the most microbial activity at the surface horizons (Harris and Steer, 1997), so it is not surprising to see all four land types sampled here producing similar levels.

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Soil Health of Mountaintop Removal Mines in Southern West Virginia

Revised Project Report

By

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January 24, 2001

Abstract

Minesoils are young soils developing in drastically disturbed earth materials. The health and quality of these soils will deviate from native soils. Although minesoil quality in some places may be worse than the native soil quality, research has shown that overburden materials may be manipulated to improve minesoil quality, especially soil physical and chemical properties. However, very little information about microbiological activity in minesoils is available. Therefore, this study was designed to evaluate physical, chemical and microbiological properties of minesoils developing on reclaimed mountaintop removal coal mines in southern West Virginia. Minesoils of different ages and the contiguous native soils were described and sampled on three mines. Routine physical and chemical properties were determined as well as microbial biomass C and N, potentially mineralizable N, and microbial respiration. All minesoils were weakly developed compared to the native soils, but most had a transition horizon (AC) or a weak B horizon (Bw) developing between the A horizon at the surface and the C horizons. The minesoils would be classified as Entisols, while most of the native soils were Inceptisols. Both native and minesoil biomass C and N, potentially mineralizable N, and microbial respiration were generally within ranges of other reported data. In general, there were more similarities between the properties of the oldest minesoils and the native soils than between the younger minesoils and the native soils. There is a trend of C accumulation as the minesoils become older, and it appears that the stable organic pool is increasing with age. This study indicates that the minesoils are approaching stable, developed soils and should become more like the native soils as they continue to develop.

Introduction

Soil quality or health can be broadly defined as the capacity of a living soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (Doran et al., 1999). Minesoil health is important, not only for initial revegetation, but also for continued long-term productivity and environmental quality. Since minesoils are drastically disturbed soils, their initial properties will be different than the surrounding native soils. However, minesoils are subject to the same soil forming factors and processes that have developed the contiguous native soils. These processes will eventually develop minesoils with properties similar to the native soils. Therefore, studies of minesoil health should include some documentation of minesoil property changes or differences with time. The objective of this study was to document differences in selected minesoil properties, especially those related to microbial activity, on mountaintop removal coal mines of different ages, and to compare the minesoils to the major contiguous native soils.

Methods and Materials

Site Descriptions And Field Sampling

Minesoils and native soils were sampled at the Dal-Tex mine in the Spruce Fork watershed in Logan County, the Hobet-21 mine in the Mud River watershed of Boone County, and the Cannelton mine in the Twentymile Creek watershed in Fayette County. Two different ages of minesoils, with three sampling points each, were selected for sampling at the Hobet-21 (8 and 17 years old) and Cannelton sites (16 and 30 years old). All sampling points at these two mines were 250 m apart, and they were placed 50 m away from the nearest wildlife sampling point. Specific location of each sampling point is presented in Appendix Table 1.

At Hobet-21, the 8-year-old site had slopes ranging from 3 to 5% with a south-southwest aspect. The Hobet-21 17-year-old site had slopes ranging from 3 to 28% with a northwest aspect. Slope inclination at each sampling point is presented in Appendix Table 2. All Hobet-21 sampling points were located at mid slope. At Cannelton, all minesoil sampling points also were located at mid slope and had a south-southwest aspect. Slopes ranged from 5 to 10% on the 16-year-old site, and all slopes were 2% on the 30-year-old site. All minesoils on both of these sites had similar geology and topography, and they had been mined and reclaimed by similar methods.

Three sampling points also were located on the contiguous steeply sloping native soils at both mine sites. These sampling points were located at mid slope and had south-southwest aspects at both sites. Hobet-21 soils had 45 to 72% slopes, and Cannelton soils had 45 to 70% slopes.

Sampling sites at the Dal-Tex mine had been selected for another study (Thomas et al., 2000), but also were used for this study. Four different ages (23, 11, 7, and 2 years old) of minesoils were sampled. Three gently sloping and three steeply sloping sampling points were located on each of the different aged sites. Two steeply sloping native soils were sampled. All minesoil and native soil sampling points had south-southwest aspects. Slope inclination at each sampling point is presented in Appendix Table 2. The distance between sampling points on this mine differed for each age. Each of the sampling points at the 2-year-old site was within a distance of 20 m from the next point. Sampling points on the native soils and on each of the other minesoil ages were more than 20 m apart. The longest distance between points was approximately 100 meters on the 23-year-old site.

Native soils mapped at the three locations are presented below. In general, they are very similar. They are moderately deep and acid with loamy textures.

a. Cannelton – Muskingum; fine-loamy, mixed, active, mesic Typic Dystrochrepts (Gorman and Espy, 1975)

b. Hobet-21 – Berks; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts Gilpin; fine-loamy, mixed, semiactive, mesic Typic Hapludults (Wolf, 1994)

c. Dal-Tex - Berks; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts Matewan; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts (Rob Pate, Natural Resources Conservation Service, personal communication)

All native soils at each of the sites were forested. Both minesoil sampling sites at Cannelton were predominantly vegetated with grasses and legumes. The 16-year-old site had scattered black locust (*Robinia pseudoacacia* L.) trees, but the 30-year-old site had more trees of a variety of species including black locust, maples (*Acer* sp.), pines (P*inus* sp.), sweet gum (*Liquidambar styraciflua* L.) and sourwood (*Oxydendrum arboreum* L.). The 8-year-old site at Hobet-21 was covered with grasses and legumes. The major cover on the Hobet-21 17-year-old site was black locust with ground cover of grasses and legumes. At Dal-Tex, the 23-year-old site was predominantly forested with some grasses and legumes on the gently sloping sites. The 7-year-old site had predominantly grasses and legumes with some shrubs. The 11-year-old and the 2- year-old sites were covered with grasses and legumes with scattered trees at the 11-year-old site.

At each sampling point, a soil pit was dug to a depth of 40 cm or more to expose enough of the soil to determine the thickness of the surface mineral horizon and to observe one or more subsurface horizons. The soil was described to the exposed depth, and bulk samples were collected from the surface horizon for laboratory analyses. The average thickness of surface horizons for all soils is presented in Table 1. These samples were collected in early to mid June 2000. All samples were refrigerated at 4^{o} C until they were analyzed. Bulk density of the surface horizon was determined in the field by a frame excavation technique developed by soil scientists at the National Soil Survey Laboratory in Lincoln, NE (Grossman, R.B., unpublished procedure).

Laboratory Analyses

Texture, pH and electrical conductivity were determined by standard methods of the National Soil Survey Laboratory (Soil Survey Staff, 1996). A LECO CNS-2000 analyzer was used to determine total carbon, sulfur, and nitrogen. Microbial biomass C and N were determined by a chloroform-fumigation-extraction procedure (Rice et al., 1996). Twenty grams of sample at field moisture content were used for this extraction procedure. Nitrogen in extracts was determined by a Kjeldahl method, and C was determined by a Tekmar-Dohrman DC-190 automated carbon analyzer. Potentially mineralizable N was determined by an anaerobic incubation procedure (Drinkwater et al., 1996). Microbial respiration was determined by static soil incubation in closed bottles (Zibilske et al., 1994). Triplicate soil samples (25 g field moist) were placed in funnels lined with Whatman #1 filter paper. Soils were then completely saturated with 100 ml of distilled water and allowed to drain for 24 hr to normalize soil moisture. Wetted soil (20 g) was weighed into serum bottles (160 ml) and incubated uncovered in the dark for 24 hr. Each bottle was capped with a butyl rubber stopper, and initial headspace CO_2 levels were established by injecting 1 ml via a syringe into an infrared gas analyzer (IRGA) equipped with a gas recirculation loop. This process was repeated for each bottle at 24, 48, 72, and 96 hr. Microbial respiration rates were determined using linear regression analysis of CO_2 concentrations at each sampling time.

Results and Discussion

The GPS latitude and longitude for each of the minesoil and native soil sampling points are presented in Appendix Table 1. Detailed profile descriptions are presented in Appendix Table 2. All of the minesoils had developed A horizons and most of the profiles had some weak development in the subsoil, so AC or Bw horizons were described. Minesoils at the Dal-Tex 1976-01 and the Hobet-21 1992-01 sites have cambic horizons and would be classified as Inceptisols (Soil Survey Staff, 1998), while all other minesoils are Entisols. All native soils, except Hobet-21 native-01, are classified as Inceptisols. Hobet-21 native 01 has an argillic horizon and is classified as an Ultisol.

In general, A horizons of the strongly sloping minesoils at Dal-Tex were thicker than the A horizons of the gently sloping minesoils (Table 1). Thickness of A horizons directly relates to the depth of incorporation and accumulation of organic matter primarily from root growth, but also from aboveground biomass. Since bulk densities of the gently sloping minesoils were generally greater than the bulk densities of the strongly sloping minesoils (Thomas et al., 2000), roots should have penetrated more deeply on the strongly sloping minesoils developing thicker A horizons. A review of Appendix Table 2 shows that A horizons had more roots than subsurface horizons.

Rock fragment content of minesoil subsoil horizons averaged greater than 35% by volume and was greater than the rock fragment content of A horizons (Appendix Table 2). Therefore, all minesoils were classified as skeletal (Soil Survey Staff, 1998). Some of the native soils had more than 35% and others had less than 35% rock fragments in the subsoil horizons (Appendix Table 2). The average A-horizon rock fragment content for all soils was less than 35% by volume (Table 1, Appendix Table 2).

Minesoil physical and chemical properties are presented in Table 2. Most of the minesoils and native soils had loamy textures, i.e. sandy loam, loam, silt loam, or silty clay loam. Electrical conductivity values were very low for all soils. Minesoil pH ranged from 4.1 on the 23-year-old Dal-Tex site to 7.0 on the 8-year-old Hobet-21 site. Native soil pH values generally ranged from 4.5 to 5.6, but one site at Dal-Tex had a pH of 3.7. Low total S values for all minesoils and native soils in this study were similar to values reported by Smith et al. (1976) for soils and overburdens in nearby Mingo County.

Our minesoil and native soil C and N values are similar to other minesoils with comparable vegetation (Li, 1991; Prince and Raney, 1961; unpublished soil survey data, National Soil Survey Laboratory, Lincoln, NE). However, except for Dal-Tex native-02, the native soil C and N values are on the low end of the range of the other native soils used for comparison. The Dal-Tex native-02 C value of 12.45% is higher than most soils in the region. Total N and C values tended to be lower for minesoils than for native soils on the Dal-Tex site. However, the older minesoils on the Cannelton and Hobet-21 sites, had higher C and N values than the native soils.

Both native soil and minesoil biomass C and N, potentially mineralizable N and microbial respiration (MR) (Table 3) are generally within ranges given for other soils (Myrold, 1987; Insam and Domsch, 1988; Rice et al., 1996). The minesoil biomass C values are generally higher than values reported for soils from long-term cropping experiments, but minesoil biomass N and potentially mineralizable N are similar to values from these experiments (Bonde et al., 1988). The native soils at Dal-Tex and at Cannelton are similar to each other in all three parameters, but the Hobet native soil is lower for all three. The reasons for this difference are not understood at this time since soils and vegetation are similar for the three sites.

Rice et al. (1996) suggest that the ratio of microbial biomass to total soil organic carbon and nitrogen may provide a measure of soil organic matter dynamics and soil quality. These authors quote other studies for agricultural soils (Anderson and Domsch, 1989; Jenkinson, 1988; Sparling, 1992) indicating that microbial biomass C (MBC) normally comprises 1 to 4% of total organic C and microbial biomass N (MBN) comprises 2 to 6% of the total organic N. The biomass C to total C (TC) ratios for all of our minesoils and native soils are within this quoted range (Table 4). The biomass N to total N (TN) ratios of the native soils at Dal-Tex are within this range, but the ratios present in the native soils at the other two mines are generally higher than the reported range. The fact that these soils are forest soils may explain why the MBN:TN range is different than that reported for agricultural soils. Extremely high MBN:TN values for Dal-Tex 7-year-old and 11-year-old sites indicate that these soils have not developed a stable organic matter base.

As the organic carbon pool becomes more stable with time, ratios of MBC:TC, MBN:TN and potentially mineralizable nitrogen (PMN):TC should decrease. This relationship is apparent at the Dal-Tex site. No total N was detectable in the Dal-Tex 2-year-old site, so the ratios could not be calculated. This site is apparently so young that the C and N pools are very unstable. However, the MBN:TN and PMN:TN ratios generally decrease in the following order: 7 years > 11 years > 23 years > native soil. For the MBC:TC ratios, there is a decrease in the following order: 11 years > 7 years = 23 years > native soil. We do not understand at this time why the MBC:TC ratio for the 7-year-old minesoil is not higher than the 11 or 23-year-old minesoil. These same relationships of decreasing ratios with age are not readily apparent at the Cannelton and Hobet-21 sites. The total C values may not be an accurate estimate of organic C in some minesoils because of the presence of coal or high C rock fragments in the samples. Therefore, the N values and ratios are probably more reliable comparisons.

Soil respiration previously has been used to assess decomposition dynamics in West Virginia minesoils (Stroo and Jencks, 1985). Kennedy and Papendick (1995) suggested that a respiratory quotient such as the MR/MBC ratio relates both the size and activity of microbial biomass. A lowering of the ratio indicates a trend to a more stable and mature system (Insam and Domsch, 1988). The respiratory quotient for the Dal-Tex soils decreased in the following order: 7 years > 11 years > 23 years > native soil (Table 4). Again excluding the 2-year-old soil, this trend indicated a maturation of soils at the Dal-Tex site. A decreasing respiratory quotient with site age was not observed at the Cannelton and Hobet sites.

Based upon these data, we conclude that there is a trend toward the accumulation of C as these minesoils age. Also, it appears that the stable organic pool is increasing. The older minesoils, especially the 23-year-old minesoils at Dal-Tex and the 30-year-old minesoils at Cannelton, have properties similar to the native soils. These data and other data (Thomas et al., 2000) indicate that the minesoils sampled in this study are approaching stable, developed soils.

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Appendix Table 1. GPS Coordinates of Minesoils and Native Soils at Three Sites.

Site	Latitude	Longitude
Dal-Tex		
Gently Sloping		
23 yr old		
1976-01	N 37 deg 53 min 48 sec	W 81 deg 51 min 20 sec
1976-03	N 37 deg 53 min 40 sec	W 81 deg 51 min 32 sec
1976-05	N 37 deg 53 min 40 sec	W 81 deg 51 min 33 sec
11yr old		
1988-01	N 37 deg 54 min 56 sec	W 81 deg 51 min 21 sec
1988-03	N 37 deg 54 min 58 sec	W 81 deg 51 min 11 sec
1988-05	N 37 deg 54 min 52 sec	W 81 deg 50 min 58 sec
7 yr old		
1992-01	N 37 deg 55 min 22 sec	W 81 deg 50 min 17 sec
1992-03	N 37 deg 55 min 21 sec	W 81 deg 50 min 20 sec
1992-05	N 37 deg 55 min 20 sec	W 81 deg 50 min 25 sec
2 yr old		
1997-01	N 37 deg 56 min 11 sec	W 81 deg 51 min 16 sec
1997-03	N 37 deg 56 min 11 sec	W 81 deg 51 min 14 sec
1997-05	N 37 deg 56 min 10 sec	W 81 deg 51 min 12 sec
Strongly Sloping		
23 yr old		
1976-02	N 37 deg 53 min 42 sec	W 81 deg 51 min 27 sec
1976-04	N 37 deg 53 min 41 sec	W 81 deg 51 min 33 sec
1976-06	N 37 deg 53 min 41 sec	W 81 deg 51 min 34 sec
11yr old		
1988-02	N 37 deg 54 min 56 sec	W 81 deg 51 min 21 sec
1988-04	N 37 deg 54 min 57 sec	W 81 deg 51 min 11 sec
1988-06	N 37 deg 54 min 53 sec	W 81 deg 50 min 58 sec
7 yr old		
1992-02	N 37 deg 55 min 23 sec	W 81 deg 50 min 19 sec
1992-04	N 37 deg 55 min 22 sec	W 81 deg 50 min 22 sec
1992-06	N 37 deg 55 min 21 sec	W 81 deg 50 min 25 sec
2 yr old		
1997-02	N 37 deg 56 min 10 sec	W 81 deg 51 min 16 sec
1997-04	N 37 deg 56 min 10 sec	W 81 deg 51 min 14 sec
1997-06	N 37 deg 56 min 10 sec	W 81 deg 51 min 13 sec
Natives		
Native-01	N 37 deg 56 min 24 sec	W 81 deg 51 min 17 sec

Native-02	N 37 deg 56 min 25 sec	W 81 deg 51 min 14 sec
Cannelton		
Minesoil		
30 yr old		
1970-01	N 38deg 12 min 39.5 sec	W 81 deg 16 min 45.9 sec
1970-02	N 38 deg 12 min 34.7 sec	W 81 deg 17 min 01.4 sec
1970-03	N 38 deg 12 min 35.0 sec	W 81 deg 16 min 56.0 sec
16 yr old		
1984-01	N 38 deg 14 min 12.9 sec	W 81 deg 16 min 46.6 sec
1984-02	N 38 deg 14 min 40.7 sec	W 81 deg 16 min 32.3 sec
1984-03	N 38 deg 14 min 42.4 sec	W 81 deg 16 min 09.4 sec
Natives		
Native-01	N 38 deg 14 min 58.2 sec	W 81 deg 15 min 25.2 sec
Native-02	N 38 deg 14 min 59.1 sec	W 81 deg 15 min 18.3 sec
Native-03	N 38 deg 15 min 02.5 sec	W 81 deg 15 min 10.6 sec
Hobet 21		
Minesoil		
17 yr old		
1983-01	N 38 deg 07 min 12.2 sec	W 81 deg 53 min 01.5 sec
1983-02	N 38 deg 06 min 58.7 sec	W 81 deg 52 min 56.6 sec
1983-03	N 38 deg 06 min 50.3 sec	W 81 deg 52 min 46.2 sec
8 yr old		
1992-01	N 38 deg 04 min 46.3 sec	W 81 deg 55 min 42.3 sec
1992-02	N 38 deg 04 min 41.0 sec	W 81 deg 55 min 58.8 sec
1992-03	N 38 deg 04 min 48.9 sec	W 81 deg 56 min 03.8 sec
Natives		
Native-01	N 38 deg 07 min 03.4 sec	W 81 deg 52 min 35.3 sec
Native-02	N 38 deg 07 min 01.9 sec	W 81 deg 52 min 36.2 sec
Native-03	N 38 deg 06 min 59.9 sec	W 81 deg 52 min 38.9 sec

Appendix Table 2. Profile Descriptions for the Dal-Tex, Cannelton, and Hobet -21 Mine Sites

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Dal-Tex											
1976-01	**Oi**	0--2									
23-years-old	**Oe**	2--3							aw		
(2% slope)	**A**	3--7		2.5Y 5/3	SIL	2, f, sbk breaking to 2, f-m, gr	fr		cw	many, vf-c	20% SS
	AC	7--22		2.5Y 5/3, 10YR 5/6, 10YR 6/2, N 2.5/0	SICL	1, m-c, sbk	fr		cw	com, vf-c	30% SS, MS, C
	C	22--65		7.5YR 5/8, 10YR 5/6, 2.5Y 7/4, 10YR 6/2 N 2.5/0	SICL	0, ma	fr		aw	few, vf-f	35% SS, MS, C
	2Cr	65--79			Gray shale and mudstone				aw		
	2R	79+			Sandstone						
1976-02	**Oi**	0--3									
23-years-old	**Oe**	3--6							aw		
(30% slope)	**A**	6--13		10YR 4/2, 10YR 5/3	L	1, m, sbk breaking to 1, f-m, gr	fr		cw	many, vf-m	4% SS, MS, C
	AC	13--31		10YR 4/2	L	1, m-c, sbk	fr		cw	few, vf-m	50% SS, MS, C
	C/B	31--75		2.5Y 5/3	LS	80% 0, ma 20% 1, f, sbk	vfr		gw	com, vf-m	65% SS, MS, C
	C	75--105+		2.5Y 5/2	LS	0, ma	vfr		aw	few vf-m	75% SS
	2R	79+			Sandstone						

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1976-03	**Oi**	0--1			Leaf and stem litter						
23-years-old	**Oe**	1--5			Partially decomposed leaf and stem litter						
(6% slope)	**A**	5--12		10YR 4/2	SL	2, f, sbk	fr	6.5	cw	many, vf-m	35%
						breaking to					SS, MS, C
						2, f-m, gr					
	AC	12--30		10YR 3/2	SL	1, c, sbk	fr	6.0	cw	com, vf-m	50%
						breaking to					SS, MS, C
						1, m, sbk					
	C1	30--87	com, f 10YR 5/8	N 3/0	SL	0, ma	fr	4.0	cw	few, vf-f	80%
											SS, MS, C
	C2	87--115+	many, f, 7.5YR 4/6	10YR 4/3	L	0, ma	fr				40%
			10YR 5/8, N 2.5/0								SS, MS, C
			10YR 7/4								
1976-04	**Oi**	0--1			Leaf and stem litter						
23-years-old	**Oe**	1--4			Partially decomposed leaf and stem litter				aw		
(42% slope)	**A**	4--12		10YR 5/4	SL	2, f-m, gr	vfr		aw	many, vf-vc	30%
											SS, MS
	AC	12--38	Discontinuous layers	10YR 5/4, 10YR 5/6	SL	1,m-c, sbk	fr		gw	com, vf-vc	60%
			10YR 2/1								SS, MS, C
	C	38--69		10YR 5/4, 10YR 5/6	LS	0, ma	fr	5.0	gw	few, vf-c	45%
											SS, MS, C
	C/B	69--150+	Discontinuous layers	10YR 5/4, 10YR 5/6,	L	75% 0, ma	fr	6.0		com, vf-c	50%
			10YR 4/1	10YR 4/4	SL/L	25% f-m, sbk					SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1976-05 23-years-old (4% slope)	**Oe**	0--3			Partially decomposed litter				aw		
	A	3--8		10YR 3/3	LS	2, f, gr	vfr	6.2	cw	many, vf-m	30% SS, C
	AC	8--26		10YR 4/1, 10YR 4/2	SL	1, m, sbk breaking to 1, m, gr	fr	6.0	cw	many, vf-m	50% SS, C
	C1	26--61	few, f-m 10YR 5/8	10YR 4/2	SL	0, ma	fr	8.0	gw	few, vf-f	80% SS, C
	C2	61+			Fragmental--large sandstone boulders with large voids						
1976-06 23-years-old (23% slope)	**Oi**	0--2			Leaf and stem litter						
	Oe	2--5			Partially decomposed litter				aw		
	A	5--11		2.5Y 5/3	L	1, f-m, sbk breaking to 1, m, gr	fr		cw	many, vf-m	30% SS, CO, MS
	Bw	11--26	com, f-m, 10YR 5/8, 10YR 3/1	10YR 5/4	L	1, m-c, sbk	fr		cw	com, vf-c	40% SS, CO, MS, C
	C	26--120+	com, f-m, 10YR 5/6, 10YR 3/1, 7.5YR 5/6	10YR 4/3	L	0, ma	fr			few, f-m	60% SS, MS, C
1988-01 11-years-old (1% slope)	**Oe**	0--3		10YR 4/2	Root Mat		fr		as	many, vf-f	
	A	3--11		2.5Y 5/3	SL	1, m, sbk breaking to 2, m, gr	fr		aw	many, vf-f	26% SS, C
	AC	11--37		2.5Y 5/1	L	1, m, sbk	fr		cw	com, vf-f	40% SS, C, MS
	C1	37--89		10YR 5/3	SL/LS	0, ma	fr		gw	few, vf-f	70% SS, C
	C2	89--160+		2.5Y 5/3	SL	0, ma	fr			vfew, vf-f	70% SS, MS, C

(Sandstone in all horizons with low and high chroma)

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1988-02 11-years-old (44% slope)	**Oi**	0--3	Root mat	10YR 3/3					as	many, vf-f	
	A	3--12		10YR 4/6	L	1, m, sbk breaking to 2, m, gr	fr		cw	com, vf-m	30% SS
	AC	12--41		10YR 4/6	SL	1, f-m, sbk	fr		aw	few, vf-m	35% SS, C
	C1	41--75		10YR 4/2	SL	90% 0, ma 10% 2, f, sbk	vfr		gw	com, vf-m	70% SS, MS, C
	C2	75--125+		10YR 4/2	SL	0, ma	vfr			few, vf-f	70% SS, MS, C
1988-03 11-years-old (7% slope)	**A**	0--3		10YR 4/2	SL	1-2, m, sbk	vfr		aw	many, vf-f	20% SS
	AC	3--16		10YR 4/1	SL	1, m, sbk	fr		cw	com, vf-f	50% SS, C
	C1	16--49		2.5Y 4/1	SL	0, ma	fr		aw	few, vf	60% SS, C
	C2	49--91		10YR 4/3	SL	0, ma	fr		cw	few, vf	50% SS, C
	C3	91--125+	com, f, 10YR 5/6	10YR 4/4	CL		fr			vfew, vf	50% SS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist Consistence[5]	pH	Boundary[6]	Roots[7]	Rock Fragments[8]
1988-04 11-years-old (34% slope)	**Oe**	0--2			Root mat-partially decomposed leaves and roots				aw	many, vf-m	30% SS
	A	2--10		10YR 4/3	SL	2, f-m, gr	vfr		cw	many, vf-m	50% SS
	C1	10--24		10YR 5/4	SL/LS	95% 0, ma 5% 1, m, sbk breaking to 1, m, gr	fr		cw	com, vf-m	60% SS, C
	C2	24--59		10YR 5/4, 10YR 5/8	SL/SCL	95% 0, ma 5% 1, m, sbk	fr		cw	few, vf-m	SS, C
	C3	59--114		10YR 4/6, 10YR 5/6	L	0, ma	fi in place fr in hand		aw	vfew, vf-m	SS, C SS, C
	C4	114--125+	com, f, 10YR 5/6	10YR 4/1	L/CL	0, ma	fr				60% SS, C
1988-05 11-years-old (8% slope)	**A**	0--9		10YR 3/3	SL	1, m, sbk breaking to 1, f, gr	vfr		cw	many, vf-f	30% SS
	C1	9--22		10YR 4/1	SL	0, ma	fr		cw	com, vf-f	55% SS, MS, C
	C2	22--45		2.5Y 4/2	SL	0, ma	fr		gw	few, f-vf	70%
	C3	45--79		2.5Y 4/1	LS	0, ma	fr		gw	few, vf-f	55% SS, MS, C
	C4	79--135+		2.5Y 4/1	SL	0, ma	fr			vfew, vf	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1988-06 11-years-old (48% slope)	**A**	0--7		10YR 3/3, 10YR 4/3	L	2, f-m, gr	vfr		cw	many, vf-f	30% SS
	AC	7--36		10YR 4/3	L	1-2, m-c, sbk	fr		gw	com, vf-f	60% SS, C
	CB	36--72	few, m-c, 7.5YR 5/6	10YR 4/3	SL	1, c, sbk	fr		cw	few, vf-f	75% SS, C
	C	72--150+		2.5Y 5/3	SL	0, ma	fi in place fr in hand		gw	vfew, vf-f	50% SS, C
1992-01 7-years-old (0.5% slope)	**A**	0--8		10YR 3/3	SL	1, m, sbk breaking to 2, vf-f, gr	vfr	7.5	cw	many, vf-f	25% SS
	C1/B	8--30		2.5Y 4/3	LS	75%, 0, ma 25% , 1,f-m, sbk	fr	8.0	gw	com, vf-f	60% SS, MS, C
	C2/B	30--77		10YR 4/2	LS	90%, 0, ma 10%, 1, f, sbk	fr	8.0	cw	few, vf-f	70% SS, MS, C
	C	77--125+	com, f, 10YR 6/8	10YR 5/4	LS	0, ma	vfr	8		few, vf-f	75% SS, MS, C
1992-02 7-years-old (27% slope)	**Oi**	0--2			Leaf and stem litter						
	A	2--8		10YR 4/1	SL	2, f-m, gr	vfr		cw	many, vf-f	25% SS
	AC	8--24		10YR 4/1	SL	1, m, sbk	fr		ci	com, vf-f	40% SS, MS, C
	C1/B	24--60		10YR 4/2, 10YR 4/3	SL	90% 0, ma 10% 1, m, sbk	fi in place fr in hand		gw	com, vf-f	50% SS, C
	C2/B	60--107		10YR 4/2	SL/LS	90% 0, ma 10% 1, m, sbk	fi in place fr in hand		gw	few, vf-f	50% SS, MS, C
	C	107-207+		10YR 4/2	SL/LS	95% 0, ma 5% 1, m, sbk (roots continue past 207 cm)	vfr			few, vf-f	50% SS, MS, C

Appendix Table 2. Continued

Site ID &	Horizon	Depth	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5]	pH	Boundary[6]	Roots[7]	Rock[8]

Soil Age		(cm)					Consistence				Fragments
1992-03 7-years-old (1% slope)	**Oe**	0--2				Partially decomposed organic matter			aw		
	A	2--6		10YR 4/1	L	2, f, sbk breaking to 1, f-m, sbk	vfr		cw	many, vf-f	30% SS, MS
	AC	6--24	few, c, 7.5 YR 5/6	10YR 3/1	L	1, c, sbk 2, m, sbk-- around roots	fr		aw	com, vf-f	25% MS, SS
	C/B	24--48		2.5Y 5/3	SL	60% 0, ma 40%, 2, f-m, sbk	fr		gw	com, vf-f	71% SS, C
	C1	48--66		10YR 5/3	SL	95%, 0, ma 5%, 1, m, sbk	fi in place fr in hand		gw	few, vf-f	75% SS, MS, C
	C2	66--97		10YR 5/3	SL	0, ma	fr		gw	few, vf-m	75% SS, MS, C
	C3	97--160+		10YR 5/3	SL	0, ma	fr		gw	vfew, f-m	90% SS, MS
1992-04 7-years-old (33% slope)	**A**	0--7		10YR 3/1	SL/L	2, m, gr	vfr	4.2	cw	many, vf-m	15% SS
	Bw	7--21	com, f, 10YR 5/6	10YR 4/2, 10YR 5/3	SL	1, m, sbk	fr	4.2		com, vf-m	30% SS
	C1	21--42		2.5Y 5/3	SL/LS	0, ma	fi in place fr in hand	4.2	gw	few, vf-m	45% SS, MS, C
	C2	42--101		2.5Y 5/3	SL/LS	0, ma	fi in place fr in hand	4.2	cw	none	45% SS, MS, C
	C3	101--160+		2.5Y 5/3	SL/LS	0, ma	fr			none	56% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments

1992-05	**Oe**	0--2				Partially decomposed leaf and stem litter			aw		35%
7-years-old											SS
(1% slope)	**A**	2--6		2.5Y 3/2	SL	1, f-m, gr	vfr	6.0	cw	many, vf-m	35%
											SS
	AC	6--24		2.5Y 4/1, 2.5Y 3/1	SL	1-2, f-m, sbk	fr	6.5	cw	com, vf-m	50%
											SS, MS, C
	C1/B	24--48		2.5Y 3/1	L	60%, 0, ma	fr	7.0	gw	com, vf-m	60%
						40%, 1, f, sbk					SS, MS, C
						breaking to					
						1, f, gr					
	C2/B	48--66		2.5Y 3/1	L	85%, 0, ma	vfr/l	6.5		few, vf-m	70%
						15%, 1, f, sbk					SS, MS, C
						breaking to					
						1, f, gr					
						(Roots continue past lowest horizon described)					
1992-06	**A1**	0--10		10YR 3/2, 10YR 4/2	SL	2, f-m, gr	vfr	4.2	cw	many, vf-m	30%
7-years-old											SS, C
(39% slope)	**A2**	10--19		10YR 5/3	SL	1, m, gr	vfr		cw	many, vf-m	35%
											SS
	AC	19--32		10YR 6/4	SL	1, m, sbk	fr	4.2	cw	com, vf-m	40%
						breaking to					SS
						1, m, gr					
	C1	32--73		10YR 5/4	LS/SL	75%, 0, ma	vfr	4.2	gw	few, vf-m	50%
						25%, 1, m, sbk					SS
	C2	73--110+		10YR 5/4	SL	0, ma	vfr	4.5		vfew, vf-f	50%

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-01	**Oi**	0--1			Grass stems						

2-years-old (15% slope)	**A**	1--4		10YR 4/3	SL	1, f, gr	vfr		cw	many, vf-f	40% SS, MS, C
	AC	4--10		10YR 4/3	SL	1, m, sbk	fr		cw	com, vr-f	40% SS, MS, C
	C1	10--41	com, f-m, 2.5Y 6/6, N 2.5/0	2.5Y 4/2	L/SL	0, ma	vfr		gw	few, vf-f	50% SS, C, MS
	C2	10--92	com, m, N 2.5/0, 10YR 5/6, 7.5YR 5/8 2.5YR 5/8, 2.5Y 6/6 10YR 6/6	2.5Y 4/3	SL	0, ma	fr		aw	few, vf-f	60% SS, C, MS
	C3	92--150+	few, f, 2.5Y 7/1	7.5YR 5/8	LS	0, ma	fi in place fr in hand				90% SS
1997-02 2-years-old (43% slope)	**Oi**	0--2			Grass and legume stems						
	A	2--6		2.5Y 3/2	SL	1, f-m, gr	vfr		cw	com, vf-m	30% SS, MS, C
	C1	6--51	com, f-m, 10YR 5/6, N 2.5/0, 10YR 4/4	2.5Y 3/2	SL	90%, 0, ma 10%, 1, f, sbk	fr		gi	few, vf-m	50% SS, MS, C
	C2	51--104	com, f, N 2.5/0, 10YR 5/6	10YR 5/2	L/SL	0, ma	fi in place		ci	few, vf-f	75% SS, MS, C
	C3	104--140+	few, m, N 2.5/0	10YR 3/2, 10YR 4/2	SL	0, ma	fr			vfew, vf-f	40% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-03	**Oi**	0--1			Grass and legume stem litter						
2-years-old	**A**	1--7		2.5Y 3/2	L	1, m, sbk	fr		cw	many, vf-m	20%

(10% slope)						breaking to					SS, MS, C
						2, m, gr					
	AC	7--13		2.5Y 3/2	L	1, m, sbk	fr		gw	com, vf-m	20%
											SS, MS, C
	C1	13--56	few, m-c, 10YR 5/6	2.5Y 3/1	L	0, ma	fi		aw	few, vf-f	35%
											MS, SS, C
	C2	56--82	many, f-m, 2.5Y 6/6,	10YR 6/6	L	0, ma	fr		aw	few, vf-f	30%
			N 2.5/0, 7.5YR 5/6,								SS, MS, C
			10YR 6/3								
	2Cr	82--92+			Soft grey mudstone						
1997-04	**Oi**	0--1			Grass and legume stems						
2-years-old	**A**	1--7		2.5Y 3/2	SL	1-2, f, gr	vfr		cw	many, vf-f	25%
(44% slope)											SS, MS, C
	C1	7--37	com, f, 10YR 6/1,	2.5Y 3/2, 2.5Y 4/2	CL	90% 0, ma, with	fi		gw	many, vf-m	45%
			10YR 6/6			pockects of 1, pl					SS, MS, C
						10% 1, f, sbk					
	C2	37--120	few, m, N 2.5/0	2.5Y 3/2, 2.5Y 5/3	CL	0, ma	fi		cw	few, vf-m	75%
										at rock	SS, MS, C
										faces	
	C3	120--152+	com, f, 10YR 4/1,	10YR 5/6, 2.5Y 5/4	SL	0, ma	fr			vfew, vf	50%
			10YR 3/1								SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-05	**Oi**	0--1			Grass and legume stem litter						
2-years-old	**A**	1--5		10YR 3/2	SL	1, m, sbk	fr		cw	many, vf-f	25%
(1% slope)						and					SS, MS, C

						1, m, gr					
	AC	5--22	few, f-m, N 2.5/0, 2.5 6/4	2.5Y 4/2	SL	1, f-m, sbk	fi		cw	com, vf-f	35% MS, SS, C
	C	22--64	many, f-m, 2.5Y 6/4, 7.5YR 5/6, N 2.5/0	2.5Y 4/3, 2.5Y 4/1	CL	0, ma	fi		aw	few, vf-m	40% SS, MS, C
	2Cr	64--91+			Soft grey mudstone						
1997-06 2-years-old (53% slope)	**Oi**	0--2			Grass and legume stem litter						
	A	2--8		10YR 3/3	SL	1, f, gr	fr		cw	many, vf-f	30% SS, MS, C
	AC	8--14		10YR4/2, 10YR 5/6	SL/L	1, f-m, sbk	fr		aw	many, vf-f	30% SS, MS, C
	C/B	14--29	com, c, 10YR 5/6	2.5Y 4/3	SL	75% 0, ma 25% 1, f, sbk	fr		gw	many, vf-m	70% SS, MS, C
	C	29--120+	few, m, N 2.5/0	2.5Y 5/3, 10YR 6/1	SL	0, ma	fi			few, vf-m	70% SS, MS, C
Native-01 (31% slope)	**Oi**	4--0			Leaf and twig litter						
	A	0--9		10YR 2/2	SIL	2, f, gr	vfr		cw	many, vf-c	5% SS
	BA	9--18		10YR 4/2	SIL	1, m, sbk breaking to 1, m, gr	vfr		cw	many, f-c	10% SS
	Bw1	18--43		10YR 6/4	SIL	2, m-c, sbk	fr		gw	com, f-m	25% SH
	Bw2	43--67		10YR 5/6	SIL	2, f-m, sbk	fr		ab	few, f-m	40% SS
	R	67--104+			Shale						

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Native-02 (58% slope)	**Oi**	5--0			Leaf and twig litter						
	OA	0--2			Decomposed oraganic matter						
	A/E	2--5		10YR 3/1, 10YR 4/2	SL	1, f, gr	vfr		aw	many, vf-m	20% SS

	BA	5--23		10YR 5/6	SL/LS	1, f, sbk	vfr/l		cw	many, vf-c	40%
						and					SS
						1, f, gr					
	Bw	23--59		10YR 6/6	SL/LS	1, m, sbk	fr		gw	com, f-vc	45%
											SS
	BC	59--88		10YR 6/6	SL/LS	1, m-c, sbk	fr		aw	com, f-vc	55
											SS
	R	88-107+		Fractured sandstone, with few roots in fractures							
Cannelton											
1970-01	**Oi**	0--1									
30-years-old	**A**	1--4		10YR 3/3	SIL	2, f, gr	vfr	5.3	aw	many, vf-m	1%
(2% slope)	**AC**	4--13		10YR 6/3, 7.5YR 5/6	SICL	1, m, sbk	fr	4.7	cw	com, f-m	10%
				10YR 6/1, N 2/0							MS, SS, C
	C	13--43+		7.5 YR 6/6, 7.5YR 7/1	SICL	0, ma	fi	5.0		few, vf-f	25%
				10YR 6/1, N 2/0		and					MS, SS, C
				10YR 6/3		1, t, pl					
1970-02	**Oi**	0--1									
30-years-old	**A**	1--4		10YR 4/3	L	2, f-c, gr	vfr	6.5	aw	many, vf-m	1%
(2% slope)	**AC**	4--46		2Y 5/3, 10YR 5/6,	L	1, f-m, sbk	fr	7.0	cw	com, vf-m	20%
				N 2/0, 7.5YR 4/6							
	C	16--40+		2Y 5/3, 10YR 5/6,	SL	0, ma		8.0		vfew, m	85%
				N 2/0, 7.5YR 4/6							

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1970-03	**Oi**	0--1									
30-years-old	**A**	1--3		10YR 3/2	L	2, f-m, gr	vfr	6.5	cw	many, vf-m	5%
(2% slope)	**AC**	3--15		N 2/0, 7.5YR 4/6,	SICL	2, m, sbk	fr	7.0	gw	com, vf-m	25%
				10YR 5/2, 10YR 6/1,		breaking to					
				7.5YR 6/8		2, f-c, gr					

	C	15--45+		N 2/0, 7.5YR 4/6, 10YR 5/6, 10YR 5/8, 10YR 5/2		0, ma	fi	8.0		few, f-m	50%
1984-01 16-years-old (10% slope)	**Oi**	0--3									
	A	3--7		10YR 4/2	SL	1, f, gr	vfr	7.5	cw	com, vf-f	0
	AC	7--14		2.5Y 5/2	LS	1, f, sbk	vfr	8.0	cw	few, vf-f	60% SS, C, MS
	C	14--50+		2.5Y 5.2	LS	0, ma	l	8.0		vfew, vf	70% SS, C, MS
1984-02 16-years-old (5% slope)	**Oi**	0--2									
	A	2--8		2.5Y 4/2	SICL	2, m-c, gr breaking to 2, m, sbk	fr	7.0	cw	many, vf-m	35%
	AC	8--18		2.5YR 5/2,10YR 5/6	SICL	1--2,c,gr breaking to 2, f, sbk	fi	8.0	cw	com, f-m	50% SS, SH
	C	18--45+		2Y 5/2, 10YR 5/6	CL	0, ma		8.0		vfew, f	75% SS, SH
1984-03 16-years-old (5% slope)	**Oi**	0--2									
	A	2--7		2.5Y 4/2	SIL	2, f-m, gr	fr	7.0	cw	many, f-m	35%
	AC	7--17		2.5Y 4/1, 7.5YR 5/8, N 2/0	L	1, f-m, sbk	fi	8.0	aw	few, f-m	65%
	C	17--40+		10YR 4/1, N 2/0	SL	l		8.0		vfew, f-m	85%

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Native-01 (70% slope)	**Oi**	0--5									
	A	5--17		10YR 4/3	SIL	2, f-m, gr	vfr	5.5		many, f-m	5%
	Bw1	17--33		10YR 4/4	SIL	1, m, sbk breaking to 2, f-c, gr	fr	5.0		many, m-c	15%
	Bw2	33--50+		10YR 5/6	SIL	1, m, sbk	fr	5.0		few, m-c	30%

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
						breaking to					
						2, f-c, gr					
Native-02	**Oe**	0--4									
(45% slope)	**A**	4--12		10YR 3/3	SIL	2, f-m, gr	fr	5.5	aw	many, vf-f	5%
	AB	12--18		10YR 3/4	SIL	1, f, sbk	fr	5.5	cw	com, vf-f	5%
						breaking to					
						2, f-c, gr					
	Bw1	18--31		10YR 3/4	SIL	2, m, sbk	fr	5.5	cw	com, vf-c	10%
						breaking to					
						2, f-c, gr					
	Bw2	31--45+		10YR 4/4	SIL	2, m-c, sbk	fr	5.5		few, m-c	10%
						breaking to					
						2, f-c, gr					
			(Very few discontinuous clay films in Bw1 and few discontinuous clay films in Bw1)								
Native-03	**Oi**	0--3									
(67% slope)	**A**	3--16		10YR 4/2	SIL	1, f-m, sbk	fr	5.5	aw	many, vf-c	25%
						breaking to					
						2, f-m, gr					
	Bw1	16--29		10YR 5/4	SIL	2, f-m, sbk	fr	5.5	cw	few, f-c	40%
	Bw2	29--45+		10YR 5/6	SIL	2, m, sbk	fr	5.5		vfew, f-m	60%
				(few discontinuous clay films in lower horizons)							

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Hobet-21											
1983-01	**Oi**	0--2			Leaf and twig litter						
17-years-old	**A**	2--4		2.5Y 3/2	SIL/L	1, f, sbk	fr		cw	many, vf-c	20%
(12% slope)						breaking to					SS
						2, m, gr					
	AC	4--16		2.5Y 5/2	L	1, f, sbk	fr		cw	many, vf-m	50%
											SS,C

	C	16--45+		5Y 3/1	SL	0, ma	fi			few, vf-f	80% SS, C
1983-02 17-years-old (28% slope)	**Oi**	0--2									
	A	2--5		7.5YR 3/1	SL	2, c, gr	vfr		cw	many, vf-m	20% SS, SH
	AC	5--19		2.5Y 3/2	CL	1, f, sbk	fr		cw	com, vf-c	45% SS, SH, C
	C	19--45+		2.5Y 3/2		0, ma	fi			few, vf-f	75% SS, C
1983-03 17-years-old (3% slope)	**Oi**	0--1									
	A	1--5		10YR 3/3	SIL/L	2, f-m, gr	vfr		aw	many, vf-m	15% SS, SH
	AC	5--18		10YR 5/8, 10YR 5/1	CL	1, f, sbk	fr		cw	many, vf-m	50% SS, SH, C
	C	18--45+		2.5Y 3/2	L	0, ma	fi, in place, fr in hand			few, vf-f	80% SS, C
1992-01 8-years-old (3% slope)	**Oi**	0--2			Ground moss						
	A	2--5		10YR 3/2, 10YR 4/2	SL	2, vf-f, gr	vfr		aw	many, vf-m	
	Bw	5--26		10YR 4/3, 10YR 6/4, N 2/0	CL	2, f-m, sbk	fr		cw	many, vf-m	45% SS, C
	C	26--50+		2.5Y 3/2	SCL	0, ma	fi			com, vf-f	55% SS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1992-02 8-years-old (5% slope)	**Oi**	0--2			Mat of moss and roots						
	A	2--6		2.5Y 3/3	L	1, f-m, gr	vfr		aw	many, vf-m	20% SS
	AC	6--28		2.5Y 5/3, 10YR 6/6 N 2/0	SL	1, f-m, sbk	fr		cw	many, vf-m	65% SS
	C	28--45+		2.5Y 5/3, 7.5YR 5/6, N 2/0	SL	0, ma	fi			few, vf-f	65% SS

1992-03 8-years-old (5% slope)	**Oi**	0--1		Leaf litter from forages							
	A	1--5		2.5Y 4/2	L	1, f-m, gr	vfr		cw	many, vf-m	25% SS
	AC	5--11		2.5Y 4/2	SL	1, f, sbk breaking to 2, m, gr	vfr		cw	many, vf-m	25% SS
	C	11-45+		2.5Y 4/2	SL	0, ma	fr			few, vf-f	80% SS
Native-01 (45% slope)	**Oi**	0--3		Leaf and twig litter							
	Oe	3--4									
	A	4--13		10YR 4/2	SL	2, f-m, gr	vfr	5.5	aw	com, vf-m	5% SS
	E	13--27		10YR 6/4	SL	1, m, sbk	fr	5.5	cw	com, vf-c	5% SS
	Bt1	27--44		10YR 5/6	SCL	2, m, sbk	fr	5.5	gw	few, vf-c	5%
	Bt2	44--57+		10YR 5/6	CL	2, m, sbk	fr	4.8		few, vf-c	10% SS
	(few patchy clay films on ped faces and in pores in the Bt1 and common patchy clay films on ped faces and in pores on Bt2)										

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Native-02 (70% slope)	**Oi**	0--5		Leaf and twig litter							
	A	5--11		10YR 3/3	SL	2, f, gr	vfr	5.5	cw	many, vf-c	15 SS% SS
	BA	11--26		10YR 4/4	SL	1, f, sbk breaking to 1, f-m, gr	vfr	5.2	cw	many, vf-vc	20% SS
	Bw1	26-38		10YR 5/4	SL	1, m, sbk	fr	5.2	gw	com, f-vc	20% SS
	Bw2	38--60+		10YR 5/4	SL	1, m, sbk	fr	4.7		com, f-vc	25%

										SS
Native-03 (72% slope)	**Oi**	0--5		Leaf litter						
	Oe/Oa	5--9								
	A	9--17	10YR 3/2	SL	2, f-m, gr	vfr	4.7	cw	many, vf-m	20% SS
	AB	17--35	10YR 3/4, 10YR 5/6	SL	2, f-m, gr	vfr	5.0	cw	many, vf-vc	35% SS
	Bw1	35--51	10YR 5/6	SL	1, m, sbk	fr	5.0	gw	many, vf-c	35% SS
	Bw2	51--81+	7.5YR 4/6	SL	1, m, sbk	fr	4.5		com, vf-c	45% SS

[1]-f=fine, m=medium, c= coarse, com=common

[2]-Colors derived with Munsel color book

[3]-CL=clay loam, L=loam, LS= loamy sand, SCL=sandy clay loam, SICL=silty clay loam, SIL=silt loam, SL=sandy loam

[4]-0=stuctureless, 1=weak, 2=moderate
vf=very fine, f=fine, m=medium, c=coarse, t=thick
gr=granualr, ma=massive, pl=platy, sbk=subangular blocky

[5]-fr=friable, fi=firm, L=loose, vfr=very friable

[6]-aw=abrupt wavy, cw=clear wavy, gw=gradual wavy, ab=abrupt broken, ci=clear irregular, gi=gradual irregular, as=abrupt smooth

[7]-com=common, vfew=very few, vf=very fine, f=fine, m=medium, c=coarse, vc=very coarse

[8]-C=carbolithic material, CO=conglomerate, MS=mudstone, SH=shale, SS=sandstone

Table 3. Minesoil microbial biomass carbon and nitrogen, potentially mineralizable nitrogen, and microbial respiration

Soil ID	Microbial Biomass Carbon	Microbial Respiration	Microbial Biomass Nitrogen	Potentially Mineralizable Nitrogen
	mg/kg	ug-CO_2-C/kg/hr	mg/kg	mg/kg
Dal-Tex				
Gently Sloping				
23 yrs old				
1976-01	1080	1452	55	83
1976-03	659	780	76	79
1976-05	1111	1163	100	119
mean	**950**	**1132**	**77**	**94**
11 yrs old				
1988-01	989	2025	84	156
1988-03	786	1791	27	180
1988-05	1061	1098	102	95
mean	**945**	**1638**	**71**	**144**
7 yrs old				
1992-01	907	2288	62	172
1992-03	1506	2055	148	180
1992-05	1014	3971	78	248
mean	**1142**	**2772**	**96**	**200**
2 yrs old				
1997-01	219	104	13	27
1997-03	362	260	17	42
1997-05	216	133	20	34
mean	**266**	**166**	**17**	**68**
Strongly Sloping				
23 yrs old				
1976-02	618	1347	19	94
1976-04	387	261	22	55
1976-06	567	784	36	55
mean	**524**	**798**	**26**	**68**

Table 3. Continued

Soil ID	Microbial Biomass Carbon mg/kg	Microbial Respiration ug-CO_2-C/kg/hr	Microbial Biomass Nitrogen mg/kg	Potentially Mineralizable Nitrogen mg/kg
11 yrs old				
1988-02	698	1632	50	103
1988-04	481	728	27	75
1988-06	669	1237	48	94
mean	**616**	**1199**	**42**	**90**
7 yrs old				
1992-02	789	1986	65	135
1992-04	573	592	62	30
1992-06	106	255	15	13
mean	**489**	**944**	**47**	**59**
2 yrs old				
1997-02	1236	2792	93	238
1997-04	799	467	49	156
1997-06	1031	676	68	115
mean	**1022**	**1312**	**70**	**170**
Natives				
Native-01	1171	988	90.0	70.8
Native-02	1885	1839	138.0	43.3
mean	**1528**	**1414**	**114**	**68**
Cannelton				
Gently Sloping				
30 yrs old				
1970-01	4893	6119	505	400
1970-02	2261	2810	203	269
1970-03	2898	3481	278	256
mean	**3351**	**4137**	**329**	**308**

Table 3. Continued

	Microbial Biomass	Microbial Respiration	Microbial Biomass	Potentially Mineralizable

	Carbon	ug-CO_2-C/kg/hr	Nitrogen mg/kg	Nitrogen mg/kg
16 yrs old				
1984-01	307	193	35	26
1984-02	220	271	12	39
1984-03	314	277	31	45
mean	**280**	**247**	**26**	**37**
Strongly Sloping				
Natives				
Native-01	883	526	91	57
Native-02	1120	1008	145	77
Native-03	1085	853	123	70
mean	**1029**	**796**	**119**	**68**
Holbet 21				
17 yrs old				
Gently Sloping				
1983-01	1822	1477	170	134
1983-02	1078	1050	98	102
1983-03	2885	2931	302	221
	1928	1819	190	152
8 yrs old				
1992-01	1455	1014	154	119
1992-02	675	798	58	103
1992-03	1264	686	112	111
	1166	833	108	111
Strongly Sloping				
Natives				
Native-01	1011	639	65	48
Native-02	834	658	73	60
Native-03	804	479	69	51
	883	592	69	53

Soil Health of Mountaintop Removal Mines in Southern West Virginia

Revised Project Report

By

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January 24,2001

Abstract

Minesoils are young soils developing in drastically disturbed earth materials. The health and quality of these soils will deviate from native soils. Although minesoil quality in some places may be worse than the native soil quality, research has shown that overburden materials may be manipulated to improve minesoil quality, especially soil physical and chemical properties. However, very little information about microbiological activity in minesoils is available. Therefore, this study was designed to evaluate physical, chemical and microbiological properties of minesoils developing on reclaimed mountaintop removal coal mines in southern West Virginia. Minesoils of different ages and the contiguous native soils were described and sampled on three mines. Routine physical and chemical properties were determined as well as microbial biomass C and N, potentially mineralizable N, and microbial respiration. All minesoils were weakly developed compared to the native soils, but most had a transition horizon (AC) or a weak B horizon (Bw) developing between the A horizon at the surface and the C horizons. The minesoils would be classified as Entisols, while most of the native soils were Inceptisols. Both native and minesoil biomass C and N, potentially mineralizable N, and microbial respiration were generally within ranges of other reported data. In general, there were more similarities between the properties of the oldest minesoils and the native soils than between the younger minesoils and the native soils. There is a trend of C accumulation as the minesoils become older, and it appears that the stable organic pool is increasing with age. This study indicates that the minesoils are approaching stable, developed soils and should become more like the native soils as they continue to develop.

Introduction

Soil quality or health can be broadly defined as the capacity of a living soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (Doran et al., 1999). Minesoil health is important, not only for initial revegetation, but also for continued long-term productivity and environmental quality. Since minesoils are drastically disturbed soils, their initial properties will be different than the surrounding native soils. However, minesoils are subject to the same soil forming factors and processes that have developed the contiguous native soils. These processes will eventually develop minesoils with properties similar to the native soils. Therefore, studies of minesoil health should include some documentation of minesoil property changes or differences with time. The objective of this study was to document differences in selected minesoil properties, especially those related to microbial activity, on mountaintop removal coal mines of different ages, and to compare the minesoils to the major contiguous native soils.

Methods and Materials

Site Descriptions And Field Sampling

Minesoils and native soils were sampled at the Dal-Tex mine in the Spruce Fork watershed in Logan County, the Hobet-21 mine in the Mud River watershed of Boone County, and the Cannelton mine in the Twentymile Creek watershed in Fayette County. Two different ages of minesoils, with three sampling points each, were selected for sampling at the Hobet-21 (8 and 17 years old) and Cannelton sites (16 and 30 years old). All sampling points at these two mines were 250 m apart, and they were placed 50 m away from the nearest wildlife sampling point. Specific location of each sampling point is presented in Appendix Table 1.

At Hobet-21, the 8-year-old site had slopes ranging from 3 to 5% with a south-southwest aspect. The Hobet-21 17-year-old site had slopes ranging from 3 to 28% with a northwest aspect. Slope inclination at each sampling point is presented in Appendix Table 2. All Hobet-21 sampling points were located at mid slope. At Cannelton, all minesoil sampling points also were located at mid slope and had a south-southwest aspect. Slopes ranged from 5 to 10% on the 16-year-old site, and all slopes were 2% on the 30-year-old site. All minesoils on both of these sites had similar geology and topography, and they had been mined and reclaimed by similar methods.

Three sampling points also were located on the contiguous steeply sloping native soils at both mine sites. These sampling points were located at mid slope and had south-southwest aspects at both sites. Hobet-21 soils had 45 to 72% slopes, and Cannelton soils had 45 to 70% slopes.

Sampling sites at the Dal-Tex mine had been selected €or another study (Thomas et al., 2000), but also were used for this study. Four different ages (23, 11, 7, and 2 years old) of minesoils were sampled. Three gently sloping and three steeply sloping sampling points were located on each of the different aged sites. Two steeply sloping native soils were sampled. All minesoil and native soil sampling points had south-southwest aspects. Slope inclination at each sampling point is presented in Appendix Table 2. The distance between sampling points on this mine differed for each age. Each of the sampling points at the 2-year-old site was within a distance of 20 m from the next point. Sampling points on the native soils and on each of the other minesoil ages were more than 20 in apart. The longest distance between points was approximately 100 meters on the 23-year-old site.

Native soils mapped at the three locations are presented below. In general, they are very similar. They are moderately deep and acid with loamy textures.

a. Cannelton – Muskingum; fine-loamy, mixed, active, mesic Typic Dystrochrepts (Gorman and Espy, 1975)

b. Hobet-21 – Berks; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts Gilpin; fine-loamy, mixed, sciniactive, mesic Typic Hapludults (Wolf, 1994)

c. Dal-Tex - Berks; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts Matewan; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts (Rob Pate, Natural Resources Conservation Service, personal communication)

All native soils at each of the sites were forested. Both minesoil sampling sites at Cannelton were predominantly vegetated with grasses and legumes. The 16-year-old site had scattered black locust (*Robinia pseudoacacia* L.) trees, but the 30-year-old site had more trees of a variety of species including black locust, maples (*Acer* sp.), pines (*Pinus* sp.), sweet gum (*Liquidambar styraciflua* L.) and sourwood (*Oxydendrum arboreum* L.). The 8-year-old site at Hobet-21 was covered with grasses and legumes. The major cover on the Hobet-21 17-year-old site was black locust with ground cover of grasses and legumes. At Dal-Tex, the 23-year-old site was predominantly forested with some grasses and legumes on the gently sloping sites. The 7-year-old site had predominantly grasses and legumes with some shrubs. The 11-year-old and the 2- year-old sites were covered with grasses and legumes with scattered trees at the 11-year-old site.

At each sampling point, a soil pit was dug to a depth of 40 cm or more to expose enough of the soil to determine the thickness of the surface mineral horizon and to observe one or more subsurface horizons. The soil was described to the exposed depth, and bulk samples were collected from the surface horizon for laboratory analyses. The average thickness of surface horizons for all soils is presented in Table 1. These samples were collected in early to mid June 2000. All samples were refrigerated at 4" C until they were analyzed. Bulk density of the surface horizon was determined in the field by a frame excavation technique developed by soil scientists at the National Soil Survey Laboratory in Lincoln, NE (Grossman, R.B., unpublished procedure).

Laboratory Analyses

Texture, pH and electrical conductivity were determined by standard methods of the National Soil Survey Laboratory (Soil Survey Staff, 1996). **A** LECO CNS-2000 analyzer was used to determine total carbon, sulfur, and nitrogen. Microbial biomass C and N were determined by a chloroform-fumigation-extraction procedure (Rice et al., 1996). Twenty grams of sample at field moisture content were used for this extraction procedure. Nitrogen in extracts was determined by a Kjeldahl method, and C was determined by a Tekmar-Dohrman DC-190 automated carbon analyzer. Potentially mineralizable N was determined by an anaerobic incubation procedure (Drinkwater et al., 1996). Microbial respiration was determined by static soil incubation in closed bottles (Zibilske et al., 1994). Triplicate soil samples (25 g field moist) were placed in funnels lined with Whatman #1 filter paper. Soils were then completely saturated with 100 ml of distilled water and allowed to drain for 24 hr to normalize soil moisture. Wetted soil (20 g) was weighed into serum bottles (160 ml) and incubated uncovered in the dark for 24 hr. Each bottle was capped with a butyl rubber stopper, and initial headspace CO_2 levels were established by injecting 1 ml via a syringe into an infrared gas analyzer (IRGA) equipped with a gas recirculation loop. This process was repeated for each bottle at 24, 48, 72, and 96 hr. Microbial respiration rates were determined using linear regression analysis of CO_2 concentrations at each sampling time.

Results and Discussion

The GPS latitude and longitude for each of the minesoil and native soil sampling points are presented in Appendix Table 1. Detailed profile descriptions are presented in Appendix Table 2. All of the minesoils had developed A horizons and most of the profiles had some weak development in the subsoil, so AC or Bw horizons were described. Minesoils at the Dal-Tex 1976-01 and the Hobet-21 1992-01 sites have cambic horizons and would be classified as Inceptisols (Soil Survey Staff, 1998), while all other minesoils are Entisols. All native soils, except Hobet-21 native-01, are classified as Inceptisols. Hobet-21 native 01 has an argillic horizon and is classified as an Ultisol.

In general, A horizons of the strongly sloping minesoils at Dal-Tex were thicker than the **A** horizons of the gently sloping minesoils (Table 1). Thickness of **A** horizons directly relates to the depth of incorporation and accumulation of organic matter primarily from root gowth, but also from aboveground biomass. Since bulk densities of the gently sloping minesoils were generally greater than the bulk densities of the strongly sloping minesoils (Thomas et al., 2000), roots should have penetrated more deeply on the strongly sloping minesoils developing thicker **A** horizons. A review of Appendix Table 2 shows that A horizons had more roots than subsurface horizons.

Rock fragment content of minesoil subsoil horizons averaged greater than 35% by volume and was greater than the rock fragment content of **A** horizons (Appendix Table 2). Therefore, all minesoils were classified as skeletal (Soil Survey Staff, 1998). Some of the native soils had more than 35% and others had less than 35% rock fragments in the subsoil horizons (Appendix Table 2). The average A-horizon rock fragment content €or all soils was less than 35% by volume (Table 1, Appendix Table 2).

Minesoil physical and chemical properties are presented in Table 2. Most of the minesoils and native soils had loamy textures, i.e. sandy loam, loam, silt loam, or silty clay loam. Electrical conductivity values were very low for all soils. Minesoil pH ranged from 4.1 on the 23-year-old Dal-Tex site to 7.0 on the S-yew-old Hobet-21 site. Native soil **pH** values generally ranged from 4.5 to 5.6, but one site at Dal-Tex had a pH of 3.7. Low total S values for all minesoils and native soils in this study were similar to values reported by Smith et al. (1976) for soils and overburdens in nearby Mingo County.

Our minesoil and native soil C and N values are similar to other minesoils with comparable vegetation (Li, 1991; Prince and Raney, 1961; unpublished soil survey data, National Soil Survey Laboratory, Lincoln, NE). However, except for Dal-Tex native-02, the native soil C and N values are on the low end of the range of the other native soils used for comparison. The Dal-Tex native-02 C value of 12.45% is higher than most soils in the region. Total N and C values tended to be lower for minesoils than for native soils on the Dal-Tex site. However, the older minesoils on the Cannelton and Hobet-21 sites, had higher C and N values than the native soils.

Both native soil and minesoil biomass C and N, potentially mineralizable N and microbial respiration (MR) (Table 3) are generally within ranges given for other soils (Myrold, 1987; Insam and Dornsch, 1988; Rice et al., 1996). The minesoil biomass C values are generally higher than values reported for soils from long-term cropping experiments, but minesoil biomass N and potentially mineralizable N are similar to values from these experiments (Bonde et al., 1988). The native soils at Dal-Tex and at Cannelton are similar to each other in all three parameters, but the Hobet native soil is lower for all three. The reasons for this difference are no: understood at this time since soils and vegetation are similar for the three sites.

Rice et al. (1996) suggest that the ratio of microbial biomass to total soil organic carbon and nitrogen may provide a measure of soil organic matter dynamics and soil quality. These authors quote other studies for agricultural soils (Anderson and Domsch, 1989; Jenkinson, 1988; Sparling, 1992) indicating that microbial biomass C (MBC) normally comprises 1 to 4% of total organic C and microbial biomass N (MBN) comprises 2 to 6% of the total organic N. The biomass C to total C (TC) ratios for all of our minesoils and native soils are within this quoted range (Table 4). The biomass N to total N (TN) ratios of the native soils at Dal-Tex are within this range, but the ratios present in the native soils at the other two mines are generally higher than the reported range. The fact that these soils are forest soils may explain why the MBN:TN range is different than that reported for agricultural soils. Extremely high MBN:TN values for Dal-Tex 7-year-old and 11-year-old sites indicate that these soils have not developed a stable organic matter base.

As the organic carbon pool becomes more stable with time, ratios of MBC:TC, MBN:TN and potentially mineralizable nitrogen (PMN):TC should decrease. This relationship is apparent at the Dal-Tex site. No total N was detectable in the Dal-Tex 2-year-old site, so the ratios could not be calculated. This site is apparently so young that the C and N pools are very unstable. However, the MBN:TN and PMN:TN ratios generally decrease in the following order: 7 years > 11 years > 23 years > native soil. For the MBC:TC ratios, there is a decrease in the following order: 11 years > 7 years = 23 years > native soil. We do not understand at this time why the MBC:TC ratio for the 7-year-old minesoil is not higher than the 11 or 23-year-old minesoil. These same relationships of decreasing ratios with age are not readily apparent at the Cannelton and Hobet-21 sites. The total C values may not be an accurate estimate of organic C in some minesoils because of the presence of coal or high C rock fragments in the samples. Therefore, the N values and ratios are probably more reliable comparisons.

Soil respiration previously has been used to assess decomposition dynamics in West Virginia minesoils (Stroo and Jencks, 1985). Kennedy and Papendick (1995) suggested that a respiratory quotient such as the MR/MBC ratio relates both the size and activity of microbial biomass. A lowering of the ratio indicates a trend to a more stable and mature system (Insam and Domsch, 1988). The respiratory quotient for the Dal-Tex soils decreased in the following order: 7 years > 11 years > 23 years > native soil (Table 4). Again excluding the 2-year-old soil, this trend indicated a maturation of soils at the Dal-Tex site. **A** decreasing respiratory quotient with site age was not observed at the Cannelton and Hobet sites.

Based upon these data, we conclude that there is a trend toward the accumulation of C as these minesoils age. Also, it appears that the stable organic pool is increasing. The older minesoils, especially the 23-year-old minesoils at Dal-Tes and the 30-year-old minesoils at Cannelton, have properties similar to the native soils. These data and other data (Thomas et al., 2000) indicate that the minesoils sampled in this study are approaching stable, developed soils.

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Appendix Table 1. GPS Coordinates of Minesoils and Native Soils at Three Sites.

Site	Latitude	Longitude
Dal-Tex		
Gently Sloping		
23 yr old		
1976-01	N 37 deg 53 min 48 sec	W 81 deg 51 min 20 sec
1976-03	N 37 deg 53 min 30 sec	W 81 deg 51 min 32 sec
1976-05	N 37 deg 53 min 30 sec	W 81 deg 51 min 33 sec
11yr old		
1988-01	N 37 deg 54 min 56 sec	W 81 deg 51 min 21 sec
1988-03	N 37 deg 54 min 58 sec	W 81 deg 51 min 11 sec
1988-05	N 37 deg 54 min 52 sec	W 81 deg 50 min 58 sec
7 yr old		
1992-01	N 37 deg 55 min 22 sec	W 81 deg 50 min 17 sec
1992-03	N 37 deg 55 min 21 sec	W 81 deg 50 min 20 sec
1992-05	N 37 deg 55 min 20 sec	W 81 deg 50 min 25 sec
2 yr old		
1997-01	N 37 deg 56 min 11 sec	W 81 deg 51 min 16 sec
1997-03	N 37 deg 56 min 11 sec	W 81 deg 51 min 14 sec
1997-05	N 37 deg 56 min 10 sec	W 81 deg 51 min 12 sec
Strongly Sloping		
23 yr old		
1976-02	N 37 deg 53 min 42 sec	W 81 deg 51 min 27 sec
1976-04	N 37 deg 53 min 41 sec	W 81 deg 51 min 33 sec
1976-06	N 37 deg 53 min 41 sec	W 81 deg 51 min 34 sec
11yr old		
1988-02	N 37 deg 54 min 56 sec	W 81 deg 51 min 21 sec
1988-04	N 37 deg 54 min 57 sec	W 81 deg 51 min 11 sec
1988-06	N 37 deg 54 min 53 sec	W 81 deg 50 min 58 sec
7 yr old		
1992-02	N 37 deg 55 min 23 sec	W 81 deg 50 min 19 sec
1992-04	N 37 deg 55 min 22 sec	W 81 deg 50 min 22 sec
1992-06	N 37 deg 55 min 21 sec	W 81 deg 50 min 25 sec
2 yr old		
1997-02	N 37 deg 56 min 10 sec	W 81 deg 51 min 16 sec
1997-04	N 37 deg 56 min 10 sec	W 81 deg 51 min 14 sec
1997-06	N 37 deg 56 min 10 sec	W 81 deg 51 min 13 sec
Natives		
Native-01	N 37 deg 56 min 24 sec	W 81 deg 51 min 17 sec
Native-02	N 37 deg 56 min 25 sec	W 81 deg 51 min 14 sec

Cannelton		
Minesoil		
30 yr old		
1970-01	N 38deg 12 min 39.5 sec	W 81 deg 16 min 45.9 sec
1970-02	N 38 deg 12 min 34.7 sec	W 81 deg 17 min 01.4 sec
1970-03	N 38 deg 12 min 35.0 sec	W 81 deg 16 min 56.0 sec
16 yr old		
1984-01	N 38 deg 14 min 17.9 sec	W 81 deg 16 min 46.6 sec
1984-02	N 38 deg 14 min 40.7 sec	W 81 deg 16 min 32.3 sec
1984-03	N 38 deg 14 min 42.4 sec	W 81 deg 16 min 09.4 sec
Natives		
Native-01	N 38 deg 14 min 58.2 sec	W 81 deg 15 min 25.2 sec
Native-02	N 38 deg 14 min 59.1 sec	W 81 deg 15 min 18.3 sec
Native-03	N 38 deg 15 min 02.5 sec	W 81 deg 15 min 10.6 sec
Hobet 21		
Minesoil		
17 yr old		
1983-01	N 38 deg 07 min 13.2 sec	W 81 deg 53 min 01.5 sec
1983-02	N 38 deg 06 min 58.7 sec	W 81 deg 52 min 56.6 sec
1983-03	N 38 deg 06 min 50.3 sec	W 81 deg 52 min 46.2 sec
8 yr old		
1992-01	N 38 deg 04 min 46.3 sec	W 81 deg 55 min 42.3 sec
1992-02	N 38 deg 04 min 41.0 sec	W 81 deg 55 min 58.8 sec
1992-03	N 38 deg 04 min 48.9 sec	W 81 deg 56 min 03.8 sec
Natives		
Native-01	N 38 deg 07 min 03.4 sec	W 81 deg 52 min 35.3 sec
Native-02	N 38 deg 07 min 01.9 sec	W 81 deg 52 min 36.2 sec
Native-03	N 38 deg 06 min 59.9 sec	W 81 deg 52 min 38.9 sec

Appendix Table 2. Profile Descriptions for the Dal-Tex, Cannelton, and Hobet -21 Mine Sites

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Dal-Tex											
1976-01	Oi	0--2									
23-years-olc	Oe	2--3							aw		
(2% slope)	A	3--7		2.5Y 513	SIL	2, f, sbk breaking to 2, f-in, gr	fr		cw	many, vf-c	20% SS
	AC	7--22		2.5Y 5/3, 10YR 516, 10YR 6/2, N 2.510	SICL	1, m-c, sbk	fr		cw	com, vf-c	30% SS, MS, C
	C	22--65		7.5YR 5/8, 10YR 5/6, 2.5Y 7/4, 10YR 612 N 2.510	SICL	0, ma	fr		aw	few, vf-f	35% SS, MS, C
	2Cr	65--79			Gray shale and mudstone				aw		
	2R	79+			Sandstone						
1976-02	Oi	0--3									
23-years-olc	Oe	3--6							aw		
(30% slope)	A	6--13		10YR 4/2, 10YR 5/3	L	1,m, sbk breaking to 1, f-m, gr	fr		cw	many, vl-m	4% SS, MS, C
	AC	13--31		10YR 4/2	L	1, m-c, sbk	fr		cw	few, vf-m	50% SS, MS, C
	C/B	31--75		2.5Y 513	LS	80% 0, ma 20% 1, f, sbk	vfr		gw	com, vf-m	65% SS, MS, C
	C	75--105+		2.5Y 512	LS	0, ma	vfr		aw	few vf-m	75% SS
	2R	79+			Sandstone						

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary'	Roots[7]	Rock' Fragments
1976-03	Oi	0--1			Leaf and stem litter						
23-years-old	Oe	1--5			Partially decomposed leaf and stem litter						
(6% slope)	A	5–12		10YR 4/2	SL	2, f, sbk breaking to 2, f-m, gr	fr	6.5	cw	many, vf-m	35% SS, MS, C
	AC	12–30		IOYR 3/2	SL	1, c, sbk breaking to 1, m, sbk	fr	6.0	cw	com, vf-m	50% SS, MS, C
	C1	30--87	com, f IOYR 5/8	N 310	SL	0, ma	fr	4.0	cw	few, vf-f	80% SS, MS, C
	C2	87--115+	many, f, 7.5YR 4/6 10YR 5/8, N 2.510 1OYR 7/4	IOYR 413	L	0, ma	fr				40% SS, MS, C
1976-04	Oi	0--1			Leaf and stem litter						
23-years-old	Oe	1--4			Partially decomposed leaf and stem litter				aw		
(42% slope)	A	4--12		10YR 5/4	SL	2, f-m, gr	vfi		aw	many, vf-vc	30% SS, MS
	AC	12--38	Discontinuous layers 1OYR 2/1	10YR 5/4, 10YR 516	SL	1,m-c, sbk	fr		gw	com, vf-vc	60% SS, MS, C
	C	38--69		1OYR 5/4, 10YR 5/6	LS	0, ma	fr	5.0	gw	few, vf-c	45% SS, MS, C
	C/B	69--150+	Discontinuous layers 10YR 4/1	IOYR 5/4, 10YR 5/6, IOYR 4/4	L SL/L	75% 0, ma 25% f-m, sbk	fr	6.0		com, vf-c	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling'	Moist Color'	Texture'	Structure[4]	Moist' Consistence	pH	Boundary[6]	Roots'	Rock[8] Fragments

1976-05 23-years-old (**4%** slope)	Oe	0--3			**Partially** decomposed litter				aw		
	A	3--8		10YR 3/3	LS	**2, f,** gr	vfr	*6.2*	cw	many, vf-m	30% SS, *C*
	AC	8--26		10YR 4/1, 10YR 4/2	SL	1, m, sbk breaking to 1, m, gr	fr	6.0	**cw**	many, vf-m	50% SS, C
	C1	26–61	few, f-m IOYR 518	10YR 4/2	SL	0, ma	fr	8.0	**gw**	few, **vf-f**	80% SS, C
	C2	61+			Fragmental--large sandstone boulders with large voids						
1976-06 23-years-old (23% slope)	**Oi**	0--2			Leaf and stem litter						
	Oe	2--5			Partially decomposed litter				**aw**		
	A	5--11		2.5Y 5/3	L	1, f-m, sbk breaking to **1, m, gr**	fr		cw	many, vf-m	30% SS, CO, MS
	Bw	11–26	com, f-m, IOYR 518, .10YR 3/1	1OYR *514*	L	1, m-c, sbk	fr		cw	corn, vf-c	40% SS, CO, MS, C
	C	26--120+	coni, f-m, IOYR 516, **10YR 3/1, 7.5YR *5/6***	10YR 4/3	L	0, **ma**	fr			**few,** f-m	60% SS, MS, C
1988-01 11-years-old (1% slope)	**Oe**	0--3		10YR 4/2	Root Mat		fr		as	many, vf-f	
	A	3--11		2.5Y 513	SL	1, m, sbk breaking to 2, **m,** gr	fr		**aw**	many, vf-f	26% **SS, C**
	AC	11--37		2.5Y 5/1	L	1, m, sbk	fr		cw	corn, vf-f	40% SS, C, MS
	C1	37-49		IOYR 513	SL/LS	0, ma	fr		**gw**	**few,** vf-f	70% **SS, C**
	C2	89--160+		2.5Y 513	SL	0, ma	fr			vfew, vf-f	70% SS, **MS,** C

1988-02 11-years-old	**Oi**	0--3	Root mat	lOYR 313					as	many, vf-f	
	A	3--12		lOYR 416	L	1, m, sbk	fr		cw	com, vf-m	30%

(44% slope)						breaking to 2, m, gr				SS
	AC	12--41		10YR 4/6	SL	1, f-m, sbk	fr	aw	few, vf-m	35% SS, C
	C1	41--75		10YR 4/2	SL	90% 0, ma 10% 2, f, sbk	vfr	gw	com, vf-m	70% SS, MS, C
	c2	75--125+		10YR 4/2	SL	0, ma	vfr		few, vf-f	70% SS, MS, C
1988-03 11-years-old (*7%* **slope)**	A	0--3		10YR 4/2	SL	1-2, m, sbk	vfr	aw	many, vf-f	20% SS
	AC	3--16		10YR 4/1	SL	1, m, sbk	fr	cw	com, vf-f	50% SS, C
	C1	16--49		2.5Y 4/1	SL	0, ma	fr	aw	few, vf	60% SS, C
	c2	49--91		10YR 4/3	SL	0, ma	fr	cw	few, vf	50% SS, C
	c 3	91--125+	com, f, 10YR 5/6	10YR 4/4	CL		fr		vfcw, vf	50% SS, C

1988-04 11-years-old (34% slope)	Oe	0--2		Root mat-partially decomposed leaves and roots				aw	many, vf-m	30% SS
	A	2--10		10YR 4/3	SL	2, f-m, gr	vfr	cw	many, vf-m	50% SS

	C1	10--24		10YR 5/4	SL/LS	95% 0, ma 5% 1, m, sbk breaking to 1, m, gr	fr		cw	corn. vf-m	60% SS, C
	c2	24--59		10YR 5/4, 10YR 5/8	SL/SCL	95% 0, ma 5% 1, m, sbk	fr		cw	few, vf-m	SS, C
	c3	59--114		10YR 4/6, 10YR 5/6	L	0, ma	fi in place fr in hand		aw	vfcw, vf-m	SS, C SS, C
	c 4	114--125+	com, f, 10YR 5/6	1OYR 4/1	L/CL	0, ma	fr				60% SS, C
1988-05 11-years-old (8% slope)	A	0--9		10YR 313	SL	1, m, sbk breaking to 1, f, gr	vfr		cw	many, vf-f	30% SS
	C1	9--22		10YR 4/1	SL	0, ma	fr		cw	com, vf-f	55% SS, MS, C
	c2	22--45		2.5Y 412	SL	0, ma	fr		gw	few, f-vf	70%
	c3	45--79		2.5Y 4/1	LS	0, ma	fr		gw	few, vf-f	55% SS, MS, C
	c4	79--135+		2.5Y 4/1	SL	0, ma	fr			vfew, vf	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1988-06 11-years-old (48% slope)	A	0--7		10YR 3/3, 10YR 4/3	L	2, f-m, gr	vfr		cw	many, vf-f	30% SS
	AC	7--36		10YR 413	L	1-2, m-c, sbk	fr		gw	corn, vf-f	60% SS, C
	CB	36--72	few, m-c, 7.5YR 5/6	10YR 4/3	SL	1, c, sbk	fr		cw	few, vf-f	75% SS, C
	C	72--150+		2.5Y 5/3	SL	0, ma	fi in place		gw	vfew, vf-f	50%

							fr in hand				SS, C
1992-01 7-years-old (0.5% slope:	A	0--8		10YR 3/3	SL	1, m, sbk breaking to 2, vf-f, gr	vfr	7.5	cw	many, vf-f	25% SS
	C1/B	8--30		2.5Y 413	LS	75%, 0, ma 25% ,1,f-m, sbk	fr	8.0	gw	com, vf-f	60% SS, MS, C
	C2/B	30--77		1OYR 412	LS	90%, 0, ma 10%, 1, f, sbk	fr	8.0	cw	few, vf-f	70% SS, MS, C
	C	77--125+	com, f, 10YR 618	10YR 514	LS	0, ma	vfr	8		few, vf-f	75% SS, MS, C
1992-02 7-years-old (27% slope)	Oi	0--2			Leaf and stem litter						
	A	2--8		10YR 4/1	SL	2, f-ni, gr	vfr		cw	many, vf-f	25% SS
	AC	8–24		10YR 4/1	SL	1, m, sbk	fr		ci	com, vf-f	40% SS, MS, C
	C1/B	24–60		10YR 4/2, 10YR 4/3	SL	90% 0, ma 10% 1, m, sbk	fi in place fr in hand		gw	com, vf-f	50% SS, C
	C2/B	60--107		10YR 4/2	SL/LS	90% 0, ma 10% 1, m, sbk	fi in place fr in hand		gw	few, vf-f	S0% SS, MS, C
	C	107-207+		10YR 4/2	SL/LS	95% 0, ma 5% 1, m, sbk (roots continue past 207 cm)	vfr			few, vf-f	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1992-03 7-years-old (1% slope)	Oe	0--2			Partially decomposed organic matter				aw		
	A	2--6		10YR 4/1	L	2, f, sbk breaking to 1, f-m, sbk	vfr		cw	many, vf-f	30% SS, MS
	AC	6--24	few, c, 7.5 YR 5/6	10YR 3/1	L	I, c, sbk 2, m, sbk-- around roots	fr		aw	com, vf-f	25% MS, SS
	C/B	24-48		2.5Y 5/3	SL	60% 0, ma 40%, 2, f-m, sbk	fr		gw	com, vf-f	71% SS, C

	C1	48--66		10YR 5/3	SL	95%, 0, ma 5%, 1, m, sbk	fi in place fr in hand		gw	few, vf-f	75% SS, MS, C
	C2	66--97		10YR 5/3	SL	0, ma	fr		gw	few, vf-m	75% SS, MS, C
	C3	97--160+		10YR 5/3	SL	0, ma	fr		gw	vfew, f-m	90% SS, MS
1992-04 7-years-old (33% slope)	A	0--7		10YR 3/1	SL/L	2, m, gr	vfr	4.2	cw	many, vf-m	15% SS
	Bw	7--21	com, f, 10YR 5/6	10YR 4/2, 10YR 5/3	SL	1, m, sbk	fr	4.2		com, vf-m	30% SS
	C1	21--42		2.5Y 5/3	SL/LS	0, ma	fi in place fr in hand	4.2	gw	few, vf-m	45% SS, MS, C
	C2	42--101		2.5Y 5/3	SL/LS	0, ma	fi in place fr in hand	4.2	cw	none	45% SS, MS, C
	C3	101--160+		2.5Y 5/3	SL/LS	0, ma	fr			none	56% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1992-05 7-years-old	Oe	0--2		Partially decomposed leaf and stem litter					aw		35% SS
	A	2--6		2.5Y 3/2	SL	1, f-m, gr	vfr	6.0	cw	many, vf-m	35% SS
	AC	6--24		2.5Y 4/1, 2.5Y 3/1	SL	1-2, f-m, sbk	fr	6.5	cw	com, vf-m	50% SS, MS, C
	C1/B	24-48		2.5Y 3/1	L	60%, 0, ma 40%, 1, f, sbk breaking to 1, f, gr	fr	7.0	gw	com, vf-m	60% SS, MS, C
	C2/B	48--66		2.5Y 3/1	L	85%, 0, ma	vfr/l	6.5		few, vf-m	70%

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist Consistence[5]	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
						15%, 1, f, sbk breaking to 1, f, gr					SS, MS, C
						(Roots continue past lowest horizon described)					
1992-06 7-years-old (39% slope)	A1	0--10		10YR 312, 10YR 412	SL	2, f-m, gr	vfr	4.2	cw	many, vf-m	30% SS, C
	A2	10--19		10YR 513	SL	1, m, gr	vfr		cw	many, vf-m	35% SS
	AC	19--32		lOYR 6/4	SL	1, m, sbk breaking to 1, m, gr	fr	4.2	cw	com, vf-m	40% SS
	C1	32--73		10YR 514	LS/SL	75%, 0, ma 25%, 1, m, sbk	vfr	4.2	gw	few, vf-m	50% SS
	C2	73--110+		10YR 5/4	SL	0, ma	vfr	4.5		vfew, vf-f	50%

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist Consistence[5]	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-01 2-years-old (15% slope)	Oi	0--1			Grass stems						
	A	1--4		1OYR 4/3	SL	1, f, gr	vfr		cw	many, vf-f	40% SS, MS, C
	AC	4--10		10YR 4/3	SL	1, m, sbk	fr		cw	corn, vr-f	40% SS, MS, C
	C1	10--41	com, f-m, 2.5Y 6/6, N 2.510	2.5Y 412	USL	0, ma	vfr		gw	few, vf-f	50% SS, C, MS
	c2	10--92	com, m, N 2.510, lOYR 5/6, 7.5YR 518 2.5YR 5/8, 2.5Y 616 lOYR 616	2.5Y 413	SL	0, ma	fr		aw	few, vf-f	60% SS, C, MS
	c3	92--150+	few, f, 2.5Y 7/1	7.5YR 518	LS	0, ma	fi in place fr in hand				90% SS

1997-02	Oi	0--2			Grass and legume stems						
2-years-old (43% slope)	A	2--6		2.5Y 312	SL	1, f-m, gr	vfr		cw	com, vf-m	30% SS, MS, C
	C1	6–51	com, f-m, 10YR 5/6, N 2.5/0, 10YR 4/4	2.5Y 312	SL	90%, 0, ma 10%, 1, f, sbk	fr		gi	few, vf-m	50% SS, MS, C
	C2	51--104	com, f, N 2.5/0, 10YR 5/6	10YR 512	L/SL	0, ma	fi in place		ci	few, vf-f	75% SS, MS, C
	C3	104--140+	few, m, N 2.510	10YR 3/2, 10YR 4/2	SL	0, ma	fr			vfew, vf-f	40% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-03	Oi	0--1			Grass and legume stem litter						
2-years-old (10% slope)	A	1--7		2.5Y 3/2	L	1, m, sbk breaking to 2, m, gr	fr		cw	many, vf-m	20% SS, MS, C
	AC	7–13		2.5Y 312	L	1, m, sbk	fr		gw	com, vf-m	20% SS, MS, C
	C1	13–56	few, m-c, 10YR 516	2.5Y 3/1	L	0, ma	fi		aw	few, vf-f	35% MS, SS, C
	C2	56--82	many, f-m, 2.5Y 6/6, N 2.5/0, 7.5YR 516, 10YR 6/3	10YR 6/6	L	0, ma	fr		aw	few, vf-f	30% SS, MS, C
	2Cr	82--92+			Soft grey mudstone						
1997-04	Oi	0--1			Grass and legume stems						
2-years-old	A	1--7		2.5Y 312	SL	1-2, f, gr	vfr		cw	many, vf-f	25%

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
(44% slope)											SS, MS, C
	C1	7--37	com, f, IOYR 6/1, 10YR 6/6	2.5Y 3/2, 2.5Y 4/2	CL	90% 0, ma, with pockects of 1, pl 10% 1, f, sbk	fi		gw	many, vf-m	45% SS, MS, C
	C2	37--120	few, m, N 2.5/0	2.5Y 3/2, 2.5Y 5/3	CL	0, ma	fi		cw	few, vf-m at rock faces	75% SS, MS, C
	C3	120--152+	com, f, 10YR 4/1, 10YR 3/1	IOYR 5/6, 2.5Y 5/4	SL	0, ma	fr			vfew, vf	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-05	Oi	0--1			Grass and legume stem litter						
2-years-old	A	1--5		10YR 3/2	SL	1, m, sbk and 1, m, gr	fr		cw	many, vf-f	25% SS, MS, C
(1% slope)											
	AC	5--22	few, f-m, N 2.5/0, 2.5 614	2.5Y 4/2	SL	1, f-m, sbk	fi		cw	com, vf-f	35% MS, SS, C
	C	22-44	many, f-m, 2.5Y 6/4, 7.5YR 5/6, N 2.5/0	2.5Y 4/3, 2.5Y 4/1	CL	0, ma	fi		aw	few, vf-m	40% SS, MS, C
	2Cr	64--91+			Soft grey mudstone						
1997-06	Oi	0--2			Grass and legume stem litter						
2-years-old	A	2--8		10YR 3/3	SL	1, f, gr	fr		cw	many, vf-f	30% SS, MS, C
(53% slope)											
		8–14		10YR4/2, IOYR 5/6	SL/L	1, f-m, sbk	fr		aw	many, vf-f	30% SS, MS, C
		14–29	com, c, IOYR 516	2.5Y 4/3	SL	75% 0, ma	fr		gw	many, vf-m	70%

						25% 1, f, sbk					SS, MS, C
	C	29--120+	few, m, N 2.510	2.5Y 513, 10YR 6/1	SL	0, ma	fi			few, vf-m	70% SS, MS, C
Native-0 1 (31% slope)	Oi	4--0			Leaf and twig litter						
	A	0--9		10YR 2/2	SIL	2, f, gr	vfr		cw	many, vf-c	5% SS
	BA	9–18		10YR 4/2	SIL	1, m, sbk breaking to 1, m, gr	vfr		cw	niany, f-c	10% SS
	Bw1	18-43		10YR 614	SIL	2, m-c, sbk	fr		gw	corn, f-m	25% SII
	Bw2	43--67		lOYR 516	SIL	2, f-m, sbk	fr		ab	few, f-m	40% SS
	R	67--104+			Shale						

Soil Age		(cm)					Consistence				Fragments
Native-02 (58% slope)	Oi	5--0			Leaf and twig litter						
	OA	0--2			Decomposed oraganic matter						
	A/E	2--5		10YR 3/1, 10YR 4/2	SL	1, f, gr	vfr		aw	many, vf-m	20% SS
	BA	5--23		10YR 5/6	SL/LS	1, f, sbk and 1, f, gr	vfr/fr		cw	many, vf-c	40% SS
	Bw	23–59		lOYR 6/6	SL/LS	1, in, sbk	fr		gw	corn, f-vc	45% SS
	BC	59-48		lOYR 6/6	SL/LS	1, m-c, sbk	fr		aw	com, f-vc	55 SS
	R	88-107+			Fractured sandstone, with few roots in fractures						

Cannelton

1970-01 30-years-old (2% slope)	Oi	0--1									
	A	1--4		lOYR 313	SIL	2, f, gr	vfr	5.3	aw	many, vf-m	1%
	AC	4–13		lOYR 6/3, 7.5YR 516	SICL	1, m, sbk	fr	4.7	cw	com, f-m	10% MS, SS, C
	C	13--43+		10YR 6/1, N 210 7.5 YR GIG, 7.5YR 7/1	SICL	0, ma	fi	5.0		few, vf-f	25%

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
				10YR 6/1, N 210		and					MS, SS, C
				10YR 6/3		1, t, pl					
1970-02	Oi	0--1									
30-years-old	A	1--4		10YR 4/3	L	2, f-c, gr	vfr	6.5	aw	many, vf-in	1%
(2% slope)	AC	4--16		2Y 5/3, 10YR 5/6,	L	1, f-m, sbk	fr	7.0	cw	corn, vf-m	20%
				N 2/0, 7.5YR 4/6							
	C	16--40+		2Y 513, 10YR 5/6,	SL	0, m a		8.0		vfew, m	85%
				N 2/0, 7.5YR 4/6							

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1970-03	Oi	0--1									
30-years-old	A	1--3		10YR 3/2	L	2, f-m, gr	vfr	6.5	cw	many, vf-m	5%
(2% slope)	AC	3--15		N 2/0, 7.5YR 4/6,	SICL	2, m, sbk	fr	7.0	gw	com, vf-m	25%
				10YR 512, 10YR 6/1,		breaking to					
				7.5YR 6/8		2, f-c, gr					
	C	15--45+		N 2/0, 7.5YR 4/6,		0, ma	fi	8.0		few, f-m	50%
				10YR 5/6, 10YR 5/8,							
				1OYR 5/2							
1984-01	Oi	0--3									
16-years-old	A	3--7		10YR 412	SL	1, f, gr	vfr	7.5	cw	corn, vf-f	0
(10% slope)	AC	7--14		2.5Y 5/2	LS	1, f, sbk	vfr	8.0	cw	few, vf-f	60%
											SS, C, MS
	C	14--50+		2.5Y 5.2	LS	0, ma	1	8.0		vfew, vf	70%
											SS, C, MS
1984-02	Oi	0--2									
16-years-old	A	2--8		2.5Y 4/2	SICL	2, m-c, gr	fr	7.0	cw	many, vf-m	35%
(5% **slope)**						breaking *to*					
						2, m, sbk					
	AC	8--18		2.5YR 5/2, 10YR 516	SICL	1--2, c, gr	fi	8.0	cw	corn, f-m	50%

						breaking to 2, f, sbk					SS, SH
	C	18--45+		2Y 512, 1OYR 516	CL	0, ma		8.0		vfew, f	75% SS, SH
1984-03 16-years-old (5% slope)	Oi	0--2									
	A	2--7		2.5Y 412	SIL	2, f-m, gr	fr	7.0	cw	many, f-m	35%
	AC	7–17		2.5Y 4/1, 7.5YR 518, N 210	L	1, f-m, sbk	fi	8.0	aw	few, f-m	65%
	C	17--40+		10YR 4/1, N 2/0	SIL	1		8.0		vfew, f-m	85%

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Native-01 (70% slope)	Oi	0--5									
	A	5–17		10YR 4/3	SIL	2, f-m, gr	vfr	5.5		many, f-m	5%
	Bw1	17–33		10YR 4/4	SIL	1, m, sbk breaking to 2, f-c, gr	fr	5.0		many, Ill-c	15%
	Bw2	33–50+		10YR 5/6	SIL	1, m, sbk breaking to 2, f-c, gr	fr	5.0		few, m-c	30%
Native-02 (45% slope)	Oe	0--4									
	A	4--12		10YR 3/3	SIL	2, f-m, gr	fr	5.5	aw	many, vf-f	5%
	AB	12--18		10YR 3/4	SIL	1, f, sbk breaking to 2, f-c, gr	fr	5.5	cw	com, vf-f	5%
	Bw1	18--31		10YR 3/4	SIL	2, m, sbk breaking to 2, f-c, gr	fr	5.5	cw	com, vf-c	10%
	Bw2	31--45+		10YR 4/4	SIL	2, m-c, sbk breaking to 2, f-c, gr	fr	5.5		few, m-c	10%
				(Very few discontinuous clay films in Bwl and few discontinuous clay films in Bw1)							
Native-03	Oi	0--3									

(67% slope)	A	3--16		lOYR 412	SIL	1, f-m, sbk breaking to 2, f-m, gr	fr	5.5	aw	many, vf-c	25%
	Bw1	16–29		lOYR 5/4	SIL	2, f-m, sbk	fr	5.5	cw	few, f-c	40%
	Bw2	29--45+		10YR 5/6	SIL	2, m, sbk	fr	5.5		vfew, f-m	60%
					(few discontinuous clay films in lower horizons)						

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock' Fragments
Hobet-21											
1983-01 17-years-old (12% slope)	Oi	0--2			Leaf and twig litter						
	A	2--4		2.5Y 312	SIL/L	1, f, sbk breaking to 2, m, gr	fr		cw	many, vf-c	20% SS
	AC	4--16		2.5Y 5/2	L	1, f, sbk	fr		cw	many, vf-m	50% SS,C
	C	16--45+		5Y 3/1	SL	0, ma	fi			few, vf-f	80% SS, C
1983-02 17-years-old (28% slope)	Oi	0--2									
	A	2--5		7.5YR 3/1	SL	2, c, gr	vfr		cw	many, vf-m	20% SS,SH
	AC	5--19		2.5Y 312	CL	1, f, sbk	fr		cw	com, vf-c	45% SS, SH, C
	C	19--45+		2.5Y 3/2		0, ma	fi			few, vf-f	75% SS, C
1983-03 17-years-old (3% slope)	Oi	0--1									
	A	1--5		10YR 3/3	SIL/L	2, f-m, gr	vfr		aw	many, vf-m	15% SS, SH
	AC	5--18		lOYR 5/8, lOYR 5/1	CL	1, f, sbk	fr		cw	many, vf-m	50% SS, SH, C
	C	18--45+		2.5Y 312	L	0, ma	fi, in place, fr in hand			few, vf-f	80% SS, C

1992-01 8-years-old (3% slope)	Oi	0--2		Ground moss						
	A	2--5	10YR 3/2, 10YR 4/2	SL	2, vf-f, gr	vfr		aw	many, vf-m	
	Bw	5--26	10YR 4/3, 10YR 6/4, N 2/0	CL	2, f-m, sbk	fr		cw	many, vf-m	45% SS, C
	C	26--50+	2.5Y 3/2	SCL	0, ma	fi			com, vf-f	55% SS, C

Soil Age		(cm)				Consistence				Fragments
1992-02 8-years-old (5% slope)	Oi	0--2		Mat of moss and mots						
	A	2--6	2.5Y 3/3	L	1, f-m, gr	vfr		aw	many, vf-m	20% SS
	AC	6--28	2.5Y 5/3, 10YR 6/6 N 2/0	SL	1, f-m, sbk	fr		cw	many, vf-m	65% SS
	C	28--45+	2.5Y 5/3, 7.5YR 5/6, N 2/0	SL	0, ma	fi			few, vf-f	65% SS
1992-03 8-years-old (5% slope)	Oi	0--1		Leaf litter from forages						
	A	1--5	2.5Y 4/2	L	1, f-m, gr	vfr		cw	many, vf-m	25% SS
	AC	5--11	2.5Y 4/2	SL	1, f, sbk breaking to 2, m, gr	vfr		cw	many, vf-m	25% SS
	C	11-45+	2.5Y [illegible]	SL	0, ma	fr			few, [illegible]	80% SS
Native-01 (45% slope)	Oi	0--3		Leaf and twig litter						
	Oe	3--4								
	A	4--13	10YR 4/2	SL	2, f-m, gr	vfr	5.5	aw	com, vf-m	5% SS
	E	13--27	10YR 6/4	SL	1, m, sbk	fr	5.5	cw	com, vf-c	5% SS
	Bt1	27-44	10YR 5/6	SCL	2, m, sbk	fr	5.5	gw	few, vf-c	5%
	Bt2	44--57+	10YR 5/6	CL	2, m, sbk	fr	4.8		few, vf-c	10% SS

(few patchy clay films on ped faces and in pores in the Bt1 and common patchy clay films on ped faces and in pores on Bt2)

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Native-02 (70% slope)	Oi	0--5			Leaf and twig litter						
	A	5--11		10YR 3/3	SL	2, f, gr	vfr	5.5	cw	many, vf-c	15% SS
	BA	11--26		10YR 4/4	SL	1, f, sbk breaking to 1, f-m, gr	vfr	5.2	cw	many, vf-vc	20% SS
	Bw1	26-38		10YR 5/4	SL	1, m, sbk	fr	5.2	gw	com, f-vc	20% SS
	Bw2	38--60+		10YR 5/4	SL	1, m, sbk	fr	4.7		com, f-vc	25% SS
Native-03 (72% slope)	Oi	0--5			Leaf litter						
	Oe/Oa	5--9									
	A	9--17		10YR 3/2	SL	2, f-m, gr	vfr	4.7	cw	many, vf-m	20% SS
	AB	17--35		10YR 3/4, 10YR 5/6	SL	2, f-m, gr	vfr	5.0	cw	many, vf-vc	35% SS
	Bw1	35--51		10YR 5/6	SL	1, m, sbk	fr	5.0	gw	many, vf-c	35% SS
	Bw2	51--81+		7.5YR 4/6	SL	1, m, sbk	fr	4.5		com, vf-c	45% SS

[1]-f=fine, m=medium, c= coarse, com=common

[2]-Colors derived with Munsel color book

[3]-CL=clay loam, L=loam, LS= loamy sand, SCL=sandy clay loam, SICL=silty clay loam, SIL=silt loam, SL=sandy loam

[4]-0=stuctureless, 1=weak, 2=moderate
vf=very fine, f=fine, m=medium, c=coarse, t=thick
gr=granualr, ma=massive, pl=platy, sbk=subangular blocky

[5]-fr=friable, fi=firm, L=loose, vfr=very friable

[6]-aw=abrupt wavy, cw=clear wavy, gw=gradual wavy, ab=abrupt broken, ci=clear irregular, gi=gradual irregular, as=abrupt smooth

[7]-com=common, vfew=very few, vf=very fine, f=fine, m=medium, c=coarse, vc=very coarse

[8]-C=carbolithic material, CO=conglomerate, MS=mudstone, SH=shale, SS=sandstone

Table 3. Minesoil microbial biomass carbon and nitrogen, potentially mineralizable nitrogen, and microbial respiration

[illegible]	Microbial Biomass Carbon mg/kg	Microbial Respiration $ug\text{-}CO_2\text{-}C/kg/hr$	Microbial Biomass Nitrogen mg/kg	Potentially Mineralizable Nitrogen mg/kg
Dal-Tex				
Gently Sloping				
23 yrs old				
1976-01	1080	1452	55	83
1976-03	659	780	76	79
1976-05	1111	1163	100	119
mean	950	**1132**	**77**	**94**
11 yrs old				
1988-01	989	2025	84	156
1988-03	786	1791	27	180
1988-05	1061	1098	102	95
mean	**945**	**1638**	**71**	**144**
7 yrs old				
1992-01	907	2288	62	172
1992-03	1506	2055	148	180
1992-05	1014	3971	78	248
mean	**1142**	**2772**	**96**	**200**
2 yrs old				
1997-01	219	104	13	27
1997-03	362	260	17	42
1997-05	216	133	20	34
mean	**266**	**166**	**17**	**68**
Strongly Sloping				
23 yrs old				
1976-02	618	1347	19	94
1976-04	387	261	22	55
1976-06	**567**	784	36	55
mean	**524**	**798**	**26**	**68**

Table 3. Continued

	Carbon		Nitrogen	Nitrogen
	mg/kg	ug-CO_2-C/kg/hr	mg/kg	mg/kg
11 yrs old				
1988-02	698	1632	*50*	103
1988-04	451	728	27	75
1988-06	669	1237	48	94
mean	616	**1199**	**42**	**90**
7 yrs old				
1992-02	739	1986	65	135
1992-04	*573*	592	62	30
1992-06	106	255	15	13
mean	**489**	**944**	47	**59**
2 yrs old				
1997-02	1236	2792	93	238
1997-04	799	467	49	156
1997-06	1031	676	68	115
mean	**1022**	1312	**70**	170
Natives				
Native-01	1171	988	90.0	70.8
Native-02	1885	1839	138.0	43.3
mean	1528	1411	114	68
Cannelton				
Gently Sloping				
30 yrs old				
1970-01	4893	6119	505	400
1970-02	2261	2810	203	269
1970-03	2898	3481	273	256
mean	3351	4137	329	**308**

Table 3. Continued

	Microbial Biomass Carbon	Microbial Respiration	Microbial Biomass Nitrogen	Potentially Mineralizable Nitrogen
		ug-CO_2-C/kg/hr	mg/kg	mg/kg

16 yrs old				
1984-01	307	193	35	26
1984-02	220	271	12	39
1984-03	314	377	31	45
mean	280	**247**	**26**	**37**
Strongly Sloping				
Natives				
Native-01	883	526	91	57
Native-02	1120	100s	145	77
Native-03	1085	853	123	70
mean	**1029**	**796**	**119**	**68**
Holbet 21				
17 yrs old				
Gently Sloping				
1983-01	1822	1477	170	134
1983-02	1078	1050	98	102
1983-03	2885	2931	302	221
	1928	1819	190	152
8 yrs old				
1992-01	1435	1014	154	110
1992-02	675	79s	5s	103
1992-03	1204	686	112	111
	1166	833	108	111
Strongly Sloping				
Natives				
Native-01	1011	639	65	48
Native-02	834	658	73	60
Native-03	804	479	69	51
	883	592	69	53

Table 4. Ratios of microbial biomass C (MBC) to total C (TC), microbial biomsss N (MBN) to total N (TN), potentially mineralizable N (PMN) to TN, and microbial respiration (MR) to MBC on native soils and minesoils at the Dal-Tex site, Smithers site, and the Holbet 21 site.

Soil ID	Slope Class#	MBC / TC	MR / MBC	MBN / TN	PMN / TN
		%	CO_2-C/hr x10^{-4}	%	%
Dal-Tex					
Native	SS	1.7	9.2	4.1	2.4
23-year-old	GS	2.4	12.0	4.9	5.8
	SS	2.2	15.6	7.7	16.8
11-year-old	GS	3.6	17.5	19.6	35.9
	SS	3.8	19.6	41.7	90.4
7-year-old	GS	2.5	23.9	24.1	50.0
	SS	1.3	19.3	59.0	84.7
2-year-old	GS	0.9	6.1	--	--
	SS	2.2	12.1	13.4	33.9
Cannelton					
Native	SS	2.5	7.7	7.4	4.2
30-year-old	GS	3.3	12.3	6.1	5.7
16-year-old	GS	1.2	8.8	13.1	18.3
Hobet 21					
Native	SS	2.7	6.7	11.4	8.8
17-year-old	GS	2.0	9.4	4.2	3.4
8-year-old	GS	2.2	7.1	7.7	7.9

#- GS=Gently Sloping; SS=Strongly Sloping

Responses to questions on the report, "Soil Health of Mountaintop Removal Mines in Southern West Virginia."

General Comments

1. Why were no native soils collected from gently sloping sites, such as cove areas or at the base of the mountains?

Our approach was to sample the predominant landscapes of both the minesoils and the native soils. The predominant landscape of the native soils had steep to very steep slopes, whereas, the minesoils were nearly level to gently sloping at the Hobet and Cannelton sites. Also, we wanted to sample native soils as close as possible to the minesoil areas so that geology of both minesoils and native soils would be similar, and to sample native soils that were similar to the native soils covering the mined areas before mining.

2. Since A horizons are naturally thin in forest soils and thick in grassland soils, and there are probably other differences between forested and grassland soils, isn't comparing these two data sets somewhat of an "apples and oranges" exercise? Would it be more appropriate to evaluate data for the reclaimed mine soils to peer-reviewed literature values for grassland soils in the eastern U.S.? There should be more of an effort in the report to compare the results to those of other peer-reviewed studies to provide some context for the mine soil results.

In this study, we were simply comparing two contiguous soils in the area: minesoils and native soils. If we start comparing our soils to well-developed grassland soils, we definitely will have an "apples and oranges" exercise. Geology, climate and elevation would differ for our study and grassland soils in the literature. When the morphology of the total profile is considered, our minesoils are very similar to the contiguous native soils. Most of the native soils had Bw horizons (classified as cambic), and thin, light-colored A horizons (classified as ochric). Therefore, they would fit the Inceptisols order in Soil Taxonomy. Most of the minesoils had AC or Bw horizons. If the Bw was present, it was either classified as cambic or approaching cambic. AC horizons are transitional horizons that are also approaching cambic. In other words, given a few more years of weathering and soil development, these minesoils will have cambic horizons. All minesoils had ochric epipedons (surface horizons) just like the native soils. Most grassland soils in midwestern and eastern U.S. are classified as Alfisols or Mollisols. Our minesoils will most likely become Inceptisols (the classification of the native soils) as they mature**.** Data from numerous studies support this conclusion. After the minesoils become Inceptisols, they may become Alfisols, Ultisols, or Mollisols at some later date. Data would indicate that many of the minesoils that are now classified as Entisols will become Inceptisols within a few to 10s of years. Most of the native soils in this area are classified as Inceptisols. The minesoils will not become Alfisols, Ultisols, or Mollisols for probably hundreds to thousands of years. Therefore, the minesoils are similar to the surrounding native soils.

Since funding and time were limited for this study, we did not include detailed comparisons with depth for the the major morphological, chemical or physical properties of the minesoils or native soils. The morphological properties were given primarily for background soil property information. The main emphasis of the study was microbial biomass which we evaluated by determining microbial biomass C and N, potentially mineralizable N, and microbial respiration of surface horizons. We used literature references to compare our biomass data to other studies. On page 5 of the report we comare our data to data from Anderson and Domsch (1989), Bonde et al. (1988), Insam and Domsch (1988), Jenkinson (1988), Li (1991), Myrold (1987), Prince and Raney (1961), Rice et al. (1996), and Sparling (1992). We showed where our data were similar to and where they differed from these studies.

3. It would be helpful if the report would elaborate more on why these particular parameters (microbial biomass, etc.) were chosen for study (e.g., their significance in understanding soil development), as well as what parameters were not studied due to time/funding constraints and how the omitted parameters might also be important to evlauating soil development.

Various references recommend a data set of soil physical, chemical, and biological indicators for screening the condition, quality and health of soil (See Doran et al., 1999). These indicators are grouped into three categories: physical, chemical and biological. The major indicators listed under the biological category are <u>microbial biomass C and N, potentially mineralizable N, and soil respiration</u>, which are the same properties that we measured. Many minesoil studies have concentrated on the chemical and physical properties, but we could find only very limited data on minesoil microbial biomass data. Since our funding and time for this study were limited, we chose to concentrate on the microbial properties. This was discussed at one of the early meetings of the research group, and my understanding from that meeting was that although other data were desirable, it was clear to everyone that limitations of funding and time would preclude additional information. In order to assist with the time constraints, we used sites at Dal-Tex that were already selected for another study. Therefore, we used the same soil pits exposed for that study, and we used laboratory chemical and physical data collected for that study. I felt that the Dal-Tex data were important for our study although we did not have enough funds to select new sample sites and collect new chemical, physical and morphological data. We simply sampled existing soil pits for the microbial analyses. Plus we used additional areas at two other sites where terrestrial habitat studies were taking place, and located our sampling stations near Dr. Wood's transects.

Also, the study would have been more solid if we could have compared the key properties with depth in the minesoil profiles. Again, the limitations of funding and time placed upon us precluded those comparisons.

Specific Comments

1. The reviewer stated that page 2, first paragraph needed clarification; specifically the following sentences: "However, minesoils are subject to the same soil forming factors and processes that have developed the contiguous native soils. These processes will eventually develop minesoils with properties similar to the native soils."

These were general, introductory statements. The five soil forming factors are climate, organisms, relief or topography, parent material, and time. Some of the major internal soil forming processes are leaching from the soil profile, accumulation of organic matter, movement of materials from one horizon or depth to some lower depth, production and accumulation of clay. We were simply saying that these soil forming factors work within minesoils just as they work within native soils. If the factors of soil formation are similar, then the internal processes will also be similar. Therefore, minesoils should eventually (over some period of time) have properties that are very similar to the contiguous native soils because climate and parent material are the same and organisms and topography will be more similar.

2. The reviewer asked us to elaborate on which properties were documented, why they're important, and what they tell us about the soil development and soil "health."

Microbial biomass C and N, potentially mineralizable N, and soil respiration were documented for minesoils of different ages. These are considered by numerous authors (see Doran et al., 1999) as key biological properties that indicate the health of the soil. Healthy soils have stable levels of each of these properties.

Methods and Materials: Side Descriptions and Field Sampling

1. Explain how each sampling location was chosen out of all those acres of possiblilites.

As explained above, we used sampling sites on the Dal-Tex sites that had been selected for another study and had some physical, chemical, and morphological data available. This site consisted of four different aged minesoils. The sampling points were selected to represent the general vegetation and landscape position of the site. Both southern-facing, steep slopes and nearly level to gently sloping sites were selected. Native soils were sampled on southern-facing steep slopes contiguous to the minesoils.

At the Hobet and Cannelton sites we started the site selection process by contacting personnel working on Dr. Wood's wildlife study. We were shown the locations of the wildlife sampling areas in the field. We wanted to sample in the same general vicinity of the wildlife plots, so we chose to sample our soils 50 m outside the wildlife plot boundary. These initial points were selected to represent the general vegetation on the site. Two additional soil sampling points were selected on a straight-line transect so that the distance between each sampling point was 250 m. Each of the three sampling points represented similar landscape positions, slope, and vegetation. If these sampling points did not represent the dominant vegetation of the area, we moved a few meters to locate in the more representative vegetative cover. By sampling in this manner, all of our soil pits should have been close to wildlife plots.

2. Some sample locations were placed on steeply sloping, some on gently sloping sites. Is that because an intent of the sampling was to evaluate the effect of slope on soil development?

It was not the intent of this study to compare steeply sloping and gently sloping minesoils. Therefore, the dominant landscape positions at Hobet and Cannelton, i.e. gently sloping, were sampled. Likewise, the dominant landscape (steeply sloping) of the native soils was sampled. As explained above, both steeply sloping and gently sloping sites were used at Dal-Tex simply because they were available from another study.

3. A table showing the characteristics of each sampling location (vegetation, slope, aspect, age, reclamation methods used, etc.) would be very helpful.

Slope and age of all the sampling sites are provided in Appendix Table 2. Aspect of all sites is given in the text of the report on page 2. General vegetation at each site is described on page 3 of the report. I do not understand why these data would need to be repeated in another table. We do not know the reclamation methods.

4. The vegetation at the 30-year-old site at Cannelton is atypical when compared to most reclaimed mountaintop removal mines. If data from this site are to be used, the vegetation differences should be more clearly described, and an attempt made to understand what reclamation practice resulted in this soil/vegetation association.

It is evident from the data presented that the total C and N values of the A horizon of the 30-yr-old Cannelton site are much greater than the other minesoils. Therefore, microbial biomass C and N, potentially mineralizable N, and soil respiration also are greater. However, thickness of the A horizon was similar to other sites, and pH was similar to or a little lower than the other minesoils. I do not know what caused these differences. Additional information on reclamation procedures and/or vegetation establishment might be beneficial, but that information was not provided to us.

The data should not be omitted. They show that minesoils with high levels of carbon will promote microbial activity and vegetation establishment and growth.

5. On page 3, the 1st full paragraph, the 23-year-old site is described as "predominantly forested." The reader can't tell how tall or what dbh the trees are, and what tree species are present. Similarly, elsewhere in the paragraph "trees" and "shrubs" and "legumes" should be replaced by a list of species present.

A more detailed list will be provided.

6. Soil sampling methods are not fully described. How were samples "collected" (second full paragraph) and handled? From what horizon or depth were the samples collected?

At each sampling point, a soil pit was dug to a depth of 40 cm or more to expose enough of the soil to determine the thickness of the surface mineral horizon and to observe one or more subsurface horizons. The soil was described to the exposed depth, and bulk samples were collected with a shovel from the entire thickness of only the described A horizon for laboratory analyses. All samples were placed on ice in coolers and returned to the labortory where they were stored at 4^0 C until they were analyzed.

Results and Discussion

1. Page 5, last paragraph - The statement "The total C values may not be an accurate estimate of organic C in some minesoils because of the presence of coal or high C rock fragments in the sample" needs further elaboration. Is the bias introduced by coal fragments sufficient that it would be better to throw out this data?

As stated in the referenced paragraph, there are inconsistencies in the MBC:TC ratios. However, the MBN:TN ratios appear to fit expected results. Therefore, we were simply trying to present some reason for the inconsistent C ratios. This led to the statement at the end of the paragraph, "Therefore, the N values and ratios are probably more reliable comparisons."

I would not advocate omitting or "throwing out" the carbon data. The coal fragments or high-carbon shales are a natural property of minesoils. It is important to represent the natural variablilty if these soils.

2. In Appendix, Table 2, a number of soil color readings show very low chromas (e.g. N 2.5/0, N3/0, N2/0). Were these in fact coal fragments?

These colors were not of actual fragments, but of the fine-earth material left behind by the weathering of coal fragments and high-carbon shales. The fragments may have had the same color, but we did not give colors of rock fragments in these descriptions.

3. The report concludes with the statement that "the minesoils in this study are approaching stable, developed soils." It is not clear why this is true, given the weak development of soil horizons evident in the minesoils.

Part of this answer was given for item 2 under General Comments. The statement generally relates to the microbial data, especially of the Dal-Tex site, presented in the report. Also, although minesoil horizons show only weak development, they do show improvements over time, and the older minesoils already have some properties that are similar to the native soil.

MOUNTAINTOP REMOVAL MINING/VALLEY FILL ENVIRONMENTAL IMPACT STATEMENT TECHNICAL STUDY

PROJECT REPORT FOR TERRESTRIAL STUDIES

Terrestrial Vertebrate (Breeding Songbird, Raptor, Small Mammal, Herpetofaunal) Populations of Forested and Reclaimed Sites

September 2001

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Executive Summary

In this study, we quantified diversity and relative abundance of songbird, raptor, small mammal, and herpetofaunal populations on 4 treatments: 2 ages of reclaimed mountain top mining/valley fill (MTMVF) areas (younger grassland; older shrub/pole-size), fragmented forests predominantly surrounded by reclaimed land, and large tracts of intact forest. Our first objective was to quantify the richness and abundance of the wildlife community in relatively intact forest sites of the pre-mining landscape and in the grassland, shrub/pole, and fragmented forest sites of the post-mining landscape to provide objective data on gains and losses in terrestrial wildlife communities. Specifically for species that require forested habitats, we compared abundance of species in intact and fragmented forests. Our second objective was to quantify nesting success of grassland birds on the reclaimed grassland sites because grassland birds are declining in the U.S. partially due to loss of habitat, and some have suggested that these newly created grasslands are providing important habitat for grassland species.

Songbirds

For songbirds, overall richness and abundance were highest in the shrub/pole treatment, which was not surprising since the mix of habitat conditions provides more niches for greater bird diversity. These shrub/pole habitats were dominated by edge species. The grassland treatment had lowest richness and abundance, again not too surprising since grassland bird communities tend to be the least diverse. The bird community in the grassland habitat was dominated by birds in the grassland guild; though edge species were fairly common because of shrub plantings in some areas. We found no statistical difference in overall bird richness and abundance between intact and fragmented forests because increased abundance of edge and interior-edge species in fragmented forests balanced the loss of forest-interior species. Forest-interior species were significantly more abundant in the intact forest. Forest-interior species are affected 2 ways by mountaintop mining; first by a reduction in the total amount of forested habitat available and second by decreased abundance in the remaining fragmented forest.

Generally, the bird community shifted from predominantly forest interior species in the intact forests to edge and grassland species in the reclaimed areas.

Because some songbird species are known to respond negatively to forest fragmentation, we examined abundances of individual species in intact and fragmented forests. The Acadian Flycatcher, American Redstart, Hooded Warbler, Ovenbird, and Scarlet Tanager had significantly higher abundances in intact forests during at least one year of the study, suggesting that fragmentation of the landscape is having on effect on abundance of these species. Distance from mine/forest edge was a significant predictor for presence of Acadian Flycatchers, Black-and-white Warblers, Yellow-throated Vireos and Scarlet Tanagers. However, Red-eyed Vireos, Indigo Buntings, American Goldfinch, Downy Woodpeckers, Northern Parulas, Pileated Woodpeckers, and Yellow-billed Cuckoos had greater abundances in fragmented forests in at least 1 year of the study. However, because of the large size of most MTMVF areas, it is possible that they may have severe negative effects on populations of forest interior species that require large blocks of unfragmented forest for breeding. The severity of the habitat loss/fragmentation also will depend on whether or not MTMVF areas are re-forested or if they remain in early stages of succession. Non-timber post-mining land uses such as grazing or development will result in permanent fragmentation of forest habitats

Eight grassland bird species were detected in the grassland treatment. Grasshopper Sparrows were the most abundant species, and Eastern Meadowlarks were second most abundant. Henslow's Sparrows and Vesper Sparrows were rare on our sites. Vegetation characteristics were not particularly suitable for them. Bobolinks were rare and did not appear to be breeding on the study sites. We found evidence of breeding for both Dickcissels and Horned Larks. The Savannah Sparrow is fairly common on other grassland sites in West Virginia, but it was absent from our study sites.

We conducted nest searching and monitoring in grassland habitats and focused our efforts on Grasshopper Sparrows, the most common species. Our study sites had low nest densities for this species (0.06 nests/ha), and 36% of nests monitored successfully fledged young. A study in northern West Virginia on reclaimed contour mines found 0.11 nests/ha with 7% nest success. Other grasslands in 4 studies throughout the eastern and midwestern U.S. had 0.06-0.25 nests/ha with 11-41% nest success. Nest densities seemed low on our study sites based on the high number of singing males that were detected during point counts and compared to other studies. Nesting success, however, was at the upper end of the range found in other studies. Because nest densities were so low, we could not determine if grassland habitats on reclaimed mountaintop mine sites are able to sustain viable populations of grassland bird species.

In summary, MTMVF areas provided breeding habitat for both grassland and early successional species. Grassland, edge, and interior-edge songbirds were more abundant on the post-mining landscape. The highest bird species richness was found in the shrub/pole treatment and the lowest was found in the grassland treatment. Richness in fragmented forest and intact forest fell between these 2 treatments. Ponds on MTMVF areas also provided habitat for waterfowl, wading birds, swallows, and shorebirds, primarily during migration. No federally-listed endangered or threatened species were detected, but 3 grassland species (Grasshopper Sparrow, Henslow's Sparrow, and Bobolink) considered rare in West Virginia were observed. . However, abundance of the forest interior guild, some forest interior species (e. g. Ovenbird and Acadian Flycatcher) were significantly lower in fragmented forest than in intact forest. Some forest species also were detected more frequently at points further from mine/forest edges. Populations of forest birds will be detrimentally impacted by the loss and fragmentation of mature forest habitat in the mixed mesophytic forest region, which has the highest bird diversity in forested habitats in the eastern United States. Fragmentation-sensitive species such as the Cerulean Warbler, Louisiana Waterthrush, Worm-eating Warbler, Black-and-white Warbler, and Yellow-throated Vireo will likely be negatively impacted as forested habitat is lost and fragmented from MTMVF. Grassland birds nesting on MTMVF areas had nest survival rates similar to those found in the literature, but some species, particularly the Grasshopper Sparrow and Dickcissel, appeared to have high proportions of unmated males in their populations. Further research is necessary to adequately determine the impacts of MTMVF on the nest survival and population dynamics of grassland-nesting bird species.

Raptors

Thirteen species of raptors were observed during the study in 1 or more of the treatments. Of the 6 species typically associated with forested habitats, the Red-shouldered Hawk was the most common. Their abundance was greater in intact than in fragmented forests. Of the 7 species typically associated with more open habitats, the American Kestrel, Northern Harrier, Red-tailed Hawk, and Turkey Vulture were commonly observed as expected. Rough-legged Hawks and Short-eared Owls were observed in low numbers in the grassland treatment. They are more northern species that use large areas of open habitat and are rarely seen in West Virginia. A pair of adult Peregrine Falcons was observed throughout the summer on the Daltex mine in grasslands surrounding a highwall. The falcons often used the highwall for perching, but we found no evidence of breeding. Generally, these results suggest that MTMVF has resulted in a shift from a woodland raptor community to a grassland raptor community.

Small mammals

Species richness of small mammals did not differ between the 4 treatments in either 1999 or 2000. For overall abundance, there was no significant difference between the 3 treatments sampled in summer 1999. In summer 2000, however, we had increased abundance in grassland and shrub/pole treatments and decreased abundance in the 2 forest treatments with a significant difference between these 2 groups. *Peromyscus* spp. (white-footed and deer mice) were by far the most common species and they mirrored this pattern. These yearly differences were quite possibly due to weather patterns. A severe drought and high temperatures in 1999 could have affected small mammal populations in the grassland community more severely. In 2000, the extremely wet and cool conditions probably benefitted animals in the grassland habitat but adversely affected those in forested habitats.

Two other commonly captured species were chipmunks and short-tailed shrews. Both species were significantly more abundant in intact forests. The relationship for shrews holds only for 1999 when this species was common; it was rarely captured in 2000. House mice were captured only in grasslands. A species that we did not expect to find was the Allegheny woodrat. This species has been declining throughout the Northeast and is typically found using rock outcrops in forested habitats. We captured woodrats at 10 of 20 sites trapped. Capture sites were rip-rap drainage channels that had large boulders with a network of openings and some canopy cover. We captured 26 individuals, including males, females and juveniles, which suggests that some of these sites have a breeding population. However, we did not trap extensively at rock outcrops in forested habitats, so we cannot compare abundance of this species between intact forest and reclaimed sites.

Although bats and large mammals are an important part of the mammalian fauna, we did not examine impacts of MTMVF on these species because of logistical and time constraints.

Our study is in agreement with most literature surveyed in that we found small mammals to be more abundant at early stages of succession than in forest. This trend in our study was driven by the white-footed mouse, a species that is often most abundant in early successional stages (e.g. Hansen and Warnock 1978, Buckner and Shure 1985). Two species, short-tailed shrew and eastern chipmunk, were more abundant in intact forest than fragmented forest. Allegheny woodrats were captured at several shrub/pole sites where rock drains with large boulders and some canopy cover provided useable habitat.

Herpetofauna

Although the overall abundance and richness of the herpetofaunal community sampled from March through September 2000 did not differ statistically between our 4 treatments, we observed a shift from a majority of amphibian species in the 2 forested treatments to a majority of reptile species in the grassland and shrub/pole treatments. In particular, salamander species decreased while snake species increased. Summer 2000 had much more rainfall than normal which provided ample breeding habitat for toads and frogs, a group that accounted for a high proportion of species and individuals in all treatments. Thus, we may have found a more pronounced shift during a drier summer. Herpetofaunal species that require loose soil, moist conditions, and woody or leaf litter ground cover generally were absent from reclaimed sites. Minimizing soil compaction, establishing a diverse vegetative cover, and adding coarse woody debris to reclaimed sites would provide habitat for some herpetofaunal species more quickly after mining. In areas disturbed by clearcutting, researchers have found that salamander populations appear to require many years to recover to pre-disturbance levels. MTMVF results in greater soil disturbance than clearcutting so a longer time may be required for recovery of salamander populations in reclaimed mine sites.

Acknowledgements

Funding for this study was provided through the Coal and Energy Research Bureau for work during 1999 and by the West Virginia State Legislature for the work during 2000. We thank staff of Arch Coal (particularly John McDaniel and Mike Duvall) and Cannelton (particularly Ron McAhron) mining companies for their cooperation, assistance, and logistical support throughout the study. Arch Coal, Cannelton, and Amherst Corporation allowed us access to their properties. Ark Land Company provided field housing during the 2000 field season, and we particularly thank Ron Vermillion for his assistance with the field house. John McDaniel (Arch Coal), Mike Duvall (Arch Coal), Larry Emerson (Arch Coal), Pat Lewis (WVDEP), Jim Green (EPA), and Maggie Pashmore (EPA) spent time showing us around the area which greatly assisted us with finding and selecting study sites.

Several individuals provided helpful comments on an earlier draft of this report. They included Cindy Tibbott (USFWS), Russ McClain (WVDNR), Chuck Hunter (SE Partners in Flight coordinator), Ken Rosenberg (NE Partners in Flight coordinator), Jim Anderson (West Virginia University), and Ron Canterbury (Concord College), ornithologists; Mark Ford (USFS) and Mary Etta Hight (Marshall University), mammalogists; and Tom Pauley (Marshall University), herpetologist. William Thayne and Stanley Wearden (statisticians at WVU) provided statistical advice. We also acknowledge the many field technicians who assisted with data collection: John Anderson, Andrew Brown, Rob Dempsey, Elizabeth Goldsmith, Joshua Homyack, Jessica Kapp, Lisa Kendall, Todd McCoy, Robin Pumphrey, Andrew Roberts, and Dorothy Tinkler. We thank the WVU Natural Resources Analysis Center, especially Jackie Straiger, Mike Straiger, J. B. Churchhill, and Jerry Steketee, for sharing Gap information and GIS coverages. M. E. Hight and T. Pauley assisted in identifying small mammals and herpetofauna. The Natural Resources Conservation Service provided copies of aerial photographs for field use, and Dorothy Tinkler created the GIS coverages and maps. WV Cooperative Fish and Wildlife Research Unit (BRD/USGS) provided a field vehicle, access to computers, logistical and administrative support. WVU also provided logistical and administrative support.

Many people assisted in this study in various ways; if we inadvertently missed thanking anyone it was unintentional.

Terrestrial Vertebrate (Breeding Songbird, Raptor, Small Mammal, Herpetofaunal) Populations of Forested and Reclaimed Sites

Background and Justification

Fragmentation and loss of forest habitat from a variety of human-induced disturbances are major issues in wildlife conservation due to negative effects on a number of wildlife species. Because West Virginia is predominantly forested, it provides important habitat for a variety of terrestrial wildlife species that require large tracts of unbroken forest. Mountaintop mining/valley fill (MTMVF), one type of human-induced disturbance to habitat, sets back successional stages, essentially converting large areas of mature hardwood forest to early successional habitat. Forested valleys located below the target coal seams and beyond the reach of the valley fills often appear vegetatively similar to nearby contiguous tracts of forest, but are partially surrounded by actively mined or reclaimed areas resulting in large amounts of edge habitat. Forest edges exhibit numerous changes in biotic and abiotic factors that can negatively affect plant and animal communities (reviews by Yahner 1988, Paton 1994, Murcia 1995). Thus, species composition and diversity in a reclaimed landscape (one composed primarily of early successional habitats with forest remnants) is expected to change from that of a primarily forested landscape.

Many species of songbirds have shown significant population declines over the last several decades (Askins et al. 1990, Smith et al. 1992), including forest-interior species that depend on large, unbroken tracts of hardwood forest and others that are dependent on early successional habitats. Smith et al. (1992) and Rosenberg and Wells (1995) have documented that some avian populations in West Virginia are stable or increasing whereas these same species are declining in other parts of the eastern United States. Therefore, West Virginia has been identified as an important area in the eastern United States for maintenance of bird populations, particularly those of forest-interior species (Rosenberg and Wells 1995). Both conversion and fragmentation of forested habitats associated with MTMVF can have negative effects on the abundance, diversity, and reproductive success of forest-interior songbird populations (Finch 1991, Robinson et al. 1995). Simultaneously, this mining technique creates early successional habitats that are important to other groups of songbird species. Consequently, there is a tradeoff between bird populations in mature forests with those in early successional habitats, but the extent of change in species composition and diversity is not well quantified.

Large-scale MTMVF also raises questions concerning impacts on raptor populations. Several raptor species, particularly the Red-shouldered Hawk (scientific names of all bird species mentioned in the text are found in Appendix 1), are considered primarily forest species and breed in large tracts of contiguous, mature forest (Hall 1983, Crocoll 1994). Conversion of forest tracts to earlier successional habitats will change the raptor community in an area from predominantly forest-dependent species to open country species. Creation of fragmented forest patches also may decrease the suitability of forests remaining on or near MTMVF areas and lead to lower abundance of forest raptor populations. Previous studies have examined habitat and perch use by raptors on surface mines other than MTMVF areas (Mindell 1978, Forren 1981). We found no published studies comparing forested sites with reclaimed sites. The fragmentation of forest and creation of edge by MTMVF areas may have variable effects on raptor species. Greater amounts of edge can decrease suitability of an area for Red-shouldered Hawks but increase suitability for Red-tailed Hawks (Moorman and Chapman 1996) and increase competition between these species (Bednarz and Dinsmore 1981, Moorman and Chapman 1996). Species often observed hunting in open areas, such as American Kestrels and Northern Harriers (Bent 1937, Forren 1981), may benefit from open areas created by MTMVF, but low availability of suitable perches in open areas may limit use of reclaimed mine lands (Mindell 1978, Bloom et al. 1993). Thus, it is important to quantify what effect relatively large-scale MTMVF areas are having on raptor abundance, diversity, and habitat use.

Small mammals are an important component of biological diversity, and their populations are affected by forest fragmentation (e.g. Gottfried 1977). Further, small mammals are the primary prey base for a variety of mammalian and avian predators; thus changes in their abundance can affect other species. They make up a significant percentage of the diet of many animals, including hawks (Acciptrinae), owls (Strigidae and Tytonidae), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), and weasels (*Mustela* spp.) (Mindell 1978, Yearsley and Samuel 1980, McGowan and Bookout 1986). Additionally, small mammals are an important part of the food web as predators, herbivores, and detritivores, and they act as seed dispersers for many plant species (Mumford and Bramble 1973, Bayne and Hobson 1998).

Although we found no previous studies of small mammal populations on MTMVF areas, there have been several studies of small mammals on strip-mined lands throughout the coal mining regions of the mid-western and eastern United States (Verts 1957, De Capita and Bookout 1975, Sly 1976, Hansen and Warnock 1978, Urbanek and Klimstra 1980, McGowan and Bookout 1986). Several of these studies found that small mammal communities on mines differ as a function of time since mining activity ceased (Verts 1957, Sly 1976, Hansen and Warnock 1978, McGowan and Bookout 1986). Three studies compared small mammal populations on reclaimed lands with those on unmined areas (De Capita and Bookout 1975, Kirkland 1976, Urbanek and Klimstra 1980). However, results from these studies differed, with diversity and abundance greater on unmined lands in 1 study (Kirkland 1976) and on reclaimed land in another (Urbanek and Klimstra 1980). Further, unmined lands in the third study (De Capita and Bookout 1975) included habitats other than intact forests which can confound results. Consequently, additional research is needed to clarify the effects of MTMVF on small mammal populations.

Amphibians are the most abundant vertebrates in many temperate forest ecosystems (Burton and Likens 1975), but declines in their populations have been documented worldwide due to various causes including loss and degradation of habitats (Wyman 1990). Amphibian life-history traits make them especially sensitive to disturbances that alter microhabitat and microclimate characteristics (Feder 1983, Sinsch 1990, Stebbins and Cohen 1995). Thus, herpetofauna, particularly amphibians, can be ideal indicators of how well reclamation efforts have succeeded because they are susceptible to small environmental changes (Jones 1986) and make up a large part of the vertebrate biomass on certain sites (Pais et al. 1988, Heyer et al. 1994). However, a thorough literature search revealed little previous research concerning the effects of surface mining on herpetofauna. Myers and Klimstra (1963) and Fowler et al. (1985) studied the colonization of surface mine sediment ponds by herpetofauna, but we found no published literature regarding the effect of surface mining on stream, riparian, or terrestrial herpetofauna. A study of herpetofauna using ponds on MTMVF areas was recently completed (T. Pauley, personal communication), but these data are not currently available. Because the conditions resulting from MTMVF and subsequent reclamation are dramatically different from those provided by the original intact forest, more information is needed on how hepetofaunal populations are responding to these changes.

In our study, we quantified diversity and relative abundance of songbird, raptor, small mammal, and herpetofaunal populations on 4 treatments: 2 ages of reclaimed MTMVF areas (younger grassland; older shrub/pole-size), fragmented forests predominantly surrounded by reclaimed land, and large tracts of intact forest. Our first objective was to quantify the richness and abundance of the wildlife community in relatively intact forest sites of the pre-mining landscape and in the grassland, shrub/pole, and fragmented forest sites of the post-mining landscape to provide objective data on gains and losses in terrestrial wildlife communities. Specifically for species that require forested habitats, we compared abundance of species in intact and fragmented forests. Our second objective was to quantify nesting success of grassland birds on the reclaimed grassland sites because grassland birds are declining in the U.S. partially due to loss of habitat, and some have suggested that these newly created grasslands are providing important habitat for grassland species.

Review of Current Literature

Songbirds

The effects of surface mining activities on bird populations have been examined more than any other taxonomic group. Many studies were conducted in the late 1970's and early 1980's after areas mined in the late 1960's and early 1970's were either reclaimed or revegetated through natural succession (Yahner 1973, Yahner and Howell 1975, Chapman 1977, Crawford et al. 1978, Whitmore 1978, Whitmore and Hall 1978, Wray et al. 1978, Allaire 1979, Whitmore 1979, Wray 1979, Wackenhut 1980, Whitmore 1980, Strait 1981, LeClerc 1982, Wray 1982, Wray et al 1982). Allaire (1980) conducted a thorough review of ornithological literature pertaining to avian use of surface mines during all seasons.

The effects of surface mines on songbirds can be categorized several ways. First, studies can be examined based on the type of mining activity: area-wide, contour, surface, or mountaintop removal, and Allaire (1980) provides a thorough review of studies by the type of mining activity. Studies also can be separated by the hypotheses being examined. In most cases, studies fall into 1 of 3 types: 1) bird use of mines ; 2) bird-habitat relationships; and 3) reproductive success of songbirds on mines. In this review, we examine studies based on the hypotheses being tested and summarize major findings pertaining to bird use of surface mines during the breeding season, incorporating information from Allaire (1980) on MTMVF.

Avian Use of Reclaimed Mines

Most studies of avian use of small surface mines indicate that birds follow a pattern of use typical of that seen in natural succession. The bird community of recently revegetated areas is composed of grassland bird species, typically dominated by Grasshopper Sparrows, Eastern Meadowlarks, Savannah Sparrows, Vesper Sparrows, Horned Larks, and Red-winged Blackbirds. In addition, several authors have noted that the presence of reclaimed mines in eastern states have allowed the range expansion of several grassland species, including Savannah Sparrows, Dickcissels and Bobolinks (Chapman 1977, Whitmore 1978, Whitmore and Hall 1978, Allaire 1979, LeClerc 1982, Wray 1982).

As succession proceeds on mines, the songbird community also changes. Brewer (1958) was the first to study the use of strip mines by songbird species. He examined bird populations on a naturally revegetated mine in Illinois and found 44 species using the area. Most species were forest-edge species, but species composition changed as succession proceeded towards hardwood forest. Karr (1968) found that bird species diversity increased as succession proceeded on strip mines in Illinois. Typical species noted in the shrub/pole phase of succession included Field Sparrows, Gray Catbirds, Brown Thrashers, Indigo Buntings, Yellow Warblers, Prairie Warblers, White-eyed Vireos, Yellow-breasted Chats, American Goldfinch, Northern Cardinals, Eastern Towhees, Golden-winged and Blue-winged Warblers, and Common Yellowthroats (Brewer 1958, Chapman 1977, Crawford, et al. 1978, Whitmore 1978, LeClerc 1982, Wray 1982). Older stages of succession support bird species typically found in forested habitat, such as Red-eyed Vireo, American Redstart, Wood Thrush, Ovenbird, Carolina Wren, Downy and Hairy Woodpeckers, Kentucky Warbler, Scarlet Tanager, Carolina Chickadee, Hooded Warbler, Worm-eating Warbler, Eastern Wood-pewee, and Tufted Titmouse (Brewer 1958, Chapman 1977, Crawford et al. 1978, Allaire 1979).

Bird species also use wetlands associated with mine areas. Perkins and Lawrence (1985) found several species of waterfowl using wetlands created by surface mining in west-central Illinois, including Canada Goose, Mallard, Black Duck, Blue-winged Teal, Green-winged Teal, Wood Duck, Hooded Merganser, Lesser Scaup, Northern Pintail, Mute Swan, American Coot, Common Moorhen, and Pied-billed Grebe. Shorebird and wading species found using wetlands include Killdeer, Spotted Sandpiper, American Bittern, Green Heron, Great Blue Heron, Great Egrets, Cattle Egrets, Soras, and King Rails (Perkins and Lawrence 1985). Allaire (1979) also examined wetlands associated with mines in eastern Kentucky and observed the same waterfowl species as Perkins and Lawrence (1985), as well as Gadwalls, American Wigeons, Northern Shovelers, Redheads, Ring-necked Ducks, Common Goldeneyes, Buffleheads, and Common Mergansers. He also observed American Golden-plovers, American Woodcock, Common Snipe, Solitary Sandpipers, Greater and Lesser Yellowlegs, Pectoral Sandpipers, White-rumped Sandpipers, Baird's Sandpipers, Least Sandpipers, Semipalmated Sandpipers, and Western Sandpipers, in addition to the shorebirds and waders observed by Perkins and Lawrence (1985).

Lawrence et al. (1985) examined avian use of wetlands on reclaimed mines in Illinois and found 2 loon species (*Gavia* spp.), 2 grebe species, and many species of waterfowl, wading birds, and shorebirds on their sites. Researchers in Indiana, Illinois, Kentucky, West Virginia, and Pennsylvania also observed similar species using wetlands on reclaimed mines (Brooks et al. 1985, Krause et al. 1985, McConnell and Samuel 1985).

Bird-habitat Relationships on Reclaimed Mines

Several researchers have examined the relationship between bird abundance and habitat variables on reclaimed mines (Chapman 1977, Chapman et al. 1978, Whitmore 1979, Wray 1979, Wackenhut 1980, Strait 1981, LeClerc 1982). With the exception of Chapman (1977), all of these studies were conducted on small surface mines in northern West Virginia.

Chapman (1977) and Chapman et al. (1978) used linear regression to examine the relationship between bird abundance and 17 vegetation parameters on abandoned contour mines in southwest Virginia. They found a strong positive correlation between the percent ground cover and number of species found on mines. They also found that the number of species increased with canopy height heterogeneity, suggesting that vertical structure is an important predictor of species richness. Chapman et al. (1978) advise reclaimers to quickly establish a high degree of vegetative cover on reclaimed mines and also to provide for the development of higher vegetative strata by planting tree seedlings interspersed with herbs and shrubs.

Most of the West Virginia studies were conducted on 4 reclaimed surface mines in Preston County ranging in size from 9.1-ha to 41.5-ha. These studies examined both habitat selection and the effect of vegetative structure on reproductive success of grassland birds. Whitmore (1979) studied the effects of vegetation changes on Grasshopper Sparrows. He found that changes in bird density were due to changes in the amount of bare ground cover. As the amount of bare ground decreased below the optimum and the amount of litter cover increased above the optimum required by Grasshopper Sparrows, densities decreased. He found similar relationships for Savannah Sparrows and Vesper Sparrows, whereas Eastern Meadowlarks showed opposite trends: as bare ground decreased and litter increased their densities increased. Whitmore (1979) suggests that the density of ground cover is the key variable affecting a grassland bird's choice of a habitat patch. The birds need enough cover for nesting sites, but also need open areas for foraging, courtship, etc.

Habitat selection by Horned Larks on reclaimed mines was studied by Wackenhut (1980). Horned Larks appeared to avoid shrub cover and to prefer areas with little (12%) forb and grass cover. There were no differences in vegetative structure between successful and unsuccessful nests (Wackenhut 1980). Both Wray (1979) and Strait (1981) worked on the same mines as Wackenhut (1980) and examined habitat selection and niche separation of 3 sparrow species (Vesper, Grasshopper, and Savannah). Wray (1979) found that the vegetation around nests sites differed among the 3 species and that successful nests had more or taller vegetation than unsuccessful nests. Strait (1981) determined that Vesper Sparrow nests were associated with a greater amount of bare ground than Grasshopper and Savannah Sparrow nests. Grasshopper Sparrow nests also had a higher amount of forb cover than Savannah Sparrow nests. Vesper Sparrows preferred more open areas than the other 2 species, and vegetation surrounding Vesper Sparrow nests did not appear to affect the probability of nest predation. Successful Grasshopper Sparrow nests had less grass cover and greater forb height than unsuccessful nests. Successful Savannah Sparrow nests were associated with higher vegetative density (Strait 1981). These results indicate that sparrow species are selecting nest sites based on vegetative characteristics, that each species needs different parameters for nesting, and that nest survival depends on characteristics of the surrounding vegetation.

LeClerc (1982) examined the relationship between vegetative structure and bird species on 23 surface mines in northern West Virginia. Using discriminant function analysis she found 4 habitat variables that satisfactorily discriminated among mine sites: percent grass cover, percent bare ground, litter depth, and effective height of vegetation. She also examined bird communities by mine type and found that contour mines were distinctly different from surface mines in bird species composition. Five species were unique to contour mines: Northern Cardinals, Black-capped Chickadees, Prairie Warblers, Eastern Towhees, and White-eyed Vireos, all species typical of forest edge or early successional stages. She did not find any grassland bird species on contour mines. However, her results were confounded by time since reclamation. Her contour mines were 15+ years old, and her surface mines were <10 years old. Thus, it was not surprising that bird communities differed between these 2 mine types due to differences in vegetative structure.

LeClerc (1982) also used discriminant function analysis to examine habitat relationships among mine sites for 6 species of grassland birds. Both Savannah and Grasshopper sparrows were more likely to be present on mines with greater forb cover and minimal shrub cover and bare ground cover. Eastern Meadowlarks preferred mines with less shrub cover and vertical density and greater grass cover. Vesper Sparrows preferred mines with less grass cover, a deep litter depth, and higher forb cover and shrub cover. Horned Larks were associated with mines with low grass cover and low shrub cover, whereas Red-winged Blackbirds preferred mines with high grass cover and forb cover.

Reproductive Success of Songbirds on Reclaimed Mines

Several studies have documented the nesting success of songbirds on reclaimed surface mines in Preston County in northern West Virginia (Wray et al. 1978a, Wray 1979, Wackenhut 1980, Strait 1981, Wray 1982, Wray et al. 1982). We found no published studies of songbird reproductive success on any type of mine outside of West Virginia. A study was recently completed on large reclaimed mines in southern Indiana (Galligan and Lima, pers. comm.), but these data are currently unavailable.

All the West Virginia studies were conducted on the same mines and used the same data set. One study focused primarily on Horned Larks (Wackenhut 1980), while the others concentrated on sparrows. Wray (1978) concentrated on the reproductive biology of sparrows; Strait (1981) examined the habitat selection of sparrows, and Wray (1982) examined community structure and function on reclaimed surface mines. These researchers suggested that passerines breeding on surface mines may be double-brooded or triple-brooded, and that predation accounted for 48% of nest losses. The mean clutch size of the 4 most common nesting species in these studies (Vesper Sparrow, Grasshopper Sparrow, Savannah Sparrow, and Horned Lark) ranged from 3.20-5.25, and the probability of an egg producing a fledgling ranged from 0.05-0.32. Number of fledglings produced per hectare ranged from 0.05 to 1.45.

They found that Grasshopper, Savannah, Vesper, and Field Sparrows had clutch sizes that were similar to those published in the literature for these species, but the number of fledglings produced per hectare was lower than normally expected in natural grasslands (Wray et al. 1982). These studies examined nest losses over a 3-year period, and found that Vesper Sparrow losses remained relatively constant over the 3 years, while Grasshopper Sparrow losses increased and Savannah Sparrow losses fluctuated. They suggested that the primary predators on nests in reclaimed mine habitat were black racers (*Coluber constrictor constrictor*) and American Crows. They also found that adult sparrows did not appear to be replacing themselves sufficiently in reclaimed mine habitat and suggested that immigration is necessary to sustain a stable population. Fledging success ranged from 4.3-6.9% for Grasshopper Sparrows, from 3.6-4.8% for Vesper Sparrows, from 5.4-6.4%, for Savannah Sparrows, and was 6.6% for Field Sparrows (Strait 1981). They suggested that mines may not be a benefit to nesting sparrow species because of this poor breeding success (Wray et al. 1982).

Wackenhut (1980) examined 47 active Horned Lark nests on surface mines and found that the probability of nest survival was only 4.8%. Seventy percent of nest losses were due to depredation.

Effects of Mining on Forest-dwelling Songbirds

The major effect of MTMVF on forest-dwelling songbirds is the loss and fragmentation of forested habitat. Habitat loss and forest fragmentation have become major areas of focus in conservation biology (Harris 1984, Petit et al. 1995). It has been suggested that forest fragmentation has negative effects on the abundance, diversity, and reproductive success of forest-interior songbird populations (Finch 1991, Faaborg et el. 1995, Robinson et al. 1995). Fragmentation may negatively affect forest-dwelling songbirds because of isolation effects, area effects, edge effects, and competitive species interactions (Finch 1991, Faaborg et al. 1995).

In a forested landscape, fragmentation results from timber harvests, roads, powerlines, stand diversity, and natural canopy gaps. This is a much finer scale than occurs in agricultural areas, where forests appear as “islands” in a sea of crops and/or pastureland. Fragmentation on industrial forest might be viewed as “internal” or soft fragmentation, whereas fragmentation in an agricultural landscape might be viewed as “external” or hard fragmentation (Hunter 1990). Fragmentation in an agricultural landscape is often permanent, but fragmentation in forested landscapes is usually temporary (Faaborg et al. 1995). Faaborg et al. (1995) suggest that the latter type of fragmentation is less severe to forest birds than permanent fragmentation, but nonetheless, “detrimental effects still exist.” There are no published studies documenting the effect of MTMVF on forest-dwelling songbirds as forests are lost and fragmented due to mining activities. Thus, it is unclear whether or not MTMVF acts as an internal or external fragmentation event to songbird species. However, because of the large size of most MTMVF areas, it is possible that they may have severe negative effects on populations of forest interior species that require large blocks of unfragmented forest for breeding. The severity of the habitat loss/fragmentation also will depend on whether or not MTMVF areas are re-forested or if they remain in early stages of succession. Non-timber post-mining land uses such as grazing or development will result in permanent fragmentation of forest habitats

Previous research suggests that a high amount of edge habitat might be detrimental to forest-dwelling songbird species (see Paton 1991 for a review). These studies suggest that songbirds are attracted to edges for nesting, but incur higher nest predation rates and higher parasitism rates from the Brown-headed Cowbird, a nest parasite that is known to reduce the productivity of forest songbirds. These edge effects likely only occur <25m into forest (Paton 1991). Moreover, it has been determined that higher rates of predation near edges occurred more frequently in fragmented landscapes than in forested landscapes (Hartley and Hunter 1998). Brown-headed cowbird parasitism also appears to be more detrimental to songbirds in fragmented landscapes than in contiguous forest (Donovan et al. 1995, Hagan et al. 1997). Because MTMVF creates a large amount of edge habitat, the effect on forest-dwelling songbirds must be quantified.

Raptors

We found little published literature about raptors and mining. All research found concerning the effects of mining on raptor populations involved various types of surface mining other than MTMVF. These past studies, focusing on Red-tailed Hawks, American Kestrels, and Northern Harriers, attempted to describe habitat, perch use, and nesting by raptors in and around reclaimed surface mines.

Mindell (1978) described habitat use of Red-tailed Hawks on 12 reclaimed surface mines ranging from 0.7-40 ha in northern West Virginia and southern Pennsylvania. He found that red-tails selected natural or strip-mined edge as well as intact deciduous woods, over natural or strip-mined open areas. Higher use of forest edge in proportion to its availability suggested that edge is important to Red-tailed Hawks. Mindell (1978) suggested that this was due to high prey density along both strip-mined and natural edge, greater number of perches for hunting and resting, and a greater amount of concealment cover along edges. Deciduous forest also was used more than open areas, although small mammal trapping revealed lower prey densities within the forest. He attributed the selection for deciduous forest over open areas to greater availability of resting, concealment, and nesting areas. Mindell (1978) suggested that open areas were used the least, because a majority of the area was out of visual range of the edge and had little value to Red-tailed Hawks due to lack of hunting perches. Although strip-mined habitat was used the least, immature Red-tailed Hawks were seen using these areas, possibly because of the presence of high insect populations.

Forren (1981) conducted a later study on 4 reclaimed surface mines in northern West Virginia, the largest mine being 27 ha in size. Artificial perches for raptors were constructed in reclaimed surface mines to determine if this would increase use by raptors. Use of areas with perches did increase compared to those without, but perch use was restricted to a small number of raptor species. Artificial perches were mainly used by American Kestrels (99%), and minimally by Red-tailed Hawks (0.05%) and Great Horned Owls (0.03%). Perch use peaked in the morning and evening, was highest in July and August, and 6-m perches were used more than 3-m perches. According to Forren (1981), Red-tailed Hawk and Great Horned Owl use was thought to be minor due to low detectability of small mammals in the thick vegetation found on the surface mine. American Kestrels were able to avoid this problem by preying mostly on insects, which occurred at higher densities than small mammals (Forren 1981). Insects and small mammal abundance was measured through sweep netting and trap and removal methods, respectively. Finally, examination of raptor pellets (primarily American Kestrels) showed mostly mammalian remains during May and June, but mostly insect remains during July to October, the period of highest perch use.

Yahner and Rohrbaugh (1998) compared abundance of diurnal raptors on reclaimed surface mines and agricultural habitats in both northwestern and northcentral Pennsylvania. The majority of sightings included 3 species: Red-tailed Hawks, American Kestrels, and Northern Harriers. Other species observed were Cooper's Hawk, Osprey, Broad-winged Hawk, Red-shouldered Hawk, Sharp-shinned Hawk, and Northern Goshawk. Red-tailed Hawks were commonly observed in both habitats in northwestern Pennsylvania and on agricultural habitats in north-central Pennsylvania, but less than expected on reclaimed mines in north-central Pennsylvania (Yahner and Rohrbaugh 1998). American Kestrels and Northern Harriers both occurred more than expected on reclaimed surface mines in the northwest, but American Kestrels occurred less than expected in agricultural habitats in the north-central region, whereas Northern Harriers occurred less than expected in agricultural habitats in the northwestern region. Yahner and Rohrbaugh (1998) concluded that reclaimed surface mines in the northwestern region of Pennsylvania provided suitable habitat for these 3 species, possibly by providing more breeding habitat. Another study by Rohrbaugh and Yahner (1996) used probable and confirmed breeding attempts of Northern Harriers, which were based on Pennsylvania Breeding Bird Atlas data, to correlate the number of breeding attempts in 6 regions of Pennsylvania with the number of reclaimed surface mines in the same 6 regions. They found that the number of breeding attempts by Northern Harriers in the Pittsburgh Plateau Section of the Appalachian Plateau Province were significantly greater than expected, containing 49% of all breeding attempts. This region also had a greater number of surface mines than expected, with 75% of the surface mines in the 6 regions. They concluded that Northern Harriers were associated more than expected with the open grassland habitat created after surface mine reclamation, and suggested that harriers may prefer these areas for nesting over agricultural habitats due to less disturbance associated with reclaimed mine sites (Rohrbaugh and Yahner 1996). However they did not actually locate and monitor northern harrier nests on reclaimed mines, so their conclusion is speculative.

Summary

Large-scale mountaintop removal/valley fill mining has raised questions concerning impacts on raptor populations. Several raptor species, particularly the Red-shouldered Hawk, are considered primarily forest species and breed in large tracts of contiguous, mature forest (Hall 1983, Crocoll 1994). Conversion of forest tracts to earlier successional habitats will change the raptor community in an area from predominantly forest-dependent species to open country species. Creation of fragmented forest patches may also decrease the suitability of forests remaining on or near MTMVF areas and lead to lower abundance of forest raptor populations, which tend to breed in large blocks of intact forest. Although some raptor species such as Red-tailed Hawks have shown a positive response to forest edge created by a small amount of surface mining, it is unknown whether larger areas affected by mining may dissuade use by raptors, mainly because there is proportionally less edge available, there are more open areas lacking perches, and they are more likely to be reclaimed with dense vegetation with low prey detectability (Mindell 1978, Forren 1981). Previous studies examined habitat and perch use by raptors on surface mines other than MTMVF areas (Mindell 1978, Forren 1981). We found no published studies comparing forested habitats with reclaimed areas. The fragmentation of forest and creation of edge by mountaintop removal mines may have variable effects on raptor species. Greater amounts of edge can decrease suitability of an area for Red-shouldered Hawks but increase suitability for Red-tailed Hawks (Moorman and Chapman 1996) and increase competition between these species (Bednarz and Dinsmore 1981, Moorman and Chapman 1996). Other species such as American Kestrels and Northern Harriers may benefit from open areas created by mountaintop mining, since they are often observed hunting in open areas (Bent 1937, Forren 1981), but low availability of suitable perches in open areas may limit use of reclaimed mine lands (Mindell 1978, Bloom et al. 1993). Thus, it is important to quantify what effect relatively large-scale mountaintop removal mines are having on raptor abundance, diversity, and habitat use.

Mammals

Small Mammals and Mining

Although no previous study has examined small mammal populations on MTMVF areas, there have been several studies of small mammals on strip-mined lands throughout the coal mining regions of the mid-western and eastern United States (Verts 1957, De Capita and Bookout 1975, Sly 1976, Hansen and Warnock 1978, Urbanek and Klimstra 1980, McGowan and Bookout 1986). Another study assessed small mammal populations in the Adirondack Mountains of New York on reclaimed open-pit mines for ilmenite (titanium) and magnetite (iron) ores (Kirkland 1976). The mining techniques used in these studies were considerably different from mountaintop removal mining, and the studies did not take place in West Virginia. However, they provide information on small mammal populations following a severe disturbance and subsequent reclamation.

Several studies found that small mammal communities on mines differ as a function of time after the mining activity ceased (Verts 1957, Sly 1976, Hansen and Warnock 1978, McGowan and Bookout 1986). Verts (1957) studied small mammals on 18 strip-mined sites in Illinois 4-22 years after reclamation. The mining process in the relatively flat state of Illinois is somewhat different from that used in the more topographically complex landscape of West Virginia. Verts (1957) describes the process of stripping the soil and rock overburden and then piling it behind the active mine. As the mining operation progresses, a series of parallel ridges are left behind, each about 6.1 to 9.1-m high and about 15.2-m apart. Verts (1957) focused on white-footed mice (*Peromyscus leucopus*) and prairie deer mice (*P. maniculatus bairdii*) and did not report other species captured. He found that the more recently mined areas, where the prairie deer mouse was the dominant species, had the highest overall abundance. The earliest-mined sites, where only the white-footed mouse was captured, had the next highest abundance. Lowest abundance was found on intermediate-aged sites where both species occurred in approximately equal numbers. His analysis of vegetative characteristics did not show differences in species composition, relative abundance, height of vegetation, or percentage of bare ground among the different-aged strip mines. More recently mined sites did have smaller tree diameters and tree height than the earlier mined sites. Still, the data did not support the idea that differences in *Peromyscus* species occupation of these sites was due to plant succession. Instead, Verts speculated that it was caused by differences in light, water, food, accumulated litter, temperature, and relative humidity among the various-aged strip mines.

Sly (1976) conducted a similar study in Indiana, using 3 study sites of different ages. In contrast to Verts (1957), he did not focus on any particular small mammal species, but instead tried to examine the full range of small mammal fauna. However, the only additional species he captured in significant numbers were prairie voles (*Microtus ochrogaster*). His results were similar to those of Verts (1957) in that more recently mined areas had higher overall small mammal abundances than areas that had been less recently mined. The white-footed mouse appeared to select for wooded areas, and the prairie deer mouse and prairie vole selected for areas with little or no woody cover. Hansen and Warnock (1978) and Urbanek and Klimstra (1980) also worked on Illinois strip mines. Both studies had results that were in concurrence with the studies mentioned above: small mammal abundance was higher on recently mined areas than on older areas, white-footed mouse abundance was higher in forests than mined areas, and prairie deer mouse abundance was higher in reclaimed grasslands than forests. McGowan and Bookout (1986) took a slightly different approach; they compared small mammal populations between mined areas that had been reclaimed under different regulations in Ohio. Their goal was to assess whether the passage of more stringent legislation in 1972 for the reclamation of surface mines had affected small mammals. They examined 3 previously mined areas, 2 reclaimed after and 1 reclaimed before the law change. Their results suggested that small mammals were present in greater abundance on areas that had been reclaimed after 1972 than on areas reclaimed before 1972. However, their study results were confounded by the fact that the sites on which the more stringent rules were followed had been reclaimed approximately 10 years after the site that followed the old reclamation laws, so the small mammal density difference may have been related, in part, to vegetative structure.

Each of the studies mentioned above differs from our study in a significant way. Investigators in these studies focused on comparisons among several different age classes of reclaimed mines, whereas we conducted a comparison between reclaimed areas, remnant fragmented forests, and intact forests. In other words, these studies evaluated the changes in small mammal abundance and species composition as a function of time-since-reclamation, while we compared the habitats left after mining (i.e. reclaimed grasslands/shrublands and forest patches) with relatively undisturbed areas (i.e. intact forest). Kirkland (1976) performed a study on open-pit ilmenite and magnetite ore mines in the Adirondack Mountains of New York. His approach was comparable to ours since he sampled small mammals on reclaimed mines (from 1-20 years old) and compared these results to small mammal populations in nearby intact forests. He found a significant difference in species richness between the 2 areas. Overall, 13 species were captured, but only 7 of these were found on previously mined sites, while all 13 were found in intact forests. The intact forests also had higher small mammal abundance, with the deer mouse the only species represented in significant numbers on the mined areas. De Capita and Bookout (1975) compared mined to unmined areas in Ohio. They found higher abundance of *Peromyscus* species, meadow vole, and raccoon on previously mined lands than on unmined lands. Other species, such as short-tailed shrew (*Blarina brevicauda*), opossum

(*Didelphis virginiana*), groundhog (*Marmota monax*), eastern cottontail (*Sylvilagus floridanus*) , and eastern chipmunk (*Tamias striatus*) were present in higher numbers on unmined lands. Unmined lands, in this study, included 3 different habitats: old field, old field-pine, and deciduous woods. Mined land was also of three types: brush hardwoods, hardwoods, and non-vegetated. This fact may confound the results of their study as old fields and reclaimed lands may be in similar stages of succession, having similar vegetative species composition and structure.

Urbanek and Klimstra's (1980) study also yielded results that we can compare to those of our study. Although they did not trap a control (relatively large and intact) forest as we did, they evaluated the small mammal abundance and species richness indices that they found on reclaimed mines in Illinois to those of a previous study conducted on unmined areas near their sites (Terpening et al*.* 1975). This comparison indicated that small mammal abundance was higher on the mined sites than the intact forests and that species richness was not different between the 2 areas. However, small mammal abundance can vary temporally (both yearly and seasonally), so this difference in abundance could be due to temporal rather than habitat differences.

Of the studies examining small mammals and coal mining, the most relevant to our project was a study conducted by Mindell (1978) who trapped small mammals to assess coal mines as raptor habitat in Monongalia County, West Virginia and Green County, Pennsylvania. Using snap traps on reclaimed mines ranging in size from 0.7 to 40 hectares and forests adjacent to mines, he captured 5 species, with meadow voles (*M. pennsylvanicus*) the most common, representing about 70% of the total. Other species captured were short-tailed shrew, white-footed mice, deer mice, and meadow jumping mice (*Zapus hudsonius*). He combined the 2 *Peromyscus* species for analyses because they are difficult to differentiate in this part of their range. Though these 5 species were all found on reclaimed sites, chi-square tests showed that some were more common in either reclaimed areas or forest. For example, *Peromyscus* species selected for forest whereas meadow voles selected for reclaimed areas. Mindell also found that combined small mammal abundance was higher on reclaimed mines than in forests, and that there was a significant positive correlation between litter depth and small mammal abundance among all treatments. His study, however, aimed to assess abundance of small mammals as a potential prey base for raptors, so richness was not calculated nor compared between treatments. Forren (1981) also looked at small mammals in Monongalia County, West Virginia as prey for raptors on several strip-mined areas that had been reclaimed between 1971 and 1976 and ranged in size from 16 to 27 ha; however, he did not trap in forested areas. He found the same 5 species as Mindell with meadow voles representing 56.8% of the total. Like Mindell, Forren determined that there was a significant positive correlation between litter depth and small mammal numbers.

Amrani (1987) compared small mammal populations on surface mine cattail (*Typha* spp.) marshes with populations on nearby reclaimed grasslands in West Virginia. She found that *Peromyscus* (*P. leucopus* and *P. maniculatus* combined) were more abundant in marshes than in grasslands, as was overall small mammal abundance. The marsh may provide a more favorable microclimate during weather extremes such as the heat of summer (McConnell and Samuel 1985). There was, however, no difference in abundance of meadow voles between the 2 treatments. Short-tailed shrews, meadow jumping mice, and house mice (*Mus musculus*) also were captured, but too infrequently for statistical comparisons.

Small Mammals and Forest Fragmentation

Numerous studies have examined the effects of forest fragmentation on small mammals (Gottfried 1977, Yahner 1986, Yahner 1992, Nupp and Swihart 1996, Rosenblatt et al. 1999). Gottfried (1977) compared small mammal abundance and diversity between woodlot islands and large forest tracts in eastern Iowa, and found a positive relationship between forest area and small mammal diversity and abundance. Larger forest islands may have higher diversity because there is more habitat that can support a larger population and lower the chance of a species becoming locally extinct. A second possibility is that larger forest patches are more likely to contain greater diversities of microhabitats, allowing more species to coexist (MacArthur and Wilson 1967). A positive mammalian diversity to forest area relationship also was found by Rosenblatt et al. (1999) in a study of Illinois forest patches ranging from 1.8 to 600 ha. They did not limit their study to just small mammals; instead, they looked at all mammals except bats. Sciurid species such as gray squirrels (*Sciurus carolinensis*), southern flying squirrels (*Glaucomys volans*), and eastern chipmunks (*Tamias striatus*) only were found in larger islands of forest; they did not specify, however, whether small mammal abundance differed between large and small patches. Nupp and Swihart (1996) studied white-footed mice in Indiana, comparing populations in 15 woodlots of various sizes to 3 continuous forests. They found higher densities in small woodlots as well as an inverse relationship between mass of adult male mice and forest patch size. They speculated that small woodlots may have higher food availability since trees and shrubs may be more productive at forest edges, leading to a greater supply of seeds. Also, they note that sciurid species are generally absent from small woodlots, releasing the white-footed mouse from competition for mast during autumn and winter. These results are opposite of Yahner's (1986) results in a study of the spatial distribution of white-footed mice on a forested landscape fragmented by clearcuts in Pennsylvania. Yahner suggested that white-footed mice strongly select for the interior zones of forests, possibly due to differences in predation pressures or food abundance between the forest interior and the edge zones. In a later study, Yahner (1992) examined the effects of habitat fragmentation due to forestry on small mammals in Pennsylvania, trapping on sites classified as 25-, 50-, and 75% fragmented. He found that the white-footed mouse became significantly more abundant as percent fragmentation increased.

Other Mammals

Hemler (1988) researched white-tailed deer *(Odocoileus virginianus*) use of abandoned contour surface mines in Monongalia County, West Virginia. In winter months, deer crossed mines incidentally but did not spend significant amounts of time foraging. She speculated that little use occurred because abandoned, unreclaimed mines, like a natural opening, provide little cover or food for deer. Hemler also propagated bigtooth aspen (*Populus grandidentata*) and trembling aspen (*P. tremuloides*) on these mines to evaluate this technique as a reclamation alternative. She found that deer browsed heavily on the aspen suckers in the summer months where there had been no browsing prior to the study, suggesting that aspen propagation could be a management tool to improve mines as summer deer habitat.

Knotts and Samuel (1977) also studied deer use of surface mines. They found that deer trails were common on reclaimed contour mines, following along highwalls. Heavy browsing was noted in localized areas, specifically on spoil banks that had been heavily seeded with forage species. Browsing was not found to be significant in areas 90 m or more from the highwall in the winter, which they speculated was due to the lack of cover.

Red and gray fox also used reclaimed mines. Yearsley and Samuel (1980) conducted a study in Preston County, West Virginia in which they fitted 4 gray foxes and 2 red foxes with radio collars in an area where there were patches of forest and reclaimed mines. To assess fox use of reclaimed mines in relation to other available habitats, they obtained locations on the collared animals diurnally and nocturnally. Differences in habitat use between the two fox species were not discussed. They found that fox use of mines varied seasonally, with higher use in the fall, winter, and spring than summer. The authors speculated that seasonal differences occurred because foxes feed primarily on small mammals when fruits and berries are not available, and small mammal populations were higher on the mines than in the surrounding forest. They felt that this hypothesis was supported by several observations of foxes hunting for mice on mines during these periods of high use. However, they did not sample small mammal populations.

Summary

Small mammals are an important component of biological diversity, and their populations are affected by forest fragmentation (e.g. Gottfried 1977). Further, small mammals are the primary prey base for a variety of mammalian and avian predators; thus changes in their abundance can affect other species. Although we found no previous studies of small mammal populations on MTMVF areas, there have been several studies of small mammals on strip-mined lands throughout the coal mining regions of the mid-western and eastern US (Verts 1957, De Capita and Bookout 1975, Sly 1976, Hansen and Warnock 1978, Urbanek and Klimstra 1980, McGowan and Bookout 1986). Several authors found that small mammal communities on mines differ as a function of time since mining activity ceased (Verts 1957, Sly 1976, Hansen and Warnock 1978, McGowan and Bookout 1986). Three studies compared small mammal populations on reclaimed lands with those on unmined areas (De Capita and Bookout 1975, Kirkland 1976, Urbanek and Klimstra 1980). However, results from these studies were variable with richness and abundance greater on unmined lands in 1 study (Kirkland 1976) and on reclaimed land in another (Urbanek and Klimstra 1980). Further, unmined lands in the 3rd study (De Capita and Bookhout 1975) included habitats other than intact forests which can confound results. Consequently, additional research is needed to clarify the effects of MTMVF on small mammal populations.

Herpetofauna

Amphibians are the most abundant vertebrates in many temperate forest ecosystems (Burton and Likens 1975) and make up a large part of the vertebrate biomass on certain sites (Pais et al. 1988, Heyer et al. 1994). Declines of amphibian populations have been documented throughout the world due to various causes including loss and degradation of habitats (Wyman 1990). Amphibian life-history traits make them especially sensitive to disturbances that alter microhabitat and microclimate characteristics, including physiological constraints (Feder 1983), relatively poor dispersal capabilities (Sinsch 1990), and small home ranges (Stebbins and Cohen 1995). Populations of several forest amphibian species were positively correlated with the quantity and quality of coarse woody debris, litter depth and moisture, understory vegetation density, and over-story canopy closure (deMaynadier and Hunter 1995). Gibbs (1998) suggests that amphibians may be especially prone to local extinction as a result of human-caused transformation and fragmentation of habitat due to the spatially and temporally dynamic nature of their populations. Because MTMVF alters and fragments forested landscapes, it is important to document the effects on herpetofauna, particularly amphibians.

We are aware of no published studies concerning the effect of MTMVF on the herpetofaunal community inhabiting natural hardwood/stream riparian areas. An extensive search through the West Virginia University library system, and personal communication with regional experts like Dr. T. Pauley (Marshall University) and graduate students at several Appalachian universities (California University of Pennsylvania, Marshall University, and West Virginia University) turned up little published work involving reptiles and amphibians and any form of mining. Four published studies examined the herpetofauna inhabiting ponds on surface mines (Riley 1952, Myers and Klimstra 1963, Turner and Fowler 1981, Fowler et al. 1985), and a graduate student at Marshall University (Huntington, West Virginia) is currently in the process of completing an MS research project concerning MTMVF and herpetofauna (Dr. T. Pauley, pers. comm.).

Riley (1952), examined the effect of surface mining on the regional ecology of the Midwest. His work involved very little, if any, experimentation and mainly used observational data to generalize how mining impacts vegetation and wildlife. He did, however, make reference to a few reptile and amphibian species found in midwestern surface mine ponds. Five amphibian species (America toad *Bufo americanus,* green frog *Rana clamitans,* leopard frog *R. pipiens,* pickerel frog *R. palustris*, and cricket frog *Acris crepitans*), and 3 reptile species (snapping turtle *Chelydra serpentina,* painted turtle *Chrysemys picta*, and northern water snake *Natrix sipedon*) were collected in Ohio strip mine ponds. Additionally, bullfrogs (*R. catesbeiana*) were being raised commercially in at least 1 Illinois strip mine pond. No mention is made of how these findings compare to the herpetofaunal community in undisturbed areas in that region.

Meyers and Klimstra (1963) conducted their work in Perry County, Illinois on sites that had been contour mined. The mining activities in this area left alternating ridges and valleys (spoil banks) with fairly steep slopes (45%). This topography encouraged the formation of many temporary and permanent ponds that had been colonized by a variety of plant and animal life since mining activities ceased approximately 20 years before the study was conducted. A general search (hand capturing and visual observation) found 32 species of herpetofauna inhabiting the site, but only 10 were commonly encountered. The searches were not time- or area-constrained, thus no relative abundance or population estimates were calculated. Myers and Klimstra (1963) compared the 32 species they found with the 39 (Meyers 1957) and 54 (Rossman 1960) species reported by 2 separate inventories of unmined sites located within 75 miles of their Perry County, Illinois site. They concluded that strip-mined lands in general would be inhabited by plants and animals adapted to environmental conditions produced by mining, and that additional population and/or successional studies would provide useful information.

Turner and Fowler (1981) conducted a fairly thorough search of 24 ponds on a surface mine in Campbell County, Tennessee. Because mining had ceased in 1972, the ponds were at least 6 years old when sampling was conducted in the spring of 1978. Dip nets were used to sample amphibian eggs, larvae, and adults. A students t-test was used to compare the average number of species found in ponds with different pH values. Water quality and aquatic vegetation also were sampled. Twelve of the 17 species expected to be found in the area were captured. Significantly more species ($P < 0.05$) were found in ponds with higher pH. In addition to pH, Turner and Fowler (1981) mention that water hardness and presence of emergent vegetation seemed to influence whether or not some species inhabited a particular pond. The spring peeper (*Pseudacris crucifer*) was the most commonly captured amphibian and inhabited 16 of the 24 ponds. They believe that their findings provide justification for leaving mine ponds in place after cessation of active mining, because permanent water usually provides wildlife habitat and it costs less to leave a pond than to remove it.

Fowler et al. (1985) sampled the herpetofaunal community on 11 newly constructed surface mine sediment ponds on 2 separate mines in Campbell county, Tennessee. In addition to reptiles and amphibians, water quality, invertebrates, vegetation, and fish also were sampled. Amphibians were sampled with auditory surveys on 11 surface mine ponds from 1 March 1979 to 29 February 1980. Observers also identified egg masses and used a hand-held D-net to capture larval amphibians. Twelve of the 17 species of amphibians, known to breed locally in ponds, were detected. All ponds had at least 1 species. They also found that the water quality, in most cases, was of sufficient quality to support aquatic life. Apparently, searches were not time- or area-constrained so density and/or abundance were not calculated. Fowler et al. (1985) recommended the retention of these sediment ponds after mining stopped because they seemed to have a large potential for fish and wildlife.

None of these studies were conducted on MTMVF areas, they generally did not include terrestrial species, nor did they use methods that accurately quantified time and effort. Although 3 of the studies compared the number of species found to the number of species thought to inhabit the region, no direct comparisons were provided because intact habitats were not sampled. Based upon these limited data, it seems that some herpetofauna, particularly those associated with bodies of standing water, colonize surface mine sites when mining ceases or suitable habitat is provided, however it is not known if abundance or species composition is similar to unmined habitats. These studies may indicate a general trend, but their results cannot be extrapolated to how MTMVF may affect West Virginia reptiles and amphibians due to limitations studies imposed by the methods used, lack of experimentation, and geographic and temporal differences.

Summary

Herpetofauna, particularly amphibians, can be ideal indicators of how well reclamation efforts have succeeded because they are susceptible to small environmental changes (Jones 1986) and make up a large part of the vertebrate biomass on certain sites (Pais et al. 1988, Heyer et al. 1994). However, a thorough literature search revealed little previous research concerning the effects of surface mining on herpetofauna. Myers and Klimstra (1963) and Fowler et al. (1985) studied the colonization of surface mine sediment ponds by herpetofauna, but we found no published literature regarding the effect of surface mining on stream, riparian, or terrestrial herpetofauna. Because the conditions resulting from mountaintop mining and subsequent reclamation are dramatically different from those provided by the original intact forest, more information is needed on how hepetofaunal populations are responding to these changes.

Methods

Study Areas

Study sites for the terrestrial study were selected to overlap as much as possible with study sites used for the aquatic studies. The Environmental Protection Agency (EPA) aquatic team initiated aquatic studies on 5 watersheds (Mud River, Spruce Fork, Island Creek, Clear Fork, and Twentymile Creek). Two of these watersheds (Island Creek and Clear Fork) were inappropriate for use in the terrestrial wildlife studies. Human activities on Island Creek such as grazing, orchards, and homes would have confounded study results. Clear Fork was not suitable because much of the area was reclaimed recently and little vegetation had become established. Therefore the remaining 3 watersheds were used for the terrestrial study areas (Fig. 1) in summer 2000. Initial work on the study in 1999 focused primarily on the Mud River and secondarily on the Spruce Fork watersheds.

Study areas included 4 treatments: intact forest, fragmented forest, young reclaimed mine (grassland), and older reclaimed mine (shrub/pole) (Table 1). The latter 3 treatments resulted from mining and reclamation activities. Intact forest sites are relatively large intact forested areas undisturbed by mining activities and located near the reclaimed sites, either within the same watershed as a mining site or in an adjacent watershed. Although these sites are relatively contiguous forest, they do have some breaks in canopy cover from streams, roads, and natural canopy gaps. Some intact forest sites are located in close proximity to MTMVF areas, but no intact forest site shares more than 1 edge with an MTMVF area. On the other hand, we defined *fragmented* forest as a tract of forest primarily surrounded by reclaimed mine land on at least 3 sides. Young reclaimed mine areas (grassland) consist mostly of grasses and are about 5-19 years of age. Older reclaimed mine areas (shrub/pole) contain shrub and pole-sized vegetation and are about 13-27 years of age. Because these 2 treatments are defined by vegetation characteristics of early and later successional stages, lack of succession on some older grassland sites resulted in an overlap in age for these 2 treatments. Mine ages were determined from the estimated year sites were reclaimed and were provided by Arch Coal and Cannelton Mining companies.

The intact and fragmented forest areas were comprised mostly of mature hardwood species including red oak, white oak, black oak, pignut hickory, bitternut hickory, shagbark hickory, tuliptree, American beech, red maple, sugar maple, American sycamore, white ash, and black birch (scientific names of tree and shrub species are found in Appendix 2). Understory trees (seedlings, saplings, and poles) in these areas included American beech, black birch, black gum, flowering dogwood, ironwood, red and sugar maple, sourwood, spicebush, and white ash as well as other common hardwood species. These stands were second growth forests that appeared to be approximately 60-80 years old. Although forested, these stands may have been periodically disturbed over the last several decades from firewood cutting, single tree harvesting, thinning, and forest fires.

The primary vegetation on the young reclaimed mine areas included tall fescue (*Festuca arundinacea*), sericea (*Lespedesa cuneata*), autumn olive, black locust, European black alder, and scotch pine. Vegetation on older reclaimed mine areas included goldenrod (*Solidago* spp.), tall fescue, sericea, autumn olive, black locust, scotch pine, red maple, American sycamore, tuliptree, multiifora rose, and blackberry/raspberry. Tree and shrub species on these older sites were larger and more predominant than on younger sites.

Study areas included 3 MTMVF sites and nearby forest lands in southwestern West Virginia (Table 1 and 2, Fig. 1). Sample points were placed along and surrounding 15 stream drainages on the 3 watersheds (Table 1, Fig. 2-11). All figures also show locations of EPA water quality sampling points.

The Hobet 21 mine is located in the Mud River and Little Coal River watersheds in Boone County (Fig. 1 and 2). Fragmented forests on this site are forested areas surrounded on 3 sides by grassland habitat (Fig. 3). First-order streams had valley fills, whereas second-order streams were left intact. The intact forest treatment sites were located in 3 drainages; 2 were just south of the mine (Fig. 2 and 3) and 1 was located approximately 5 km northeast of the mine along the Big Buck Fork of Hewitt Creek (Fig. 4 and 5). Two areas were used for the shrub/pole treatment: 1 in the northeastern section of the mine (Fig. 2 and 3), and 1 along a valley fill at the head of the Hill Fork of Hewitt Creek (Fig. 4 and 5). All grassland sampling points were located on the mine.

The Daltex mine is located in the Spruce Fork watershed in Logan County (Fig. 1 and 6). Fragmented sites were located along a second order stream that is surrounded by reclaimed mountaintop mines and contour mines (Fig. 7). The intact forest treatment sites were located approximately 1.6 km northeast of the mine along Bend Branch of Spruce Fork, and approximately 1.6 km east of the mine along Pigeonroost Branch (Fig. 6 and 7). No shrub/pole treatment was established at Daltex because the small amount of this habitat that was available was not created by MTMVF but contour mining. All grassland sampling points were located on the mine.

The Cannelton mine is located in the Twentymile Creek watershed along the border of Kanawha and Fayette Counties (Fig. 1 and 8). The forest fragment treatment on this site was a forested areas surrounded on 3 sides by grassland habitat (Fig. 9). Intact forest sampling points were located northeast of the mine along the Ash Fork of Twentymile Creek on the border of Clay and Nicholas counties (Fig. 10-11). The EPA had selected Neil Branch, located just east of Ash Fork, as their intact site; however, recent logging activity precluded our use of this drainage. Both the grassland and shrub/pole treatments were located on the mine.

Selection of Sampling Points

Sampling points were established within each treatment at least 75 m from the edge of any other treatment and at least 250 m apart. Within the 2 forest treatments, sampling points were located 35 m from streams (to coincide with mammal transects and herpetofaunal arrays), upslope at least 75 m from streams (Fig. 12), and on or near a ridge top. Within reclaimed areas, points were positioned similarly but relative to the rip-rap channel. Sampling points were distributed over the 3 watersheds and 4 treatments (Table 2). Elevations of sampling points ranged from 241-566 m (Table 3).

Intact Forest

Points in intact forest sites were established along first- and second-order streams, with points placed 35-m from streams, 75-m upslope from streams and on or near the ridge top at the head of hollows. Sampling points were located systematically with the first point placed 75 m from an edge and 35 m from streams. Subsequent points were placed 250 m apart, alternating banks if possible. In some cases, consecutive points were on the same bank if minor edges from canopy openings or trails were present on the opposite bank. An attempt also was made to alternate consecutive points so that 1 was 35 m from the stream and the next was upslope at least 75 m. Again, this was not always possible due to the presence of edges or human disturbance. Generally we attempted to place points in the least disturbed areas, to minimize effects of edges, and to sample sites with a gradient of elevations that could be compared to head-of-hollow fills on reclaimed sites and fragmented forests along lower reaches of streams.

Fragmented Forest

The majority of fragmented forest sites occurred at the base of head-of-hollow fills (e.g. Fig. 3); therefore, the first sample point was placed 75 m from the forest/reclaimed edge and 35 m from the stream with successive points placed as described for intact forest. Fragmented forest was limited in the Spruce Fork watershed, thus points were established in what was available. Three points were placed on the south bank of Beech Creek, 2 at 35 m from the stream and 1 upslope (Figs. 6 and 7). This fragment is very narrow and the north bank was close to the road edge. The other 3 points were placed in fragments of upland forest at least 75 m from roads and other edges. At the Twentymile Creek fragment site (Hughes and Jim Forks), 6 points were established as described above along the main creek and 4 points were established along streams below head-of-hollow fills that drain into Hughes Fork (Fig. 9). Fragments with sampling points ranged in size from 30-214 ha (Table 3).

Reclaimed Grasslands

At the Mud River and Twentymile Creek sites, we placed 1 point 35 m from rip-rap channels in head-of-hollow fills on reclaimed grassland sites, and remaining points were placed upslope in areas above valley fills to sample areas of higher elevation. These latter points were not positioned relative to the channel, but were kept 250 m apart. At the Spruce Fork site (Rockhouse Creek), 6 sampling points were established along the main rip-rap channel of Rockhouse Creek, alternating banks and distances from channels. Another 6 plots were located above the valley fill on the top of the mountain. The estimated age of grassland points ranged from 5-19 years (Table 3).

Reclaimed Shrub/pole

Shrub/pole points were established at Twentymile Creek and Mud River sites. This treatment was limited, and thus our points were established without regard to streams or elevation. They were placed wherever this habitat occurred, and where points could be placed at least 75 m from the edge and at least 250 m apart. Six sample points, at the Cannelton mine, were placed in an area that we were told was the oldest MTMVF site in West Virginia. The age of shrub/pole points ranged from 13-27 years (Table 3).

Songbird Abundance

Songbird abundance was measured from 0630 to 1030 hrs on fixed-radius 50-m point count plots using standardized methods (Ralph et al. 1993). All birds seen or heard in a 10-min period were recorded. We recorded if the bird was observed visually or aurally, identified the sex if possible, whether it was flying over, and whether it was within or outside the 50 m plot. Surveys were not conducted during windy or rainy weather. Percent cloud cover and wind speed were recorded using standardized scales (Martin et al. 1997, Table 4). All point counts were surveyed twice during the breeding season (late May-June), each time by a different observer. Points were surveyed twice in order to increase the number of species detected. Petit et al. (1995) determined that 20% more bird species are detected with 2 counts than with 1 in eastern deciduous forests, and that 20 min of total counting time (two 10-min counts) is required to develop a relatively complete species list. Two observers conducted all counts in 1999; these 2 individuals plus a third person conducted all counts in 2000. All observers had previous experience identifying songbird species by sight and sound. Prior to initiating surveys, observers conducted simultaneous point counts to verify bird identification skills and distance estimation. At least 3 practice sessions in each habitat type (grass, shrub/pole, and forest) were conducted. After conducting the point counts, observers compared species and distances estimated. Observers then paced 50 m in order to improve their distance estimation skills. They also paced to approximate locations of different bird species to practice placement of birds within or outside the 50-m radius circle. The maximum number of birds at each count was used in data summaries and analyses. Each sampling point station was geographically referenced using a global positioning system (GPS).

Songbirds were placed into 1 of 4 habitat guilds based on their habitat preferences and into 1 of 5 nesting guilds based on where they place their nests. Habitat guilds were: grassland, edge, interior-edge, and forest interior. Nesting guilds were: ground, shrub, subcanopy, canopy, and cavity. Birds were placed into these guilds and groups based on Whitcomb et al. (1981), Ehrlich et al. (1988) and from personal observation of species in the study area. Abundances of each guild were compared among treatments using a two-way analysis of variance (ANOVA) with treatment and year as factors (Zar 1999). If a treatment by year interaction occurred, we conducted one-way ANOVA tests comparing treatments in each year separately. Total abundance and species richness also were compared using ANOVA. The Waller-Duncan k-ratio t-test was used to examine differences between individual treatment means. Additionally, individual species that were observed at >5% of point counts in fragmented and intact forest were tested for differences using ANOVA between fragmented and intact forest. We also used the Jaccard and Renkonen indices to examine community similarity between pairs of treatments (Nur et al. 1999). Bird species that are typically difficult to survey with point counts, such as flocking species, species with large territories, and non-vocal species, were excluded from the analyses of total abundance, species richness, and similarity. Bird abundances and guild abundances were transformed prior to analyses using the transformation $X'=\log_{10}(X+1)$, where X' is the transformed value and X is the original value (Zar 1999). Although most abundances were not normally distributed after transformation, we chose to proceed with ANOVA because ANOVA is “robust with respect to the assumption of the underlying populations’ normality” (Zar 1999). Avian nomenclature follows the American Ornithologists’ Union Check-list of North American Birds, seventh addition (AOU 1998, Appendix 1).

Partners in Flight (PIF) identified 15 songbird species as priority species for conservation in the upland forest community of the Ohio Hills and Northern Cumberland Plateau physiographic areas, the 2 areas within which our study sites fall (Table 5; Rosenberg 2000, R. McClain, personal communication). The Cerulean Warbler in particular is listed as being at Action level II (in need of immediate management or policy rangewide) by PIF. The Louisiana Waterthrush and Eastern Wood-pewee are other species of concern, listed at Action level III (management needed to reverse or stabilize populations). The other 12 species are at Action level IV (long-term planning to ensure stable populations needed). We developed logistic regression models for the 11 listed species (Cerulean Warbler, Louisiana Waterthrush, Worm-eating Warbler, Kentucky Warbler,Acadian Flycatcher, Wood Thrush, Yellow-throated Vireo, Hooded Warbler, Scarlet Tanager, Black-and-white Warbler, and Yellow-billed Cuckoo) that were found at >5% of point counts (Table 5).

We used forward logistic regression (Neter et al. 1996) to examine the relationship between habitat characteristics and the presence/absence of these 10 forest songbirds using habitat data from fragmented and intact forest point counts. The significance level chosen for entry and retention in the model was 0.10. We used presence/absence as the dependent variable because at most point counts only 1 individual of a species was detected within 50 m (Hagan et al. 1997). This technique was chosen because it has been used by other researchers examining the effects of landscapes on songbird species (Hagan et al. 1997, Villard et al. 1999), and because predictor variables do not need to follow a joint multivariate normal distribution (Neter et al. 1996). The Hosmer and Lemeshow goodness-of-fit test was used to determine if the data fit the specified model. Models were rejected if the p-value for the goodness-of-fit test was <0.10, indicating that we should not reject the null hypothesis that our data fit the specified model (Cody and Smith 1997).

Nest Searching

Nest searching was conducted in 2 grassland areas on each of the 3 mines for a total of 6 sites. To obtain a good estimate of species-specific nest survival, a minimum of 20 nests per species must be monitored (Martin et al. 1997). Therefore, we set a target of 20 nests for each of the most common species in the grassland habitat (i.e. Grasshopper Sparrow and Eastern Meadowlark). However, breeding birds in grassland habitat often have low densities, and we were not able to locate this many nests by searching a defined area (plot). Thus, a plotless nest searching method was used (Martin et al. 1997) so that a larger area could be searched for breeding birds. The amount of area actually searched for nests was estimated using GIS maps of each mine site.

Each nest searching area was searched every 3 days by 2-3 field technicians trained in proper searching and monitoring techniques (Martin and Geupel 1993). Nest searching began one-half hour after sunrise and concluded 8 hr later (approximately 0600-1400 EST). Nest searching methods followed national BBIRD (Breeding Biology Research and Monitoring Database) protocols (Martin et al. 1997). Nests were located by flushing females, by following adult birds, and by observing parental behavior (i.e. carrying nest material or food, copulation). When time allowed, other project personnel also searched for songbird nests.

All nests found were monitored every 3-4 days (Martin et al.1997). Because nests in grasslands are typically well-concealed, they were marked for relocation using 2 flag stakes. The stakes were placed on either side of the nest at a distance of 15 m. Care was taken when monitoring the nest to avoid disturbing the female. When possible, nest searchers observed the nest from a distance of no less than 15 m for up to 30 min to confirm that it was still active. The nest was approached and checked for contents a maximum of 4 times: once when it was initially found, once to confirm clutch size, once to confirm brood size, and once to confirm fledging success or failure. Nests were not approached when avian predators (e.g., American Crows and/or Blue Jays) were observed nearby because these birds will follow humans to nests (Martin et al. 1997). Observers also continued to walk in a straight line after checking nest contents to avoid leaving a dead-end scent trail directly to the nest that might be followed by mammalian predators (Martin et al. 1997). The vegetation concealing nests was moved to the side using a wooden stick to avoid putting human scent on nests if the vegetation blocked the observer’s view of contents.

A nest was considered successful if it fledged at least 1 young. Fledging success was confirmed by searching the area around the nest for fledglings or for parent-fledgling interactions. However, if no fledglings were observed, the nest was considered to have fledged young if the median date between the last nest check when the nest was active and the final nest check when the nest was empty was within 2 days of the predicted fledging date (Martin et al. 1997). Nest survival was calculated using the Mayfield method (Mayfield 1961, Mayfield 1975). Daily nest survival estimates were calculated for the incubation and brooding periods separately because nest survival may differ between these 2 periods. The overall daily survival rate was calculated as the product of incubation and brood daily survival. Survival during the egg-laying stage was not included in the calculation of overall nest survival because we found few nests during this stage of the nesting cycle.

Surveys to determine fledgling density were conducted in late July and early August on each mine. Three 500-m transects on each mine were walked at a pace of 1.5 km/hr and all fledglings seen within 25 m of either side of the transect center line were recorded. Transects were established to coincide with areas that had been searched for nests. Fledgling densities were determined by calculating the number of fledglings divided by 2.5 ha (i.e 500 m x 2(25) m) on each transect. The average of the 3 transects was used as the measure of fledgling density for each mine.

Bird and Mammal Use of Ponds

In summer 2000, we documented presence/absence of small mammals and birds that used ponds located on reclaimed mine sites during early May, late June, and late August (mammals), and early May, late June, and late September (birds). Sample dates for mammals were selected to coincide with the new moon because small mammals are more active when the moon is dark. Ponds on each mine were identified using aerial photographs and ground truthed for accuracy. Ponds were placed subjectively into 2 size classes, either small or large. Ten ponds in each size class, for a total of 20 ponds, were selected randomly and distributed over the 3 mines. Small ponds averaged 0.16 ha (range:0.03-0.28 ha), and large ponds averaged 0.53 ha (range: 0.30-1.38 ha). We placed a small mammal trapping transect 100 m in length within 10 m of each pond margin. Two Sherman live-traps placed at each of 10 trapping stations spaced 10 m apart along the transect were baited with a mixture of peanut butter and rolled oats. Traps were open for 2 nights during each sample period. All animals captured were marked and released. All birds observed using the pond were recorded as field technicians were approaching the pond and during a 10-min point count. At each pond, we established a bird point count station on the side of the pond opposite the small mammal transect. All birds seen or heard within 50 m of the pond were recorded using standard point count methods described above. Mammal and bird data from pond surveys were used only to document presence/absence.

Vegetation Measurement

All Treatments

We measured vegetation and habitat characteristics on all sampling points within each treatment using methods modified from James and Shugart (1970) and the Breeding Bird Research Database program (BBIRD; Martin et al. 1997). Within each point count circle, 4 0.04 ha vegetation subplots were established (Fig. 12). Subplots were placed at the center of the circle, and 35 m away at 0°, 120°, and 240°. At points associated with small mammal transects, 2 subplots were located on the transect line, 1 centered on the point count, and 1 upslope from the point count center. Subplots along the mammal transect were located 45 m from the center and spaced approximately 60 m from each other (Fig. 13). The upslope plot remained 35 m from the center.

Within each 0.04 ha subplot, all tree species were identified and placed into 1 of 5 diameter-at-breast height (dbh) classes: >8-23 cm, >23-38 cm, >38-53 cm, >53-68 cm, and >68 cm. Within a 5.0-m radius circle centered on the subplot, we counted number of sapling stems (woody species >0.5 m high) in 2 size classes: $\leq$2.5 cm at 10 cm above ground and >2.5-8 cm at 10 cm above the ground.

An ocular sighting tube was used to measure percent ground cover and canopy cover (James and Shugart 1970). The sighting tube was a 5.0-cm pvc pipe with cross-hairs at 1 end. If the cross hairs sighted on vegetation, then canopy cover was recorded as present (a 'hit'). Five sight-tube readings were taken on each subplot every 2.26 m along 4, 11.3-m transects that intersected at the center of the subplot (Fig. 12). The number of hits divided by 20 provided a quantitative measure of percent cover. Ground cover was recorded as the cover type in the cross hairs, either green (grass, shrubs, fern, herbaceous vegetation combined), bareground/rock, moss, woody debris, water, or leaf litter. On grassland vegetation points, green vegetation was separated into more detailed categories including: grass/sedges, forbs (herbaceous plants), and shrubs (woody species <0.5 m tall). We defined woody debris as any dead woody material $\geq$4 cm in diameter on the ground. All other woody material on the ground counted as litter. Water was recorded as ground cover if the sampling point fell across a stream or pool. Canopy cover was recorded for 6 layer classes representing shrub, sapling, understory, subcanopy, codominant, and dominant trees: 0.5-3 m, >3-6 m, >6-12 m, >12-18 m, >18-24 m, and >24 m. A structural diversity index, which takes into account the amount of canopy cover in each layer class and the number of layers present, was calculated using these variables (Nichols 1996). Canopy cover and structural diversity was only measured in the shrub/pole, fragment, and intact forest treatments.

Average canopy height and percent slope were measured with a clinometer, whereas a compass was used to determine the aspect. Elevation was determined using digital elevation models in a GIS.

Edge types represented abrupt changes in habitat and may or may not have been linear (roads, streams, etc.). We identified several potential edge types on the study areas, some of which we considered “internal” edges and some that were “external” edges. Internal edges represented relatively minor breaks in continous habitat and were usually linear. External edges were usually much larger in extent than internal edges and represented a considerable break in the habitat. In intact and fragmented forest, internal edges included streams, roads, and natural gaps, and external edges included valley fills and grasslands in mined areas. In grassland and shrub/pole habitat, internal edges included roads, valley fills, ponds, and blocks of autumn olive, and external edges were primarily forest.

We recorded 3 edge classes and determined the distance of each edge from the point count center. First, the closest internal or “minor” edge type (Table 4) and distance was recorded for each subplot. The distance to this edge was determined by pacing. The average distance of the 4 subplots from any minor edge was used in analyses as the distance from minor edge. We also calculated the percentage of subplots in each treatment that were closest to the 13 minor edge types. Second, we determined the distance from the center of each point count to the closest “habitat” edge using aerial photographs in Arcview GIS. The edge types for this edge class were: grassland-shrub/pole; forest-grassland; forest-shrub/pole, and forest-active mine. Third, we calculated the distance to the closest “mine” edge (either grassland, shrub/pole, or active mine) for forest points and the distance to the closest forest for grassland and shrub/pole points. In most cases the habitat edge and the mine/forest edge were identical, but in some cases an alternative habitat was closer than the mine/forest edge.

Slope aspects were transformed before analyses the Beers et al. (1966) procedure, using the equation:

$$A' = (COS(45-A)+1)$$

where A' is the transformation index and A is the direction the slope faces in degrees (Frazer 1992). With this transformation, northeastern facing slopes receive a value OF 2 and reflect mesic conditions, while southwestern exposures receive a value of 0 and reflect xeric conditions. Other exposures are distributed between these values. We assigned an aspect index of 0 to points on dry ridge tops, and an index of 2 to points in flat bottomlands because ridge tops and bottom lands have no slope and thus no aspect, but ridge tops tend to be xeric while bottomlands are mesic (Frazer 1992).

All percentage variables (i.e. slope, ground cover, and canopy cover) were transformed using the arcsine-square root transformation (Zar 1999) prior to analyses. Stem densities were transformed using the transformation $X'=\log_{10}(X+1)$, where X' is the transformed value and X is the original value (Zar 1999).

Habitat variables were tested for differences among treatments using two-way ANOVA (Zar 1999). Treatment and mine were the main factors in the models, and treatment by mine was included as an interaction term. The average values for all variables from the 4 subplots were used in analyses. ANOVA was used to compare treatments after variables had been transformed. Similar to analyses of songbird abundances, most habitat variables were not normally distributed after transformation, but we chose to proceed with ANOVA because it is robust to deviations from normality (Zar 1999). If there was a significant interaction ($P<0.05$) between mine and treatment, we conducted one-way ANOVA's to determine the exact nature of the interaction.

Grassland and Shrub/pole Treatments

Additional vegetative measurements were collected at grassland points. A Robel pole, described below, was used to record most of these data and was used to determine the amount of vegetative cover and grass height.

The Robel pole (Robel et al. 1970) was a stick demarcated at half-decimeter intervals (Fig. 14). The pole was placed vertically on a point. An observer moved 4 m away from the pole, and with their eyes 1 m above the level of the ground, noted the lowest interval on the pole that was not completely obscured by vegetation. This interval was recorded as the distance in decimeters from the ground to the bottom of the interval. Measurements with Robel poles have been widely used to characterize vegetation around nests of birds (Kirsch et al 1978). They are used to measure height of vegetation and provide an index of biomass (Robel et al. 1970). To quantify vegetative cover, measurements with the Robel pole were taken at the subplot center, and at 1, 3, and 5 m along each transect (Fig. 15) for a total of 16 measurements. We took 4 measurements at the center, with the observer facing towards the center of the subplot from each of the 4 transect directions. A single measurement was taken at every location away from the center with the observer facing towards the center of the subplot. Vegetative cover at a point was the average of these 16 measurements.

Maximum height of herbaceous vegetation was measured to the nearest 0.5 dm (Fig. 14) using the Robel pole placed at the following locations: the center, 1, 3, 5, and 10 m along each transect (Fig. 15). At each of these locations, the height of the tallest herbaceous vegetation within a 3.0-dm radius circle of the pole was recorded. Vegetation height for the plot was the average of the 17 measurements.

The depth (in centimeters) of organic litter was measured at 13 locations along the 4 transects:

at the center and at distances of 1 m, 3 m, and 5 m along each transect (Fig. 15). If the point landed on a rock or log, we moved our measurement location to the nearest point that had mineral soil on which litter could potentially rest. If a point fell on bare ground, litter depth was recorded as 0.0 cm. We measured litter depth using the metric ruler on a compass.

Vegetation variables measured at grassland points also were measured at Grasshopper Sparrow nests in 2000. However, results were not analyzed statistically because of small sample sizes.

Raptor Abundance

Raptor abundance and habitat use were quantified at 48 of the songbird point count stations on the study areas. Stations were located approximately 0.8 km apart according to the protocol suggested by Fuller and Mosher (1987). Twelve survey stations were sampled monthly (February - September 2000) in each of the 4 treatments with roughly equal numbers of sample points over the 3 mines (Table 2). All 48 points were sampled over a 4-6-day period. Points from at least 3 treatments were sampled on a given day to minimize temporal variability between treatments. The order that points were sampled on a given day was randomly established during the first survey. On subsequent surveys, the order in which points were sampled was systematically varied through 3 daily time periods: early, mid-, and late-day.

We used broadcast surveys to sample raptor populations because broadcasting conspecific vocalizations is an effective way to survey targeted raptor species (Rosenfield et al. 1988, Mosher et al. 1990, Kennedy and Stahlecker 1993). During winter months, broadcast surveys were conducted from one-half hour after sunrise until 1600 hrs because raptors can be active throughout the day during cooler weather. During summer months, broadcast surveys were conducted from one-half hour after sunrise until 1300 hrs, because shifts in raptor activity in the afternoon may reduce the detectability of certain raptor species such as Red-tailed Hawks and *Accipiters* (Bunn et al. 1995).

Broadcast surveys lasted 10 min, and consisted of 5 min of broadcasting vocalizations and 5 min of observation/listening time. Six calls were broadcast for a 20-sec duration at 1-min intervals (20 sec of vocalization, followed by a 40-sec listening period), leaving a final listening period of 4 min and 40 sec and thus making a total of 10 min. The broadcast speaker was held 1.5 m above the ground and rotated 120° between each broadcast. Calls were broadcast at a volume of about 110 db at 1 m from the megaphone speaker. Both Great Horned Owl and Red-shouldered Hawk vocalizations were used during the survey period. The 6 vocalizations alternated between Great Horned Owl and Red-shouldered Hawk calls. Previous studies (Mosher and Fuller 1996, McLeod and Anderson 1998) have shown that many raptor species respond to either Great Horned Owl or conspecific calls. Red-shouldered Hawk vocalizations were used to specifically elicit responses from Red-shouldered Hawks (a migratory nongame bird of management concern in the Northeast; Peterson and Crocoll 1992), while the Great Horned Owl vocalizations were used to elicit responses from other raptor species. We randomly determined which type of call (Great Horned Owl or Red-shouldered Hawk) would start the first survey each month, with the second survey starting with the call not previously used, and thus alternating throughout the entire survey session each month.

Two observers trained in identification of raptors by sight and sound were present at every survey. One individual was the primary observer and was present at each survey. The second observer alternated between a number of individuals. During the 10-min survey period, both observers actively watched and listened for raptors. Surveys were not conducted in inclement weather (moderate to heavy rain, fog, or wind).

Data recorded on surveys included weather conditions (cloud cover/precipitation, wind, and temperature), nearest edge type, distance to edge, latency (time from start of survey until first raptor detection), general vegetative cover characteristics (size class of trees, amount of cover, dominant plant species), raptor species detected, age and sex (if possible), behavior during detection (perch and call, flyby and call, silent perch, silent flyby, vocal only), time each individual bird is seen, estimated distance bird is from observer, and habitat type in which a bird is first detected. Survey data were summarized as mean number individuals detected within a season. The winter season was defined as December-March, the summer season April-July, and the migration season August-November.

Roadside surveys also were conducted once in late July on each of the 3 mines. These surveys consisted of driving a specified route at 16 km/h through grassland, shrub/pole, and fragmented forest treatments, while looking and listening for raptors. The intact forest treatment was not included in roadside surveys because this treatment had no drivable roads. Each roadside survey period was similar in time and length (about 2 hrs for 16-24 km) and covered approximately equal areas of the 3 habitat treatments for each mine. The only exception was the Daltex mine, which lacked areas representative of the shrub/pole treatment. All raptor species observed were recorded along with the time, distance away from the road (m), habitat, and behavior. Other data recorded were the length of survey (km), start and end of survey, and weather conditions (cloud cover, precipitation and wind).

Small Mammal Abundance

In May-August 2000, small mammal abundance and richness were quantified on 38 150-m long transects adjacent to riparian zones with each of the 4 treatments replicated 8-10 times (Tables 1 and 2). In May-August 1999, 24 transects in 3 treatments (grassland, fragmented forest, intact forest) were sampled. The number of transects sampled for the Mud River watershed was greater than that for the other 2 watersheds because these transects had already been established and sampled in 1999 before the study was expanded to include the Twentymile Creek watershed. Small mammal transects coincided with a randomly selected subset of the songbird point count stations located 35 m from the stream or rip-rap channel. Transects crossed the 50-m radius circle of the point count plot, about 10 m from the channel (Fig. 13) and were oriented so that their centers aligned with the center of the point count station. Transects followed a constant bearing for as long as the channel allowed, changing direction only when necessary to maintain a fairly uniform channel distance. Trapping stations were placed at 10-m intervals along each transect line, with 2 Sherman live traps (7.7 x 7.7 x 23 cm) placed within 2 m of each trapping station. Thus, each transect had 30 traps. Bait consisted of a peanut butter and oat mixture. Trapping methods followed those of Jones et al. (1996).

The 38 transect lines were divided into 5 trapping blocks. Two of these blocks included 6 transects with 2 each from 3 of the treatments. In these blocks, the older reclaimed treatment was not represented because reclaimed land of this age was not present in close proximity to the other 3 treatments. Another 2 blocks included 8 transects with 2 from each of the 4 treatments. The fifth block included 10 transects: 2 from each of the 4 treatments plus an additional 2 transects in an older reclaimed area that is now dominated by pine woodlands. Transects within each block were trapped concurrently, thus minimizing temporal effects on comparisons between treatments. Blocks contained transects located as close to one another as the landscape allowed to minimize spatial differences. The traps were rotated weekly to a new block until each block was trapped 2 times over the summer. Traps were pre-baited for 1 night and then opened and checked for 3 consecutive nights. The period between trapping sessions at a given block was about 25 days.

Captured animals were identified, weighed, sexed, and examined for reproductive status. All individuals except members of the shrew family (Soricidae) were marked with numbered metal ear tags before release. Because shrews have small external ears, these species (short-tailed shrew and masked shrew (*Sorex cinereus*) were marked by toe-clipping (ACUC# 9904-10). Any individuals that died in traps were saved as voucher specimens.

Statistical methods included calculations of relative abundance of small mammals, expressed as the number of individuals trapped per 100 trap nights, with recaptures excluded. A correction was made for sprung traps in calculations of trap effort; one-half a trap night was subtracted for each trap sprung for any reason, including the capture of an animal (Nelson and Clark 1972, Beauvais and Buskirk 1999). Species richness was calculated as the number of species captured per transect. A randomized block analysis of variance (ANOVA) (Zar 1999) was used to compare total relative abundance, species-specific relative abundance, and species richness among treatments. Concurrently trapped transects were considered blocks for this model since temporal and spatial factors were minimized by the design. When differences between treatments were detected by the ANOVA, Duncan's multiple comparison test was used to find where the differences occurred. Statistical tests were considered significant at $\underline{P} \leq 0.05$.

Surveys were not conducted for larger mammals such as carnivores and ungulates (Order Carnivora, Order Artiodactyla); however, any incidental sighting was recorded to document their presence on the study area. Surveys also were not conducted for bats (Order Chiroptera), though an important part of the mammalian fauna, due to time and logistical limitations. Because small mammal trapping initially began in 1999, we chose to continue sampling this group in 2000.

Herpetofaunal Abundance

Pitfall and funnel traps, when associated with drift fence arrays, are extremely effective in collecting large numbers of herpetofauna and in capturing the majority of species from a given area with minimal effort (Campbell and Christman 1982, Vogt and Hine 1982, Jones 1986, Bury and Corn 1987, Mengak and Guynn 1987, Pais et al. 1988, Corn 1994). Campbell and Christman (1982) also found that drift fence arrays can be used to "…provide a clear indication of relative abundances between habitat types." Drift fence arrays have been used effectively in both forested areas (Bury and Corn 1987) and grassland/wetland areas (Vogt and Hine 1982, Homyack 1999). Accordingly, we chose this method to gain relative abundance and species richness data for comparison among the 4 treatments.

Because of their ability to intercept animals traveling in any direction, we used plus (+) shaped arrays with 15 m of central separation (Fig. 16; Campbell and Christman 1982, Corn 1994). Fifteen meter sections of 30-cm tall plastic silt fencing, supported by wooden stakes, were used to construct the drift fence (Enge 1997). Silt fencing is lighter and cheaper than the traditionally used aluminum flashing, but is durable and appears to work just as well (Enge 1997, Homyack 1999). An 18.9-L plastic bucket (pitfall trap), was buried flush with the surface at the end of each individual drift fence (Campbell and Christman 1982, Vogt and Hine 1982, Pais et al.

1988, Corn 1994). Plastic bucket lids, elevated by sections of untreated 2 x 4, served as shade covers when the traps were open and were inverted to close traps when necessary (Homyack 1999). To prevent desiccation of captured herpetofauna, 2-3 cm of water was placed in the bottom of each trap (Vogt and Hine 1982). In addition, the water kills any inadvertently captured small mammals or arthropods that may otherwise injure trapped herpetofauna (Vogt and Hine 1982). All drift fence segments had funnel traps (minnow trap #1275, Frabill, Jackson, Wisc.) located at the midpoint on either side of the fence (Campbell and Christman 1982, Vogt and Hine 1982, Bury and Corn 1987, Pais et al. 1988, Corn 1994). Soil or leaves were brushed into the entrance of funnel traps to create a more natural entrance for herpetofauna (Campbell and Christman 1982). Sections of silt fencing were attached to funnel traps to provide shade for captured organisms (Homyack 1999). The 4 arms of the 'plus' and associated traps made up the drift fence array.

Arrays overlapped 12 randomly selected songbird point count stations that were positioned 35 m from a stream or rip-rap channel (Fig. 12). Arrays were distributed over the 3 watersheds with 3 arrays per treatment (Table 2). All arrays were opened simultaneously for 5 days in March and 8-12 consecutive days during each month of the field season (March – September 2000). While traps were open, they were visited at least every other day (Campbell and Christian 1982, Vogt and Hine 1982, Corn 1994). Captured organisms were identified to species using field guides, marked so that individuals recaptured during a trapping session could be identified, and released 3 m from the drift fence array (Campbell and Christian 1982, Vogt and Hine 1982, Fellers et al. 1994). Frogs, toads, salamanders, and lizards were marked using toe clipping where each individual was given a unique number based on its toe clips. When possible, missing or deformed toes were used to identify an individual rather than clipping a toe. Snakes initially were marked with a v-shaped notch at the edge of a ventral scale. We later marked snakes by painting a number on the back with white-out. We also recorded the trap number and trap type (Fig. 16) for each individual captured. Voucher specimens of all unusual or hard-to-identify herpetofauna were killed and preserved according to the techniques described by McDiarmid (1994b). Small mammals were identified to species and, if they were alive, released.

Because length of the trapping periods varied somewhat, the number of animals captured in all pitfall and funnel traps on each array during a trapping period were summed and divided by the number of nights the traps were open in a trapping period (Corn 1994). These values (mean captures per array-night in each trapping period) were used in statistical analyses. Although few individuals were recaptured, recaptures were excluded from data summaries. Treatments were compared with ANOVA with mean abundance and richness as the dependent variables and treatment, trapping period, and the interaction between treatment and trapping period as independent variables.

Quality Control Procedures

Sampling was conducted on 3 (Mud River, Spruce Fork, and Twentymile Creek) of the 5 watersheds chosen by the EPA. The Island Creek and Clear Fork sites were not selected because past and existing land use would confound study results. Four treatments (intact forest; fragmented forest; young reclaimed mine: grassland; and older reclaimed mine: shrub/pole stage) were replicated at each site (Tables 1 and 2). An unbalanced sampling design among treatments and taxa was necessary because of logistics (e.g. point counts required less time to sample per point than do small mammal transects) and a lack of some treatments at some sites. Multiple replicates allowed us to incorporate variation across sites, and enabled us to make statistical inferences regarding species abundances and diversity among treatments. Sampling points (i.e., point counts, transect lines, and trap arrays) were distributed to be representative and to minimize spatial differences, while at the same time maintaining sampling efficiency. Concurrent sampling among taxa and sites was used to minimize temporal effects.

Quality control was insured through a hierarchical oversight procedure. Data on each taxon was collected by a 2-3 person team. Each team included a supervisor (MS students for mammal and raptor studies, trained technician for herpetofaunal study, and PhD research biologist for songbird studies) and field technicians. Overall data collection was supervised by the PhD research biologist in coordination with project PIs. This team approach allowed for consistent data collection during the 1999 and 2000 field seasons. Individual team supervisors remained the same in both years, while field technicians changed the second year. This approach insured precision and consistency in methodologies and reduced sampling error.

Data collection adhered to established protocols (e.g. point counts, trapping, drift fences, raptor surveys) for each taxon and are detailed in the methods. Technicians received ample training in methodologies and species identification (e.g. simultaneous point counts) prior to any unsupervised data collection. Voucher specimens of unusual or hard-to-identify mammalian or herpetofaunal species were collected and preserved to insure data accuracy.

Results and Discussion

Habitat at Sampling Points

Habitat variables were measured at all sampling points in 1999 and 2000 (Table 6). Nineteen variables were measured in all treatments. Means for all habitat variables by treatment and mine are found in Appendix 4

Stem densities of saplings, poles, and trees in 5 size classes all differed significantly among treatments (Table 7). Pole density, and densities of trees >8-23 cm and >23-38 cm were higher in fragmented and intact forest than in the grassland and shrub/pole treatments and also higher in the shrub/pole treatment than in the grassland treatment. Density of trees >53-68 cm was greater in fragmented forest than in the intact forest, grassland, and shrub/pole treatments, and greater in the intact forest treatment than in the grassland and shrub/pole treatments. Trees >68 cm were more abundant in the intact forest and fragmented forest treatments than in the grassland and shrub/pole treatments (Table 7).

Statistical analysis revealed treatment by mine interactions for saplings and trees >38-53 cm (Table 7); therefore treatments were compared on individual mines, and mines were compared in individual treatments. Sapling density was higher at the Hobet and Daltex mines than at the Cannelton mine in the grassland treatment, and trees >38-53 cm had higher density in the shrub/pole treatment on the Cannelton mine than the Hobet mine and higher density in the intact treatment at the Daltex and Hobet mines than the Cannelton mine (Table 8). At all 3 mines, sapling density was higher in the shrub/pole, fragmented forest, and intact forest treatments than in the grassland treatment. At the Cannelton mine density of trees >38-53 cm differed among all 4 treatments, with the highest density in the fragmented forest treatment and lowest density in the grassland treatment (Table 9). At the Hobet mine, density of trees >38-53 cm was higher in both fragmented and intact forest treatments than in grassland and shrub/pole treatments (Table 9).

Ground cover variables differed significantly among treatments. Although water cover was highest in the fragmented forest treatment than in the other 3 treatments and higher in the intact forest treatment than in the grassland or shrub/pole treatment (Table 7), cover of standing water averaged <1.2%. Woody debris and moss cover were higher in fragmented and intact forest than in the grassland and shrub/pole treatments. Green cover was higher in the shrub/pole treatment than in the other 3 treatments, and higher in the grassland treatment than in the fragmented forest or intact forest treatments (Table 7).

Bareground cover and litter cover had significant treatment by mine interactions. Bareground cover was higher at the Cannelton mine in the fragmented forest treatment than at the other 2 mines and higher at the Daltex mine than the Hobet mine in the grassland treatment (Table 8). Litter cover was higher at the Hobet mine than the other 2 mines and higher at the Daltex mine than the Cannelton mine in the grassland treatment (Table 8). Bareground and litter cover also differed among treatments at the Cannelton and Hobet mines. At the Cannelton mine litter cover was higher in the fragmented and intact forest treatments than the shrub/pole and grassland treatments, and higher in the shrub/pole treatment than in the grassland treatment (Table 9). At the Hobet mine, litter cover differed among all treatments; it was highest in the fragmented forest treatment, followed by intact forest, grassland, and shrub/pole treatments (Table 9). Bareground cover at the Cannelton mine was higher in the fragmented forest, intact forest, and grassland treatment than in the shrub/pole treatment. At the Hobet mine, bareground cover was higher in the fragmented forest treatment than in the shrub/pole treatment, and higher in the intact forest treatment than in the shrub/pole and grassland treatments (Table 9).

Slope, aspect code, elevation, and distances to nearest minor, habitat, and mine/forest edges also were compared among all 4 treatments (Table 7). Distance to nearest minor edge was greater in the grassland treatment than in the other 3 treatments (Tables 6-7). There were significant mine x treatment interactions for slope, aspect code, elevation, distance to closest habitat edge, and distance to nearest mine/forest edge. The differences among treatments and mines for these variables are found in Tables 8-9.

Six variables were compared between grassland and shrub/pole treatments and mines. Litter depth was higher on the Hobet mine than the Cannelton and Daltex mines and higher in the Daltex mine than the Cannelton mine (Table 7). The Robel pole index was higher on the Cannelton mine than the other two mines and higher on the Daltex mine than the Hobet mine (Table 7). Forb cover was higher on the Cannelton and Daltex mines than on the Hobet mine (Table 7). The other variables all showed significant treatment by mine interactions. Grass height was higher at the Hobet mine than at the Daltex and Cannelton mines in the grassland treatment and higher at the Hobet mine than the Cannelton mine in the shrub/pole treatment (Table 9). Ground cover of grass and shrubs differed among mines, but not between grassland and shrub/pole treatments (Table 8-9).

Canopy height, percent canopy cover in 6 layer classes, and the structural diversity index were compared among the fragmented forest, intact forest, and shrub/pole treatments (Table 7). Percent canopy cover in 5 layer classes differed among treatments but not among mines (Table 7). There were treatment by mine interactions for canopy height and cover from >3-6 m. Canopy height was higher at the Cannelton mine than the Daltex and Hobet mines in the fragmented forest treatment, and was higher at the Daltex mine than the Hobet mine in the intact treatment (Table 8). Canopy cover from >3-6 m was higher at the Cannelton and Daltex mines than the Hobet mine in the intact forest treatment (Table 8). This cover layer also differed among treatments at the Cannelton and Hobet mines (Table 9). It was higher in the fragmented and intact forest treatments than the shrub/pole treatment at the Cannelton mine. At the Hobet mine it was highest in the intact forest, followed by fragmented forest and shrub/pole treatments (Table 9).

The majority of minor edge types in the grassland treatment were open-canopy roads and valleyfills (Table 10). In the shrub/pole treatment the majority of minor edges also were open-canopy roads and valleyfills. The majority of minor edge types were stream and open-canopy road in fragmented forest, and partially-open canopy road and stream in intact forest (Table 10). These percentages are based on subplots and not point count centers, because subplots in a point count circle could occur closer to different edge types. The average distances to any edge type were 110 m in grasslands, 67 m in shrub/pole, 38 m in fragmented forest, and 66 m in intact forest. Again, these averages are based on subplots and not the point count center.

Fifteen tree/shrub species were observed on grassland sampling points, with predominant species including autumn olive, European black alder, blackberry/raspberry, multiflora rose, red maple, sourwood, and white pine (Appendix 2). In the shrub/pole treatment, 38 species were observed, with black locust being the most predominant. Twenty-seven species were observed on the Cannelton mine in shrub/pole habitat, and twenty-one species were observed on the Hobet mine site. An additional 7 species were observed in shrub/pole treatment at the Hill Fork site, which was a valley fill associated with a contour mine. Sixty-three species were observed in fragmented forest, and 60 species were observed in intact forest (Appendix 2).

Songbirds

Comparison of Expected to Observed Bird Species

Buckelew and Hall (1994) in *The West Virginia Breeding Bird Atlas* (WV BBA) identified 92 bird species as being either “probable” or “confirmed” breeders in the counties of Boone, Fayette, Kanawha, and Logan in southern West Virginia (Table 11). Only 8 of these species were not observed during the course of this study based on pond surveys, point count surveys and incidental observations: House Wren, Warbling Vireo, Pine Warbler, Winter Wren, House Sparrow, Purple Martin, House Finch, and Rock Dove. These 8 species are found in habitats that were not surveyed during this study. The House Wren and Warbling Vireo are found in bottomland hardwood thickets and around human habitations, and the Pine Warbler, as its name suggests, is restricted to stands of pines. The House Sparrow, House Finch, Rock Dove, and Purple Martin also are found around human dwellings and generally are not often observed in the types of habitat that we surveyed. The Winter Wren is most often observed in higher elevations in West Virginia, and it is likely that this species occurs in the higher elevations of eastern Fayette County. Our study site (Cannelton mine) was located in southwestern Fayette County.

Several grassland and shrub species that we observed on mine sites were not listed by the WV BBA as being probable or confirmed breeders in southern West Virginia (Table 11). These included: Bobolink, Dickcissel, Grasshopper Sparrow, Henslow’s Sparrow, Horned Lark, Ring-necked Pheasant, Vesper Sparrow, Willow Flycatcher, Blue Grosbeak, and Purple Finch. Dickcissels and Horned Larks historically were midwestern species that have moved east from the prairies (Askins 1999). We observed several male Dickcissels defending territories and 1 female carrying food in Logan County at the Daltex mine; it is probable that this species is breeding there. They were only observed incidentally in Boone, Fayette, and Kanawha counties at the Hobet and Cannelton mines. Two Horned Lark nests were found, 1 in Boone County at the Hobet 21 mine and 1 in Logan County on the Daltex mine. Grasshopper Sparrows, a species listed as “rare” by the West Virginia Wildlife and Natural Heritage Program (2000), were abundant on our grassland sites. We found several nests of Grasshopper Sparrows at all 3 mine sites, and thus, this species is a confirmed breeder in these areas. One nest of a Willow Flycatcher was found by observers working on the Cannelton mine (D. Stover, personal communication). Willow Flycatchers and Blue Grosbeaks were most often observed defending territories in blocks of autumn olive. Several female Blue Grosbeaks were observed during the study, but no nests were found. Only 1 male Purple Finch was observed, at the Cannelton Mine, and it was likely just an incidental occurrence. Ring-necked Pheasants were observed at the Hobet mine, but it is suspected that these are released birds and not wild birds. No females or nests were located for this species.

Typical grassland species that were rare or absent on our sites included Henslow’s Sparrow, Savannah Sparrow, Vesper Sparrow, and Bobolink. Henslow’s Sparrow and Vesper Sparrow were only recorded at the Logan County mine in very low densities, and no females were observed, so it is likely that neither species are breeding at our mine sites. Henslow’s Sparrow populations are rare, scattered, and local in distribution (Herkert and Glass 1990) and are listed as a “rare” species in West Virginia (West Virginia Wildlife and Natural Heritage Program 2000). They prefer grasslands with tall, dense vegetation with a well-developed litter layer (Herkert and Glass 1990). Due to the young age of our sites, the habitat may not be suitable for this species. Vesper Sparrows prefer grasslands with high amounts of bareground for nesting (Strait 1981), courtship, and foraging (Wray 1982). Strait (1981) found that Vesper Sparrows prefer to nest in areas with a mean bareground cover of 29%, and Wray (1982) found that bareground cover on Vesper Sparrow territories averaged 35.5%. Our grassland study sites only had a mean bareground cover of 7.7%, which may have limited this species on our sites. Bobolinks, also listed as a “rare” species in the state (West Virginia Wildlife and Natural Heritage Program 2000), were only observed early in the spring and were assumed to be migrating. Savannah Sparrows were not observed on any of our sites, although they are a common grassland species in other areas of West Virginia (Wray et al. 1982, Warren and Anderson, unpub. data).

Historically, grassland bird species in the eastern United States were restricted to limited patches of habitat interspersed among forest stands (DeSelm and Murdock 1993). Virtually no natural grasslands are believed to be have been present historically in the Allegheny and Cumberland Plateaus of West Virginia (DeSelm and Murdock 1993), where most MTMVF occurs in this state. Native grasslands in these physiographic provinces are primarily found in the moderately deep to shallow soil of uplands (DeSelm and Murdock 1993). Grassy balds composed of moonshine grass (*Danthonia compressa*) with scattered hawthorn trees (*Crataegus* spp.) occur on high elevation mountain tops in the Allegheny Mountain and Ridge and Valley provinces of West Virginia. Heath barrens of heath shrubs and low-growing plants, as well as glades similar to bog communities, also occur in these provinces (Strausbaugh and Core 1977). Although natural grasslands were limited, grasslands created by Native Americans for agriculture and hunting did exist (Askins 1999). Presently, human-made grasslands in these provinces include pastures, old fields, lawns, golf courses, and surface mines. Grassland birds typically observed in these habitats include Horned Lark and Dickcissel, that have moved east from the midwestern prairies, and species such as the Eastern Meadowlark, Bobolink, Savannah Sparrow, and Grasshopper Sparrow, that are assumed to have expanded into these areas from coastal and marsh grasslands (DeSelm and Murdock 1993, Askins 1999). All of these species were reported by early ornithologists in the East (Askins 1999).

Several wetland species not listed by the WV BBA were observed at pond sites on reclaimed mines (Table 11). Fifty-seven species were observed during pond surveys within 50 m of ponds on MTMVF areas (Table 11). The majority of these species were grassland and edge species that were detected in habitats adjacent to ponds. Ducks, geese, wading birds, and shorebirds all used the ponds. Mallards and Canada Geese were observed frequently, as well as Green and Great Blue Herons. During migration several shorebirds were observed using the ponds, including Greater and Lesser Yellowlegs, and Spotted and Solitary Sandpipers. Three species of swallows (Barn, Northern Rough-winged, and Tree) as well as Chimney Swifts were observed foraging over ponds, whereas Cliff Swallows were observed foraging in adjacent grassland habitat. Sandpiper species and yellowlegs were likely migrating during the May pond surveys. None of these species were observed during the July pond surveys. Many of the species we observed also have been documented by other researchers examining wetlands on surface mines (Allaire 1979, Perkins and Lawrence 1985, Brooks et al. 1985, Krause et al. 1985, Lawrence et al. 1985, McConnell and Samuel 1985).

The West Virginia Gap Analysis Lab (J. Straiger, pers. comm.) also provided us with a list of species expected to occur in southern West Virginia based on remote sensing data of the available habitat (Table 11). Most of the species predicted to occur in our areas were observed during this study. A few exceptions included Chestnut-sided Warbler, Rose-breasted Grosbeak, Black-throated Blue Warbler, Canada Warbler, and Winter Wren. All of these species are associated with the northern hardwood forest type (Hinkle et al. 1993) and typically occur at high elevations (>900 m) in the Allegheny Mountains of West Virginia (Wood et al. 1998, Demeo 1999, Weakland 2000). This habitat and elevation were absent in our study area, and thus it is not surprising that we did not observe these species. Wetland species that Gap predicted to occur that we did not observe included the American Black Duck, Hooded Merganser, and Swamp Sparrow. We observed all of the grassland species that they predicted as well as all of the edge species, except for the Chestnut-sided Warbler, mentioned above, and the Warbling Vireo, which is found in bottomland hardwood thickets and near human dwellings.

Songbird Abundances in Grassland and Shrub/pole Habitats

We observed 63 species of birds in reclaimed sites with 30 species in the grassland treatment and 41 species in the shrub/pole treatment on MTMVF areas in southern West Virginia during point count surveys (Table 12). The most abundant songbird species in grassland areas of reclaimed mines were Grasshopper Sparrow, Eastern Meadowlark, Red-winged Blackbird, Horned Lark, and Dickcissel. Species associated with shrub/pole habitat also were observed using small shrubs as perches and nesting in blocks of autumn olive at our grassland points. These species included Indigo Bunting, Common Yellowthroat, Willow Flycatcher, Song Sparrow, American Goldfinch, Blue Grosbeak, Brown Thrasher, Orchard Oriole, Field Sparrow, and Yellow-breasted Chat. The average abundances of bird species by mine and treatment are found in Appendix 3.

The most abundant species in the older reclaimed areas (shrub/pole habitats) included American Goldfinch, Blue-winged Warbler, Common Yellowthroat, Eastern Towhee, Field Sparrow, Indigo Bunting, Northern Cardinal, Prairie Warbler, White-eyed Vireo, Yellow Warbler, and Yellow-Breasted Chat (Table 12). This bird community included all 4 habitat guilds because these areas had a mixture of vegetation characteristics (grass/forb, shrubs, and trees of small and moderate size).

Point counts measure relative abundance, so to compare our results with other studies we converted our abundance estimates to density estimates by dividing the mean number of birds observed by the number of hectares (0.79) in a 50-m radius point count circle. However, it was difficult to compare grassland bird densities with other studies because of differences in methods. For example, spot mapping and territory flush methods primarily count singing males or male territories in a defined area, whereas point counts and strip transects record all birds either seen or heard, including females and juveniles. Thus, our estimates may be higher than those observed in studies that used territory count methods.

Densities of Grasshopper Sparrows, our most abundant species in the grassland treatment, were much higher than those reported in other studies (Table 13). Allaire (1979) found a much lower density on 1-4-yr old reclaimed MTMVF areas in eastern Kentucky. Our sites have been reclaimed for at least 5 years, and the average age was 11 years. Thus, Grasshopper Sparrows may have had more time to settle on our sites than Allaire's (1979). Additionally, vegetative structure on our mines may have been more suitable for Grasshopper Sparrows than the vegetation on his sites. LeClerc (1982) found Grasshopper Sparrows preferred mines with a high amount of forb cover and a low amount of bare ground cover. Our sites were more developed vegetatively than Allaire's (1979). The amount of bareground cover on his sites averaged 17%, whereas ours averaged only 8%, and the height of foliage on his sites averaged 6.4 dm, wheareas ours averaged 7.3 dm. Other studies on reclaimed surface mines and in other types of grassland habitat report lower densities of Grasshopper Sparrows (Table 13), but these differences may be due to the method used to calculate density. Territory mapping and flushes estimate the number of territory-holding males in an area while point counts include all singing males. Our study sites may have contained high numbers of unmated males (also see nest success section below). The higher numbers detected in our study were not due to overall population increases since Allaire's study. Breeding Bird Survey data indicate a declining trend in grasshopper sparrow populations in the 2 physiographic provinces (Cumberland Plateau and Ohio Hills) that overlap our study sites (Sauer et al. 2000).

With the exception of Bobolinks and Savannah and Vesper Sparrows, densities of other species on our sites fell within the ranges reported by other researchers on reclaimed mines and other grassland habitat (Table 13). Neither Savannah nor Vesper Sparrows were observed in 2000 on our sites, and only 2 Vesper Sparrows were heard in 1999 at the Logan County mine. Bobolinks were only observed on 2 point counts in 2000, and they may have been migrants. Our sites lie at the southern extreme of the breeding range for these 3 species (Buckelew and Hall 1994).

Songbird abundances in our shrub/pole community are similar to those found by others who have examined surface mines (Brewer 1958, Chapman 1977, Crawford, et al. 1978, LeClerc 1982, Wray 1982). Because our shrub/pole treatment included a few sites on the oldest MTMVF area in West Virginia (~26 years) compared to an average of 18 years (range 13-25) for the remaining sites, we examined these different-aged sites separately (Table 14). Overall species richness and total abundance were similar between younger and older shrub/pole areas with a 65% similarity in the bird community (Table 14). Our results were similar to abundances reported by Denmon (1998) on early successional sites (33% reclaimed mines, the remainder on unmined lands) throughout West Virginia (Table 14). In addition, all of the species listed by Hinkle et al. (1993) as being present in shrub habitat or shrub-small tree habitat in the mixed mesophytic forest region were present on our shrub point counts. One shrub/pole species of conservation interest is the Golden-winged Warbler, which is listed by Partners in Flight as a species of concern in the entire Northeast region. We only observed this species at the Cannelton mine site at 3 point count stations, and it is possible that the Hobet and Daltex mine sites were out of this species' elevational or geographic ranges. If this species is limited by range, it is unlikely that MTMVF will increase habitat for this species in the Mud River and Spruce Fork watersheds.

Songbird Abundances in Fragmented and Intact Forest

Mixed mesophytic forests support the richest and most abundant avifaunal community in the eastern United States outside of bottomland and swamp habitats (Hinkle et al. 1993). All of the bird species listed by Hinkle et al. (1993) as being present in mature, mixed mesophytic forest were observed on our sites. We observed 50 species of birds in forested sites with 47 species in the fragmented forest treatment and 43 species in the intact forest treatment during point count surveys (Table 12). The most abundant forest interior species on our sites included Acadian Flycatcher, Blue-headed Vireo, Cerulean Warbler, Kentucky Warbler, Ovenbird, and Wood Thrush (Table 12).

Songbird abundances in our intact forest sites generally were similar to those reported by other researchers in undisturbed forests of the mixed mesophytic forest region (Anderson and Shugart 1974, Allaire 1979, Wood et al. 1998, Demeo 1999; Table 15). Two species of note, however, are Ovenbird and Cerulean Warbler. Ovenbirds occurred at higher densities on our intact treatment than in any other study (Table 15). The Cerulean Warbler, a species of high concern in the eastern United States, occurred at higher densities on our sites than in other areas of West Virginia, though at lower densities than in Kentucky. They were observed at 40% of all intact forest point counts and at 28% of fragmented forest point counts. Cerulean Warblers have been declining in many parts of their range, and southwestern West Virginia may represent a significant source population for this species in the eastern United States (Rosenberg and Wells 1999). It is estimated that 47% of the Cerulean Warbler population in North America occurs in the Ohio Hills physiographic area (Rosenberg 2000), which includes part of our study area.

Abundances of several species of songbirds on our study sites differed between fragmented forest and intact forest (Table 12). Six species were significantly more abundant in intact forests: Acadian Flycatcher, Ovenbird, American Redstart, Hooded Warbler, and Brown-headed Cowbird in both 1999 and 2000, and the Scarlet Tanager in 1999 (Table 12). Red-eyed Vireos and Indigo Buntings were significantly more abundant in fragmented forest than intact forest in both years, while 6 species (American Goldfinch, Downy Woodpecker, Louisiana Waterthrush, Northern Parula, Pileated Woodpecker, and Yellow-billed Cuckoo) were more abundant during 1 year. The Louisiana Waterthrush occurs near streams, where it nests in stream banks and forages in the stream. Proportionally more of the fragmented forest sampling points were located along streams than in the intact forest treatment. Therefore, we ran a subsequent analysis for this species using only points located within 50-m of a stream. With this restriction we found no significant differences in abundance of this species between fragmented and intact treatments ($F=0.36$, $P=0.55$). The American Goldfinch and Indigo Bunting are edge species, while the Downy Woodpecker, Northern Parula, Red-eyed Vireo and Yellow-billed Cuckoo are considered interior-edge species. These birds may be responding to the higher amount of edge in fragmented forest than in intact forest (Temple 1986).

The Brown-headed Cowbird had very low abundance in our study (0.07 birds/count). This species was observed only at 1 intact forest point count in 1999, and only at 1 fragmented forest and 7 intact forest point counts in 2000. The species was not observed in the Twentymile Creek watershed. Thus, we suspect that Brown-headed Cowbird parastism is likely to be low in this region and not a significant cause of nest losses. The abundance of cowbirds is relatively low in other parts of West Virginia as well (Demeo 1999, Weakland 2000).

High moisture availability in mature mixed mesophytic forests may contribute to the high densities of many species of songbirds in these habitats as compared to forests with lower ambient moisture, such as xeric oak-hickory forests (Hinkle et al. 1993). Species that are abundant and common in mixed mesophytic forests, such as Cerulean Warblers, Kentucky Warblers, Acadian Flycatchers, and Ovenbirds, are frequently less abundant and rare in drier forests (Hinkle et al. 1993). Several species in our study had higher abundance in intact forest than fragmented forest. It is possible that fragmented stands are drier because the microclimate has been altered (Faaborg et al. 1995) and that songbirds are responding negatively to this change. In addition, fragmentation also may negatively affect songbird species by leading to higher rates of predation, cowbird parasitism, interspecific competition, and to lower pairing success and nesting success (Faaborg et al. 1995). Additionally, some species have “minimum area requirements” and are not found in fragments below a certain size threshold. As forest size is reduced, specific microhabitats upon which some species depend also may be reduced or even disappear. Consequently, species associated with those microhabitats may disappear or decline in fragmented forest (Faaborg et al. 1995). The Ovenbird, Acadian Flycatcher, Hooded Warbler, and American Redstart, species that were more abundant in intact forests than fragments in our study, prefer large blocks of mature forest in eastern deciduous forests (Robbins 1980, Blake and Karr 1987). The Ovenbird is known to have lower pairing success and lower nest survival in forest fragments than in intact forests (Gibbs and Faaborg 1990, Robinson et al. 1995, Hagan et al. 1996), and the Hooded Warbler also has lower nest survival in fragmented landscapes (Robinson et al. 1995).

Species-specific Logistic Regression Models

The presence/absence of 10 forest-dwelling songbird species of conservation priority for the region were related to specific habitat variables. Logistic regression models were fit for each species and none were rejected due to lack-of-fit (Hosmer and Lemeshow goodness-of-fit tests, $P>0.10$),

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<u>Cerulean Warbler</u>

The Cerulean Warbler, with the highest conservation priority rating (Table 5), was found to be positively related to percent slope and percent canopy cover from >6-12 m (Table 16). The Ohio Hills and Northern Cumberland Plateau physiographic provinces where MTMVF mining is prominent are within the core area for the Cerulean Warbler. It is estimated that 46.8% of this species’ population is found within the Ohio Hills province alone (Rosenburg 2000). This species prefers large tracts of mature forests with large, tall trees (P. Hamel, unpub. rept.). We found Ceruleans more often on steeper slopes, as did Dettmers and Bart (1999) in southeastern Ohio. Based on habitat preferences, it is reasonable to conclude that continued

MTMVF mining will negatively impact Cerulean Warbler abundance in southwestern West Virginia.

Lousiana Waterthrush
The Lousiana Waterthrush, with the second highest conservation rating, was negatively related to percent bareground cover and pole density, and was positively related to percent moss cover (Table 16). This species is found in large tracts of mature forest and nests on the ground along stream banks (Whitcomb et al. 1981, Ehrlich et al. 1988). Bushman and Therres (1988) suggested that wooded streambanks and ravines be protected in order to maintain this species. Given valleys and streams are covered by MTMVF operations and reduces mature forest cover, it is logical to conclude that this species also will be negatively affected by loss of streamside forest habitat from this type of mining.

Worm-eating Warbler
This species was positively related to percent woody debris cover and negatively related to percent canopy cover from >12-18 m, aspect, percent litter cover, and elevation (Table 17). Worm-eating Warblers typically are found in ravines and on hillsides in deciduous woods where they nest on the ground in leaf litter (Ehrlich et al. 1988, Dettmers and Bart 1999). They are most abundant in mature forests, although they may be found in young- and medium-aged forest stands as well (Bushman and Therres 1988). Robbins (1980) and Whitcomb et al. (1981) suggested that this species requires large tracts of mature forest and may have a low tolerance for fragmentation. The greatest threat to this species from MTMVF is the loss and fragmentation of forested habitat.

Kentucky Warbler
Kentucky Warblers were present at points with a high percent of canopy cover from >6-12 m, and low sapling and pole density and also were present more often at lower elevations (Table 17). Kentucky Warblers prefer rich, moist forests and bottomlands with well-developed ground cover (Bushman and Therres 1984). This species appears to be moderately affected by fragmentation and may be found in small woodlots, but in Maryland the highest frequency of occurrence for this species was in forests from 130-700 ha in size (Bushman and Therres 1988). Loss of wooded ravines and bottomlands could negatively affect this species.

Acadian Flycatcher
This species was one of our most abundant birds and abundance was correlated to many habitat variables (Table 18). It was positively related to trees >68 cm, and negatively related to saplings and trees 8-23 cm dbh, indicating an association with mature forests. It also was positively related to distance from mine/forest edge, structural diversity, and percent bareground, and negatively associated with elevation. Acadian Flycatchers prefer moist ravines and stream bottoms. Dettmers and Bart (1999) considered this species to be a habitat “specialist” at the microhabitat (i.e. territory or home range) level. Bushman and Therres (1988) found that Acadian flycatchers prefer forests with high canopy cover, large trees, and an open understory. This species prefers large blocks of mature contiguous forest for breeding, and appears to avoid edges. We found this species to be more abundant as distance from mine edge increased and more abundant in intact forest, which could indicate that MTMVF mining is detrimental to this species.

Wood Thrush

Wood Thrush were positively related to density of trees >23-38 cm dbh and negatively associated with elevation (Table 18). Wood Thrush are found in deciduous and mixed coniferous-deciduous forest, with highest densities occurring in the Appalachian Mountain region (James et al. 1984). They prefer mature forests with some small trees in the understory for nesting and a moist, leafy litter layer for foraging (James et al. 1984).

Yellow-throated Vireo

Presence of this species was related to several variables. It was positively related to percent canopy cover from 6-12 m, aspect, slope, elevation, and density of trees from 38-53 cm (Table 19). It was negatively associated with distance to mine/forest edge and percent bareground. It is most abundant in mature forests and appears to prefer stream borders and bottomland forests (Bushman and Therres 1988). Yellow-throated Vireos appear to have a low tolerance for forest fragmentation (Whitcomb et al. 1981). MTMVF mining could potentially reduce abundance of in this species because of its preference for mature forest along streams, which may be lost due to mining.

Hooded Warbler

Hooded Warblers were positively related to percent cover of woody debris and pole density (Table 19). Hooded Warblers typically are found in moist deciduous forests and ravines with a well-developed understory (Ehrlich et al. 1988), but also may be found along ridges with a high density of shrub stems (Dettmers and Bart 1999). It is suspected that this species is fragmentation-sensitive (Bushman and Therres 1988), and we found it to occur at higher abundances in intact than fragmented forest sites.

Scarlet Tanager

This species was negatively associated with percent bareground cover. They were positively associated with elevation, percent slope, density of trees from >38-53 cm, and canopy cover from >12-18 m (Table 20). This species may be found in a wide range of successional stages of forests, but is most abundant in mature woods with a dense canopy (Bushman and Therres 1988). This species does not appear to be as fragmentation-sensitive as other forest interior species, and may tolerate smaller forests and edges (Bushman and Therres 1988); however, it was more abundant in our intact than fragmented forest sites during 1 year of the study., and was more common at points further away from mine/forest edge.

Black-and-white Warbler

Black-and-white Warblers were positively associated with pole density, percent ground cover of moss, aspect, and distance from mine/forest edge (Table 20). It was negatively associated with percent canopy cover from 3-6m and sapling density. This species nests on the ground in deciduous and mixed forests (Ehrlich et al. 1988). It appears to prefer pole-stage stands (Bushman and Therres 1988), but it is fragmentation-sensitive and was not found breeding in forests <70 ha in size in Maryland (Whitcomb et al. 1981).

Yellow-billed Cuckoo

The Yellow-billed Cuckoo was positively related to percent cover of woody debris (X^2=3.99, P=0.05) and negatively associated with elevation (X^2=7.00, P=0.01) and aspect ((X^2=2.99, P=0.08). This species is a PIF priority species for the region (Rosenberg 2000), but we observed it at only 9 sampling points in the 2 years of the study. Less than 1% of the population occurs in this region (Rosenberg and Wells 1999), and MTMVF is not likely to severely impact the population as a whole.

Other Species
The Swainson's Warbler, a species of concern in the region and a rare species in West Virginia (West Virginia Wildlife and Natural Heritage Program 2000), is typically, in West Virginia, found only in areas of dense rhododendron (Buckelew and Hall 1994). We observed this species in the Twentymile Creek watershed along Hughes Fork. Further MTMVF in this watershed could impact this species, but the effect on the population as a whole will be minimal, since <2% of the population is found in the Ohio Hills province and West Virginia is on the periphery of its range (Table 5) . The Eastern Wood-pewee is a species of conservation priority (Action level III) in the region, but we only observed it at 1.2% of our forested point counts. The Black-billed Cuckoo is a PIF priority species for this region (Rosenberg 2000), but it appears to be relatively rare; it was only observed incidentally in early successional habitat during this study and was not detected during point count surveys.

Comparison of Guild Abundances Among Treatments

All of the habitat guilds differed significantly among treatments (Table 21). As expected, the grassland guild was more abundant in the grassland treatment than in shrub/pole, fragmented forest, or intact treatments. Edge species also followed a typical pattern: they were most abundant in shrub habitat, followed by grasslands, then by fragmented and intact forest (Table 21). Interior-edge species were most abundant in the fragmented and intact forest treatments, followed by the shrub/pole and grassland treatments. Forest interior species were more abundant in intact forest, followed by fragmented forest, shrub/pole, and grassland treatments. Significantly higher abundance of forest interior species in intact than fragmented forests suggests that this group is negatively affected by habitat fragmentation.

Nesting guilds also differed among treatments. Ground nesters were more common in grassland habitat than the other 3 treatments and were more abundant in the shrub/pole treatment than in fragmented and intact forest. This result was expected because all of our grassland bird species were ground nesters with the exception of the Red-winged Blackbird and the Willow Flycatcher. Shrub nesters were more abundant in the shrub/pole treatment than the other 3 treatments, and were more abundant in grassland than fragmented or intact forest (Table 21). Subcanopy- and cavity-nesting species were more abundant in the fragmented and intact forest treatments than in the shrub/pole or grassland treatments and were more abundant in shrub/pole than grasslands. Canopy-nesting species showed a treatment-by-year interaction. In 1999 they did not differ in abundance between fragmented and intact forest, but in 2000 they were more abundant in intact forest than in fragmented forest (Table 21).

Total abundance and richness also differed among treatments. Abundance and richness were higher in the shrub/pole treatment than any of the other 3 treatments (Table 21). This was expected due to the heterogeneity of the habitat in this treatment which included grass/forbs, shrubs, and small trees. Abundance in fragmented forests did not differ between either intact forest or grassland treatments, but intact forest had higher abundance than grassland habitat (Table 21). Richness did not differ between fragmented and intact forest, but richness in grassland habitat was lower than both of these habitats (Table 21). Similarly, Allaire (1979) found songbird density and richness higher in forested habitat than in grassland habitat in eastern Kentucky, and Willson (1974) found forests and old fields to have higher bird species diversity than grasslands.

Generally, our results comparing habitat guilds among treatments are not unexpected and follow patterns reported in the literature. It is well documented that as vegetative structure and

composition change through succession that the corresponding bird community also changes (e.g. Wiens and Rotenberry 1981, James and Wamer 1982).

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Similarity Among Songbird Communities

Fragmented and intact forests shared the highest number of species, and both the Jaccard and Renkonen indices were highest for this pair of treatments (Table 22). Similarity was lowest between grassland and intact forest, and intermediate for the other treatment pairs (Table 22). The grassland/shrub pair also was relatively similar, sharing 12-23 species and having a Jaccard similarity index between 0.40 and 0.48. The grassland areas that we surveyed were not pure stands of grass but also had scattered shrubs and blocks of autumn olive that attracted shrub species. Similarly, the shrub/pole areas we surveyed were adjacent to grassland habitat and often had open patches of grass that were used by grassland birds interspersed among trees. Both fragmented and intact forests shared species with the shrub community. These species were often interior-edge species that use both forest interior as well as edge habitat. Some edge species also were encountered in forested habitats along logging roads, trails, and other gaps in the canopy.

Nesting Success of Grassland Birds

We monitored a total of 36 nests on reclaimed MTMVF areas in 1999-2000 (Table 23), for a total of 308.5 observation days (days that nests were active). Approximately 300 ha of grassland habitat were searched for nests. In 1999 only the Hobet mine was searched for nests, whereas in 2000 all 3 mines were searched.

Overall nest survival of all species combined was 31.1% for the 2 years of the study. Nesting survival in 1999 was only 4.1%, but was higher in 2000 at 52.7%. This difference may be due to the extreme drought conditions in 1999 (Fig. 17). Nest survival in 2000 varied among mine sites, ranging from a low of 1.8% at the Cannelton mine to 68.1% at the Hobet mine (Table 23). Grassland birds had lower nest survival (20.3%) than shrub-nesting birds (48.8%). Shrub nests were found incidentally by nest searchers while searching for grassland bird nests or by other researchers on the project.

More Grasshopper Sparrow nests (19) were found than for any other species (Table 23). Nest survival for this species (36.4%), was similar to that reported in Missouri and Illinois (Table 24), but was higher than other studies. Although density of Grasshopper Sparrow nests was low (~0.06 nests/ha), it was similar to densities on airport grasslands in Illinois and reclaimed mines in northern West Virginia (Table 24). Tallgrass pairie in Oklahoma had much higher nest densities, possibly because this area has the highest abundance of Grasshopper Sparrows and is the center of the species' breeding range (Wells and Rosenberg 1999).

In general, nest densities were low on our study sites. Approximately 537 person-hours were spent nest searching in 2000 by 2 full-time individuals and 3 part-time individuals, and only 25 active nests were located. We do not believe that low nest numbers were a result of nest searchers missing nests. Nest searchers were trained in proper nest searching techniques prior to the start of the study. They searched for nests using standard techniques, including rope dragging, systematically traversing the area and flushing females, and observing parental behavior. Further, the number of nests of Grasshopper Sparrows, our most abundant species in 2000, was similar to the number found by other researchers in other regions of the country in 1 year (Table 24; Wray 1982, Kershner and Bollinger 1996, Koford 1999, McCoy et al. 1999, Rohrbaugh et al. 1999). It is unlikey that nest searchers would miss finding nests of other species if they were able to locate nests of Grasshopper Sparrows, a species known for its ability to conceal its nest (Ehrlich et al. 1988). Habitat measurements surrounding Grasshopper Sparrow nests indicated a high amount of concealment cover around nest sites (Table 25).

Fledgling surveys conducted in late July and early August also indicated that nest densities were low on the mines. Approximately 1.9, 1.7, and 0.4, fledglings/ha were observed in grassland habitat on the Daltex, Hobet, and Cannelton mines, respectively.

There are several possible explanations for low nest densities. First, the habitat may be supporting a biased sex ratio favoring males. Although densities of male Grasshopper Sparrows were high on the mines, few females were observed, suggesting that populations present on these mines included a high proportion of unmated males. Dickcissels are known to have a biased sex ratio favoring males (Buckelew and Hall 1994). Male grasshopper sparrows may have only recently colonized the Daltex mine while females may not have arrived yet. Second, densities of other grassland species, especially Eastern Meadowlarks and Horned Larks, appeared to be relatively low. Our point count abundances included all birds seen or heard, and Eastern Meadowlarks, Horned Larks, and Red-winged Blackbirds were often observed in groups, thus our densities may not represent the number of potential breeding pairs. Also, Red-winged Blackbirds were primarily observed breeding in cattails around ponds and not in the grassland habitat. Since we were primarily concerned with grassland birds, these wetland areas were not as thoroughly searched as the grassland habitat. Lastly, large sections of the mines have been planted with sericea lespedeza which grows in thick, dense stands. A sub-sample of grassland sampling points (n=28) had an average of 21.6% lespedeza cover within the 50-m radius circle, and some sampling points, especially those at the Cannelton mine, had 90-100% lespedeza cover. No grassland bird nests were found in areas with such high lespedeza cover. Grassland birds need areas of open ground with sparse vegetation for foraging and courtship (Whitmore 1979), and areas with thick lespedeza do not appear to provide this requirement. Further, lespedeza cover surrounding Grasshopper Sparrow nests averaged only 4.3% (Table 25), indicating that this species prefers to nest in areas with little lespedeza cover.

Habitat characteristics surrounding Grasshopper Sparrow nests were similar to those reported by Strait (1981). He found grass, shrub, and forb covers surrounding his nests of 32.5, 1.3, and 31.7%, respectively, which are similar to our values of 44.3, 1.7, and 36.3%. Also, the mean vegetation height surrounding his nests was 5.6 dm, which fell within our range of 4.4-5.9 dm. However, he found a deeper litter depth surrounding his nests, at 6.67 cm, whereas ours only ranged from 1.5-2.1 cm (Table 25).

Summary

In summary, MTMVF areas provided breeding habitat for both grassland and early successional species. Grassland, edge, and interior-edge songbirds were more abundant on the post-mining landscape. The highest bird species richness was found in the shrub/pole treatment and the lowest was found in the grassland treatment. Richness in fragmented forest and intact forest fell between these 2 treatments. Ponds on MTMVF areas also provided habitat for waterfowl, wading birds, swallows, and shorebirds, primarily during migration. No federally-listed endangered or threatened species were detected during the study. West Virginia does not have a state threatened and endangered species listing process, but 3 observed grassland species (Grasshopper Sparrow, Henslow's Sparrow, and Bobolink) are considered rare in West Virginia. However, abundances of the forest interior guild and some forest interior species (e.

g. Ovenbird and Acadian Flycatcher) were significantly lower in fragmented forest than in intact forest. Some forest species also were detected more frequently at points further from mine edges. Populations of forest birds will be detrimentally impacted by the loss and fragmentation of mature forest habitat in the mixed mesophytic forest region, which has the highest bird diversity in forested habitats in the eastern United States. Fragmentation-sensitive species such as the Cerulean Warbler, Louisiana Waterthrush, Worm-eating Warbler, Black-and-white Warbler, and Yellow-throated Vireo will likely be negatively impacted as forested habitat is lost and fragmented from MTMVF. Grassland birds nesting on MTMVF areas had nest survival rates similar to those found in the literature, but some species, particularly the Grasshopper Sparrow and Dickcissel, appeared to have high proportions of unmated males in their populations. Further research is necessary to adequately determine the impacts of MTMVF on the nest survival and population dynamics of grassland-nesting bird species.

Raptors

During broadcast surveys, seasonal overall mean abundance for raptors across the 4 treatment types was highest for summer in the grassland treatment (Table 26). Mean abundances separated by mine and treatments are found in Appendix 5. Overall mean abundances for migration in both the grassland and shrub/pole treatments also were greater compared to all other seasons/treatments. Large numbers of Turkey Vultures were observed over grassland and shrub/pole areas during these time periods. Turkey Vultures primarily forage over large open areas, including transitional habitat (Bent 1937, Buckelew and Hall 1994). Overall mean richness was highest in the winter season for the shrub/pole treatment. Five species, including the Northern Harrier, Red-tailed Hawk, Red-shouldered Hawk, Turkey Vulture, and an unidentified *Accipiter*, were detected on surveys in the shrub/pole treatment during winter.

Red-shouldered Hawk abundance was highest in the intact forest treatment during migration and summer. Many studies have shown Red-shouldered Hawks nest primarily in contiguous mature forest habitat (Bednarz and Dinsmore 1981, Morris and Lemon 1983, Belleman 1998). Although most common in intact forest, Red-shouldered Hawks also were recorded in the shrub/pole treatment during all seasons, particularly during migration and winter periods. Some studies have reported greater use of more open areas and woodland edges by Red-shouldered Hawks during the winter months as compared to the summer months (Bohall and Collopy 1984, Crocoll 1994). *Accipiter* species such as Sharp-shinned Hawks also use transitional habitat near open areas during the winter months (Bildstein and Meyer 2000). Northern Harrier and American Kestrel abundances were highest in grasslands, although Northern Harriers also were recorded in the shrub/pole treatment. These 2 species are generally found in more open habitat and rarely are seen over forested habitat except possibly during migration (Johnsgard 1990). Red-tailed Hawks were recorded in every treatment type and were most common in grasslands during the summer months. Several studies have described the Red-tailed Hawk as an open country raptor using agricultural fields, pastures, and forest edges more than other woodland raptor species with little fluctuation in habitat use across seasons (Bent 1937, Bednarz and Dinsmore 1982, Preston and Beane 1993, Moorman and Chapman 1996).

During roadside surveys, overall abundance and richness was highest in the grasslands at the Daltex mine Table 27). Red-tailed Hawks and Turkey Vultures were observed in all 3 treatments during roadside surveys. This is consistent with these species' tendency to forage over expansive open areas and transitional habitats (Bednarz and Dinsmore 1982, Hall 1983). American Kestrels, Northern Harriers, and Broad-winged Hawks were observed in habitats typically frequented by these species. A notable species observed during roadside surveys was a Peregrine Falcon in the grassland at Daltex.

In an overall comparison of raptor species observed on the 3 mines to what would be expected in West Virginia from breeding records and habitat requirements (Table 28), 2 species (Peregrine Falcon and Northern Harrier) unexpectedly occurred on the mines. Two other species, the Rough-legged Hawk and the Short-eared Owl, unexpectedly occurred on the mines during winter.

Even prior to 1950 and the widespread use of DDT, Peregrine Falcons were rare in West Virginia, although there are some nesting records from documented eyries in Mineral, Greenbrier, and Morgan Counties. More recent breeding attempts in the state were recorded in 1991 and 1992 in Grant County after a release of birds in the New River Gorge in 1987-1989 (Buckelew and Hall 1994), and in 2000 with a pair nesting near North Fork Mountain (C. Stihler, personal communication). There are no confirmed breeding records of Peregrine Falcons in Kanawha, Boone, or Logan counties (Buckelew and Hall 1994) and most sightings of Peregrine Falcons in the state have been during migration along mountain ridges (Hall 1983). At least 2 adult Peregrine Falcons were observed throughout the summer months and during the migration season in the grasslands on the Daltex mine. These 2 birds were commonly observed near a rocky “highwall” left after mining activities, but we found no evidence of breeding. An unconfirmed sighting of a Peregrine Falcon occurred during the summer months in the grasslands at the Cannelton mine, but a confirmed sighting of an immature peregrine falcon occurred later during broadcast surveys in November 2000.

Northern Harriers are rare summer/winter residents, but can occasionally be seen in open areas during migration (Hall 1983). There are no breeding records for the species in southwestern West Virginia (Buckelew and Hall 1994). Northern harriers have also been observed in sections of northeastern West Virginia (Canaan Valley) during late summer, migration, and winter (J. Anderson, pers comm.). We observed Northern Harriers in the grasslands during the winter and migration seasons on all 3 mines, and also during the summer months on both the Hobet and Cannelton mines. Northern Harriers also were observed in the shrub treatment at Cannelton during summer and migration. A recent study speculated that reclaimed surface mines may be providing breeding habitat for Northern Harriers, because breeding attempts for Northern Harriers (based on Pennsylvania Breeding Bird Atlas data) were correlated with regions in Pennsylvania containing large numbers of surface mines (Rohrbaugh and Yahner 1996). In other studies, Northern Harriers were commonly observed on surface mines during the breeding season (Yahner and Rohrbaugh 1996, Yahner and Rohrbaugh 1998). Historically, Northern Harriers have occurred in low numbers in West Virginia because of few open areas (wetlands, agricultural lands) for breeding, but recent observations on grassland and shrub/pole areas indicate that Northern Harriers are using reclaimed MTMVF areas in West Virginia, although breeding is not confirmed.

Two winter visitors, the Rough-legged Hawk and the Short-eared Owl also were observed on the mines in open habitats (Table 28). Rough-legged Hawks have been observed in West Virginia during migration along mountain ridges and during winter around Charleston in Kanawha County (Hall 1983). Short-eared Owls are considered rare or uncommon migrants and winter residents in West Virginia due to lack of open habitat such as fields, marshes, and thickets, which this species uses during the nonbreeding season (Hall 1983, Holt and Leasure 1993). Most past sightings of Short-eared Owls occurred in the northern and western counties of West Virginia. Our observation of Short-eared Owls in the grasslands during winter suggests that reclaimed MTMVF areas may be providing wintering habitat for this species.

Broad-winged and Red-shouldered Hawks were observed not only in intact forest as expected in West Virginia, but in forest fragments, shrub/pole areas, and grasslands (Table 28). Broad-winged Hawks and Red-shouldered Hawks are mainly forest species that nest in contiguous mature forest (Crocoll and Parker 1989) although Broad-winged Hawks appear to nest in forests with more openings than Red-shouldered Hawks (Titus and Mosher 1981, Crocoll and Parker 1989). Other studies have shown that Red-shouldered Hawks inhabit more open areas during the winter months (Bohall and Collopy 1984, Peterson and Crocoll 1992). The observations of these 2 species in grassland areas may have been instances where the birds were soaring from 1 forest area to another. In addition, the Red-shouldered Hawk observations could have been territorial displays, because the majority of summer grassland observations occurred during 1999 where the birds were observed soaring extremely high and vocalizing.

Cooper's Hawks and Sharp-shinned Hawks were observed in areas where they were not expected in West Virginia. Cooper's Hawks were sighted in grassland areas during migration. Sharp-shinned Hawks were observed both in grassland during summer and shrub/pole during winter, and an unidentified *Accipiter* species (either Cooper's or Sharp-shinned Hawk) was observed in a forest fragment during winter. There is little habitat information on Cooper's Hawks during migration, but it has been noted that this species uses forest edge as primary hunting habitat in its home range during breeding and uses agricultural fields when overwintering in Texas (Rosenfield and Bielefeldt 1993). Similar to Cooper's Hawks, Sharp-shinned Hawks have been observed in open areas and transitional habitat more during the winter months than summer (Bildstein and Meyer 2000). The observation of a Sharp-shinned Hawk in grasslands during summer may have been a bird passing between forest habitats. It should be noted that most of these unexpected occurrences of a species in a particular habitat were single sightings and thus probably should not be construed as ecologically significant. Finally, the American Kestrel, Red-tailed Hawk, Barred Owl, Eastern Screech Owl, and Turkey Vulture were observed in areas mostly consistent with what was expected in West Virginia.

The Jaccard community similarity index was highest when comparing shrub/pole with fragmented forest (Table 29) and lowest when comparing grassland with either intact forest or fragmented forest treatments. These results are not unexpected based on known habitat requirements of species found in these treatments. With the Renkonen index, the similarity between shrub/pole and fragmented forest dropped considerably and this may be due to the low abundances of the 4 species shared between the 2 treatments. The Renkonen index comparing the shrub/pole and grassland treatments indicated the greatest similarity in species composition of the raptor community.

Summary

MTMVF has had an effect on overall raptor abundance and diversity through a change in the raptor community. Woodland species such as the Red-shouldered Hawk and Broad-winged Hawk were rarely observed in the open grassland and shrub/pole treatments, but more commonly observed in intact forest. Open-country species such as Northern Harriers and American Kestrels were most often observed in grasslands, with no observations occurring in wooded areas. These results suggest that MTMVF is providing a means for an overall shift from a woodland raptor community to a grassland raptor community.

Mammals

Mammal Species Detected

In 1999 and 2000 we captured (through Sherman live trapping or pitfall trapping intended for herpetofaunal species) or observed through incidental sightings 24 of 40 mammal species (excluding bats) thought to occur in our study areas in southern West Virginia (WV GAP analysis, M. Hight pers. comm.) (Table 30). Representatives from 6 orders occurring in southern West Virginia were included in the 24 species recorded.

Six of 10 carnivore species expected to occur on our study area were detected, either by sighting of the animal or by observation of some sign of the animal's presence, such as footprints, scat, or scent (Table 30). Within the grassland treatment, 50% of the carnivore species expected to occur were detected, whereas 44%, 50%, and 20% were detected in the shrub, fragmented forest and intact forest treatments, respectively. Coyote, known to prefer open areas or areas with a diversity of habitats (Whitaker and Hamilton 1998), were detected in every treatment except intact forest. We also had a single sighting of a bobcat on the road beside a fragmented forest. Bobcats use a wide variety of habitats (Lovallo and Anderson 1996), but are secretive and rarely seen, so our sighting should not be viewed as indicative of their habitat use on the mines. Black bears, detected in all 4 treatments, generally have large home ranges spanning multiple habitat types (Landers et al. 1979), which explains our observations of this species. Yearsley and Samuel (1980) found that red fox and gray fox often foraged on reclaimed strip mines in northern West Virginia but were least likely to do so in the summer. The fact that our studies were conducted in the summer and these animals are very secretive may explain why we had only 2 observations of red fox and none of gray fox. Of the other carnivores detected, the raccoon is a habitat generalist that adapts well to human-disturbed landscapes (Burks 1983, Holman 1983), so our encounters with this species in 3 treatments were not surprising. Lastly, we had a single olfactory detection of what was most likely a striped skunk (spotted skunk was not predicted to occur in this area by the WV Gap data) in the shrub/pole treatment. This treatment resembles their preferred habitat of semi-open areas, mixed woods or brush lands (Wade-Smith and Verts 1982).

Four species of carnivores were not observed: the gray fox and 3 members of the weasel family (least weasel, long-tailed weasel, and mink). Each of these species is secretive and primarily nocturnal (King 1989), so one would not necessarily come across them without using methods specifically designed to detect their presence.

Five species of the order Insectivora were expected to occur on our study areas, and all were detected (Table 30). Four shrew species were detected in all 4 treatments: northern short-tailed shrew, masked shrew, smoky shrew, and pygmy shrew. Short-tailed shrew, masked shrew, and pygmy shrew were expected to occur in all treatments as they have broad habitat requirements (George et al. 1986, Kirkland et al. 1987). The smoky shrew, which is reported to select for damp woods (Caldwell and Bryan 1982) was not predicted to occur in grasslands. The fact that summer 2000 was unusually wet (Fig. 17) may have allowed it to use grassland treatments. The only species of mole expected to be present on our study areas, the hairy-tailed mole, was observed on one occasion in fragmented forest. Moles rarely are found above ground, so they are not likely to be captured in traps or observed incidentally.

Ten species of rodent were observed out of 17 expected on our study areas (Table 30). By treatment, we detected 7 species in grassland, 5 in shrub/pole, 7 in fragmented forest, and 5 in intact forest. One of these, the southern bog lemming, was captured in all 4 treatments and is listed as a rare species by the West Virginia Wildlife & Natural Heritage Program (2000). It can exist in a variety of habitats and may be widespread on our study areas due to the virtual absence of the meadow vole, a direct competitor that is believed to displace the bog lemming where they overlap (Krupa and Haskins 1996). Meadow voles did occur in 3 treatments, but at very low numbers.

The Allegheny woodrat was an unexpected capture in shrub/pole areas. The sites were characterized by the presence of a reclaimed drainage ditch filled with large rip-rap boulders shaded by a few trees that lined the channel. This combination of features apparently simulates the natural rock outcrops where woodrats are often found (Balcom and Yahner 1996). It is listed as threatened, endangered, or as a species of special concern in Indiana, Maryland, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia due to population declines. Prior to the moratorium placed on the endangered species listing process under federal guidelines, this species was designated as a candidate Category II animal in response to apparent population declines in states along the periphery of its range (Balcom and Yahner 1996). When we realized woodrats occurred at some sites, we conducted additional trapping with Tomahawk live traps in another 40 areas of potential habitat, of which 18 were in shrub/pole, 6 were in fragmented forest, 5 were in intact forest, and 11 were around reclaimed-mine ponds. Woodrats were documented at 8 shrub/pole sites, 1 fragmented forest site, and 1 pond, though trapping effort was not equal at each site. In all, 26 woodrats were captured, including 6 adult males, 7 juvenile males, 10 adult females, and 3 juvenile females. Our limited trapping suggests that woodrats have colonized some older reclaimed areas and are breeding there. However, we did not trap extensively for woodrats at rock outcrops in forested habitat so we cannot compare abundances on reclaimed and intact sites.

Several species that were expected to occur in the counties that contained our study areas were not detected by any methods. Four squirrel species, southern flying squirrel, red squirrel, Eastern gray squirrel, and Eastern fox squirrel, were not observed or otherwise detected. The flying squirrel is strictly nocturnal, spending its days in tree cavities or leaf nests (Weigl 1978), habits that make it difficult to observe incidentally. It is possible, however to capture this species in Sherman traps, and it is surprising that none were captured. The red squirrel, gray squirrel, and fox squirrel are diurnal, so they should have been seen or heard if they were common on the mines. Red squirrels are documented in Fayette and Nicholas counties, so they may occur on the Cannelton mine; however, they may not be present on the Hobet and Daltex mines as no records exist of them in Boone and Logan Counties (M. Hight, personal communication). We also did not find southern red-backed voles or golden mice, small rodents that should have been caught in either the Sherman traps or the pitfall traps if they were present on our study sites. Of these, the golden mouse is a more southern species that is not certain to range into the areas where we trapped (M. Hight, personal communication). Southern red-backed voles are associated with mesic high-elevation forests in the Appalachians (Wharton and White 1967). We probably did not trap in their preferred habitat because trapping transects on our study sites were placed near stream channels.

Three additional orders were detected, represented by 4 species. The eastern cottontail, a member of the order Lagomorpha was expected and observed in all 4 treatments, though it was rarely detected in the forest. This is consistent with Chapman et al. (1980), who describe the cottontail as occupying diverse habitats, but not occurring abundantly in deep forests. In the order Artiodactyla, white-tailed deer and wild boar (*Sus scrofa*) were present. Deer were frequently observed in all treatments while wild boar were known to be present based on hunting records as well as a single observation of an animal near a pond. Wild boar are present only in a small portion of southern West Virginia where they were released as a game species by the WV DNR (Igo 1973, Mayer and Brisbin 1991). Lastly, Virginia opossum of the order Didelphimorphia was observed in the 2 forest treatments, though their use of many habitat types (McManus 1974) implies that they probably used the grassland and shrub/pole treatments as well.

Pond Surveys

Ponds, created as part of the reclamation process, were not considered a treatment as they were found within grassland and shrub/pole treatments. Pond surveys were conducted in 2000 to determine if they represented an important landscape feature for wildlife. In 2000, rainfall was plentiful compared to 1999, an extreme drought year (Fig. 17), and so water may not have been limiting to wildlife. The only species detected near ponds that was not detected elsewhere was the wild boar (Table 30), which is associated with watering holes for wallowing (Whitaker and Hamilton 1998). Another animal that was detected during pond surveys was raccoon, a species often found near streams and ponds where they forage for frogs, fish and waterfowl eggs (Llewellyn and Webster 1960). White-tailed deer and their tracks frequently were seen at pond edges; the deer apparently relied on these upland ponds for water while browsing in grasslands, which are located high above streams.

Two species that were expected to occur around ponds that were not detected are muskrat (*Ondatra zibethica*) and beaver (*Castor canadensis*). Many of the mine ponds seem to be ideal muskrat habitat, as they are overgrown with cattails. Muskrat's conical lodges, built of cattails and other wetland vegetation, should have been obvious if they were present, though we did not survey specifically for them. Muskrats also will tunnel into pond banks to den, with tunnel openings discretely located below water level (Whitaker and Hamilton 1998). However, rocky soil around mine ponds makes this an unlikely alternative here. Ponds also seem to provide summer habitat for beaver whose diet during this season consists of aquatic plants, algae, and herbaceous plants (Jenkins 1975). From fall to spring, their diet consists mostly of tree bark (Jenkins 1975). The lack of woody growth around mine ponds and the physical separation of mine ponds from forests by several hundred meters may restrict beaver to wooded areas on the MTMVF landscape.

Small Mammal Trapping

Numerous small mammal species—shrews, voles, and mice—were captured in Sherman live traps or pitfall traps (Table 30). The most common of these were the 2 *Peromyscus* species of mice, the white-footed mouse and the deer mouse. Although the majority (~95%) of *Peromyscus* were thought to be white-footed mice based on field markings, we did not differentiate between the 2 in our analyses because of the difficulty in distinguishing one from the other (Rich et al. 1996). Other small rodents captured included house mouse, woodland jumping mouse, meadow vole, woodland vole, and southern bog lemming. Unexpected captures in Sherman traps were juvenile eastern cottontail rabbits in grassland treatments, juvenile Virginia opossums in fragmented forest and intact forest, and Allegheny woodrats in shrub/pole treatment. Cottontail rabbits and opossums were not expected because of their size relative to trap size while the woodrat was not expected because we did not trap rock outcrops in forests, the habitat with which they are most often associated (Balcom and Yahner 1996). Of the insectivores, only 2 species were caught in Sherman traps: masked shrew and short-tailed shrew. Pitfall trapping accounted for 2 additional species: pygmy shrew and smoky shrew. The majority of shrew captures were by pitfall traps (240 individuals) compared to 40 individuals captured in Sherman traps.

Species Comparisons Among Treatments

Statistical analysis was performed on Sherman trapping results in 3 treatments in 1999 and 4 treatments in 2000. Indices of relative abundance and species richness (Table 31) were compared among the treatments, with each year's data analyzed separately due to the presence of significant ($F = 9.60$, $df = 2$, $P = 0.0001$) year by treatment interactions. Mean abundances separated by mine and treatment are found in Appendix 6. Reclaimed pond indices (Table 31) were not compared statistically to the other treatments for 2 reasons. First, it was not truly a treatment because the ponds were distributed throughout the reclaimed mines, overlapping both shrub/pole and grassland treatments. Second, sampling methods were different from the other treatments.

In 1999, species richness ranged from 1.7 species per transect in the grassland to 2.3 species per transect in the intact forest with no significant difference ($F = 2.61$, $df = 2$, $P = 0.09$) among treatments (Table 31). There were, however, differences in species composition among treatments as indicated by the Jaccard and Renkonen indices of species similarity (Table 32). In 2000, when shrub/pole areas were added as a fourth treatment, species richness ranged from 1.4 species per transect in the grassland, fragmented forest, and intact forest treatments to 1.5 species in the shrub/pole treatment. Again, there were no significant differences ($F = 0.17$, $df = 3$, $P = 0.92$) among treatments. Richness averaged over all treatments was compared between years as well. Richness in 1999 was 1.9 species per transect compared to 1.4 species per transect in 2000, a significant difference ($F = 19.86$, $df = 1$, $P < 0.0001$). This difference may be explained by changes in weather patterns between years (Gentry et al. 1966). From May through August in 1999, an extreme drought year, there was a total of 29.2 cm of rain in Charleston (Fig. 17), which is the nearest NOAA weather station to the mines we sampled. In 2000, however, 47.0 cm of rain were recorded in Charleston during the same months. Average daily high temperatures also were different between years, with 1999 having an average daily high of 29.1 C° from May to August and 2000 averaging 26.9 C° during those same months (Fig. 18). The thirty-year normal for the 4-month period is 40.8 cm of rain and an average daily high of 27.9 C° (Figs. 17 and 18).

The fact that richness indices were not significantly different among treatments in either year does not mean that the small mammal communities were the same. To compare the species composition between treatments, we calculated Jaccard and Renkonen indices of community similarity (Nur et al. 1999) (Table 32). In 1999, the Jaccard indices, which are based on the number of species shared between treatments but do not take into account species abundances, showed that the 2 forest treatments, fragments and intact, were more similar to each other than either was to the grassland treatment. Similar results were found in 2000, although the differences were not as pronounced. Also, the 2000 Jaccard indices showed that shrub/pole was more similar to grassland than it was to either of the 2 forest treatments. The Renkonen indices were in agreement with each of the trends shown by the Jaccard indices. However, this index, which incorporates similarities in species abundance as well as species composition between treatments, showed a high degree of similarity between treatments being compared. This is probably because *Peromyscus* species accounted for the vast majority of captures in all treatments.

Total relative abundance (F = 1.42, df = 2, *P* = 0.25) and *Peromyscus* species abundance (F = 1.79, df = 2, *P* = 0.18) did not differ among the 3 treatments sampled in 1999 (Table 31). In 2000, significant differences were found among treatments for both total abundance (F = 23.34, df = 3, *P* <0.001) and *Peromyscus* species abundance (F = 21.57, df = 3, *P* <0.001). In each case the grassland and shrub/pole treatments were similar, but had significantly greater abundances than fragmented forest and intact forest, which were similar to each other (Table 32). Because *Peromyscus* represent the majority of the captures, trends in its abundance are the driving factor in the difference found in overall abundance. Other studies on strip mines have shown that *Peromyscus* abundance is highest in early stages of succession (Verts 1957, Sly 1976, Hansen and Warnock 1978). Similarly, *Peromyscus* abundance has been shown to be higher in forest openings created by clearcutting than in adjacent forested areas in the southern Appalachians (Kirkland 1977, Buckner and Shure 1985).

In each year of the study, differences were found among treatments for several individual species captured. House mouse, for example, was captured only in the grassland treatment in both years, a finding consistent with other studies. In addition to human dwellings and other buildings, the house mouse has been found in grassy fields and croplands but almost never in forests (Kaufman and Kaufman 1990, Whitaker and Hamilton 1998). The woodland jumping mouse was captured only in fragmented forest and intact forest. As its name suggests, this species is generally a forest dweller, and is often found near streams (Whitaker and Hamilton 1998). It was found more frequently in fragmented forest than in intact forest. It has been reported to use habitat at the interface between forest and clearing, even venturing into open glades (Whitaker and Wrigley 1972), but no data could be found confirming that it selects for forest edge over interior forest. Except for a single grassland capture, eastern chipmunk also was found primarily in the 2 forest treatments, with intact having a greater abundance than fragmented (F = 11.20, df = 2, *P* < 0.0001). This result was not necessarily expected, as chipmunks are known to frequent forest edge habitats (Pyare et al. 1993). In 1999, short-tailed shrews differed in abundance between treatments (F = 4.59, df = 2, *P* = 0.016) with higher abundance in intact forest than in grasslands. Throughout its range, this species uses a variety of habitats, but is known to be restricted to moist woods in Indiana, Kentucky, and Tennessee (Whitaker and Hamilton 1998).

We also found several between-year differences in small mammal abundance. Total abundance in grassland habitats increased from 1999 to 2000 (F = 4.98, df = 1, *P* = 0.03). The difference may be related to weather patterns, as the combination of drought and high temperatures in summer 1999 may have made it a difficult season to exist in the open grasslands. Lewellen and Vessey (1998) reported that population growth in white-footed mice was negatively correlated with extreme weather conditions in both summer and winter. Fragmented forest (F = 14.71, df = 1, *P* < 0.0001) and intact forest (F = 34.40, df = 1, *P* <0.0001) had decreases in total abundance from 1999 to 2000. This may have been due to the dry, hot weather of 1999 that forced small mammals into the woods in search of water and relief from the high temperatures (Fig. 18), or alternatively, the cool, wet conditions in 2000 made the forest a more extreme environment than the reclaimed areas.

Other species differed in abundance between the 2 years. The number of short-tailed shrew captures dropped from 35 in 1999 to 2 in 2000. Decreased reproduction during the summer 1999 drought may be the cause of this trend. Short-tailed shrews, having a high rate of evaporation from the skin (George et al. 1986), are known to be unable to tolerate hot and dry conditions. Other studies also have noted wide yearly fluctuations in the abundance of this species, but the reason for this is not well understood (Lindeborg 1941, Fowle and Edwards

1955). Woodland jumping mice were caught at the rate of 0.5 individuals per 100 trap nights in intact forests in 2000 after not being caught at all in that treatment in 1999. However, this may not represent an actual difference because each of the individuals caught in intact forest in 2000 was trapped at a single site, one that was not trapped in 1999. Captures of woodland jumping mice also increased slightly in fragmented forest from 1999 to 2000. Southern bog lemmings were trapped in 2000 but not 1999. There is no clear reason for this, though only 2 were trapped in 2000 so the difference most likely does not represent an actual abundance difference between the years.

We also compared the results of our study with those of other small mammal studies conducted in grassland and shrub/pole habitat types (Table 33). However, interpretations of these comparisons should be made with caution for several reasons. First, capture methods differ among the studies, with the majority using snap traps rather than live traps. Capture methods have been shown to affect trapping success (Goodnight and Koestner 1942, Cockrum 1947, and Sealander and James 1958). Second, none of these studies was performed on a reclaimed MTMVF area. Most were on reclaimed strip mines, which may undergo a similar pattern of succession starting with reclamation, but differ from MTMVF areas in that the disturbance occurs on a much smaller spatial scale. A third reason that comparisons with other studies can be misleading is that abundance estimates may be calculated differently. Nelson and Clark (1973) recommended the use of a correction for sprung traps when calculating abundances. We employed this correction, but other studies, especially those prior to 1973, did not correct. In order to make comparisons with these studies, we also have listed our abundances calculated without the correction (Table 33).

Some additional differences between our results and those of other studies can be attributed to geographic differences, as the composition of small mammal communities varies by region. For example, in two of the studies to which we compared our results, those by Clark et al. (1998) in Oklahoma and Sietman et al. (1994) in Kansas, the cotton rat (*Sigmodon hispidus*) was the most abundant small mammal. The fact that they found *Peromyscus* at a much lower abundance than we did may simply be the result of competition with the cotton rat, a species that does not occur on our study areas. Also, the abundance of meadow voles in our grasslands was considerably lower than many of the other studies. For example, it was the most abundant small mammal captured by Mindell (1978) and Forren (1981) in northern West Virginia. It may not be as common in the southern part of the state due to the predominance of forest.

Summary

Our study is in agreement with most literature surveyed in that we found small mammals to be more abundant at early stages of succession than in forest. This trend in our study was driven by the white-footed mouse, a species that is often most abundant in early successional stages (e.g. Hansen and Warnock 1978, Buckner and Shure 1985). Two species, short-tailed shrew and eastern chipmunk, were more abundant in intact forest than fragmented forest. Allegheny woodrats were captured at several shrub/pole sites where rock drains with large boulders and some canopy cover provided useable habitat.

Herpetofauna

Based on habitat requirements and known records of herpetofaunal species reported in Green and Pauley (1987) and personnel communication with T. Pauley, we estimated that 59 species could be expected to occur on our study areas (Table 34), including 39 species that are predominantly terrestrial and 20 species that are predominantly aquatic. Through captures in drift fence arrays, occasional stream searches near arrays, and incidental observations, 35 (59%) species were found on our study areas, most in traps associated with drift fence arrays. No species federally-listed as endangered or threatened or state-listed as species of concern were found. Terrestrial and aquatic species of salamanders were least represented. Of the 39 terrestrial species expected to occur, we found 24 species (62%). We found 33% of species expected to occur within the grassland treatment, 81% within the shrub/pole treatment, 47% within forest fragments, and 53% within intact forests. Less developed vegetative cover and thick homogenous plantings of lespedeza likely resulted in the low value for the grassland treatment.

Only data from drift fence arrays were subjected to statistical analyses. Mean richness ($F=1.40$, $df=3$, $P=0.25$) and abundance ($F=1.14$, $df=3$, $P=0.34$) of all herpetofaunal captures combined did not differ between the 4 treatments (Table 35). We found no interactions between treatment and sampling period (richness: $F=0.69$, $df=15$, $P=0.78$; abundance: $F=0.61$, $df=15$, $P=0.85$). The number of different species captured ranged from 13 in young reclaimed grassland treatment to 16 in the fragmented forest treatment. In a study comparing herpetofaunal populations in recent clearcuts and mature forests, Pais et al. (1988) found that overall abundance did not differ between their treatments. Their study was conducted in eastern Kentucky where the herpetofaunal community is similar to our study sites and they used similar sampling methods (drift fence arrays). Thus, response of herpetofauna in overall abundance was similar in disturbed and undisturbed sites, whether the disturbance resulted from timber harvesting or from mining. However, Pais et al. (1988) found lowest species richness in their mature forest treatment, while we found no differences between treatments. As expected on our study sites, the herpetofaunal community was most similar between the grassland and shrub/pole treatments and most dissimilar between the grassland and intact forest treatments (Table 36).

Salamanders comprised about a quarter of individuals and species captured in fragmented and intact forest (Table 37). They were less common in the grassland and shrub/pole treatments, both in number of species and individuals. Red-spotted newts, both the adult and juvenile (red eft) forms were the most common species and the most widely distributed (Table 38). Both adults and juveniles were captured in all 4 treatments and at every sampling point. The only salamander species captured outside of the 2 forested treatments was a spotted salamander in a grassland array. Green and Pauley (1987) indicate that this species is typically found in deciduous forests but has been documented in newly plowed fields. In a review of 18 studies of amphibian responses to clearcutting, a disturbance that results in early successional habitats, de Maynadier and Hunter (1995) found that amphibian abundance was 3.5 times higher in unharvested stands than in recent clearcuts. So it was not surprising to find few salamanders in our early successional habitats. In 2-yr-old clearcuts in eastern Kentucky (an area with a herpetofaunal community similar to southern West Virginia), Pais et al. (1988), captured 5 species of salamanders with drift fence arrays. Their clearcuts (12-15 ha) were much smaller than our reclaimed sites and had forested habitat in closer proximity, which probably contributed to differences in salamander richness. Additionally, greater amounts of woody debris ground cover, higher soil moisure, and looser soil likely contributed to higher salamander richness in their early successional habitats (clearcuts) compared to ours (reclaimed mines). DeMaynadier and Hunter (1998) found that lack of canopy cover, litter cover, and cover from snags, stumps, and associated root channels potentially limited amphibians near forest edges created by clearcutting.

Toads and frogs were captured in high numbers in all 4 treatments, ranging from 53% to 72% of all individuals captured within a treatment (Table 37). High numbers of these species were captured during the August and September trapping periods and included many individuals that had recently metamorphosed, particularly green and pickerel frogs (Table 38). Summer of 2000 was an abnormally wet year (Fig. 17) and standing water occurred throughout the treatments providing ample habitat for breeding. The eastern American toad, green frog, and pickerel frog occurred at almost every sample point and within each treatment (Table 38). The wood frog, which typically occurs in moist, deciduous forests (Green and Pauley 1987), was captured only in the intact forest treatment.

Three species of lizards were captured in arrays; all were captured in low numbers and at few sample points (Table 38). Although only 5 species of lizards occur in southern West Virginia (Green and Pauley 1987), we had expected to capture them in greater numbers. The fence lizard in particular is known to occur in xeric habitats and was captured only in grassland and shrub/pole treatments. Because this species typically does not occur in moist forest conditions, it probably was not abundant on the study sites before mining occurred. It is not known how long it would take this species to colonize reclaimed mine sites since surrounding lands are generally forested. The ground skink, categorized by West Virginia Natural Heritage Program (2000) as a rare (“S3”) species, was found only in the intact forest treatment. This species generally inhabits the floor of dry, open woodlands and uses leaf litter and decaying wood for concealment and foraging (Conant 1975, Green and Pauley 1987)

Only 1 species of turtle, the box turtle, was captured in the arrays and it occurred in all treatments except shrub/pole (Table 38). This was the only species of terrestrial turtle expected to occur within our study areas. Turtle species generally are not sampled well by drift fence arrays, so captures of box turtles probably are not representative of the actual population.

Snakes were the most common group captured in grassland and shrub/pole habitats, ranging from 46-50% of species captured within these 2 treatments (Table 37). Within fragmented forest and intact forest, snakes accounted for 26-31% of species captured. Snakes are very mobile and may be able to colonize reclaimed sites more quickly than other herpetofaunal species and generally tolerate drier habitats resulting in the higher proportion of snake species. The total number of species and individuals was higher in the shrub/pole sites than in the forested sites. Similarly, Ross et al. (2000) found fewer species of snakes in forested areas with high tree densities. Two species were captured exclusively in the forest treatments, worm snake, and redbelly snake (Table 38). The worm snake is considered a rare (“S3”) species by the West Virginia Natural Heritage Program (2000). Green and Pauley (1987) state that redbelly snakes frequent open forests and forest edges and the species appears to prefer mountainous terrain. Similarly, eastern worm snakes prefer forest lands. This species frequently burrows in decayed logs or underground, so it is not surprising that this species was not captured in the reclaimed grassland or shrub/pole treatments. Three species, hognose (also classed as a rare “S3” species), black racer, and northern water snake, were captured only in the 2 reclaimed treatments. The hognose and black racer are known to frequent dry, open sites. The northern water snake will occur in almost any habitat if there is a reasonable amount of water (Green and Pauley 1987), and the wet summer during 2000 provided such areas in the reclaimed grassland and shrub/pole treatments.

Summary

The herpetofaunal community sampled from March through September 2000, shifted from a majority of amphibian species in the 2 forested treatments to a majority of reptile species in the grassland and shrub/pole treatments. In particular, salamander species decreased while snake species increased. Summer 2000 had much more rainfall than normal (see mammal results section) which provided ample breeding habitat for toads and frogs, a group that accounted for a high proportion of species and individuals in all treatments. Thus, we may have found a more pronounced shift during a drier summer. Herpetofaunal species that require loose soil, moist conditions, and woody or leaf litter ground cover generally were absent from reclaimed sites. Minimizing soil compaction, establishing a diverse vegetative cover, and adding coarse woody debris to reclaimed sites would provide habitat for some herpetofaunal species more quickly after mining. Salamander populations, however, appear to require several years to recover in areas disturbed by clearcutting (50-70 years: Petranka et al. 1993; 20-24 years: Ash 1997). MTMVF results in greater soil disturbance than clearcutting so a longer time may be required for recovery of salamander populations in reclaimed mine sites.

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Table 1. Watersheds and stream drainages with songbird (S), raptor (R), mammal (M), and herpetofaunal (H) sampling points by treatment in 3 watersheds in southwest West Virginia.

		Treatment			
Watershed	Streams	Grassland	Shrub/pole	Fragmented Forest	Intact Forest
Mud River	Big Horse	SRM		SRMH	
	Lavender Fork	SRMH		SMH	
	Stanley Fork	SRM		SRM	
	Spring Branch				SRMH
	Big Buck Fork				SR
	Hill Fork		SRM		
	Long Branch		SRMH		
Spruce Fork	Rockhouse Creek	SRMH			
	Bend Branch				SRM
	Beech Creek			SRM	
	Pigeonroost Branch				SRH
Twentymile Creek	Bullpush Fork	SRMH	SRMH		
	Ash Fork				SRMH
	Hughes Fork			SRMH	

Table 2. Number of replicates in each treatment and watershed for each taxa in 2000.

		Treatment			
Taxa	Watershed	Grassland	Shrub/pole	Fragmented Forest	Intact Forest
Songbirds	Mud River	18	17	20	20
	Spruce Fork	12	0	6	17
	Twentymile Creek	10	16	10	10
Mammals	Mud River	6	4	6	6
	Spruce Fork	2	0	2	2
	Twentymile Creek	2	4	2	2
Raptors	Mud River	4	6	4	5
	Spruce Fork	4	0	4	4
	Twentymile Creek	4	6	4	3
Herps	Mud River	1	1	2	1
	Spruce Fork	1	0	0	1
	Twentymile Creek	1	2	1	1

Table 3. Mean and range of estimated age and elevation of grassland, shrub/pole, fragmented forest, and intact forest treatments and total area of each treatment at each mine site.

	Treatment							
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest	
Mine	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Age (yrs)								
Hobet 21	12	8-14	16	16	--[a]	--	--	--
Daltex	8	5-11	--	--	--	--	--	--
Cannelton	13	9-19	23	13-27	--	--	--	--
Elevation (m)								
Hobet 21	367	304-423	322	241-375	308	253-358	328	276-406
Daltex	424	341-516	--	--	343	299-452	440	358-533
Cannelton	444	388-476	439	382-467	374	332-428	477	360-566
Area (ha)	Total	Range	Total	Range	Total	Range	Total	Range
Hobet 21	2003	--	428	--	339	83-157	--	--
Daltex	1819	--	106[b]	--	155	30-86	--	--
Cannelton	1672	--	508	--	214	--	--	--

[a] Data not applicable to this treatment or mine site.
[b] This shrub/pole habitat was not used for the study because it did not result from MTMVF.

Table 4. Codes for wind speed, sky cover, and edge types used in point count surveys.

Wind Speed	Sky Cover	Edge Types
0 = Smoke rises vertically	0 = Clear or few clouds	1 = Paved road
1 = Wind direction shown by smoke	1 = Partly cloudy	2 = Open-canopy road
2 = Wind felt on face, leaves rustle	2 = Cloudy or overcast	3 = Partially open-canopy road
3 = Leaves, small twigs in constant motion	3 = Fog	4 = Agricultural opening
4 = Raises dust and loose paper, small branches move	4 = Drizzle	5 = Development (houses, etc.)
5 = Small trees in leaf sway	5 = Showers	6 = River or stream
		7 = Clearcut
		8 = Wildlife opening
		9 = Natural gap
		10 = Valley Fill
		11 = Grassland
		12 = Forest
		13 = Pond
		14 = Autumn Olive Block

Table 5. Partner-in Flight (PIF) conservation ratings and action levels for upland forest birds in the Ohio Hills physiographic area, the percent of each species' population estimated to be within that area, the percent of forested point counts where these species were detected during this study, and species for which logistic regression models were developed.

Species	PIF rating[a]	Action level[ab]	Percent of population[ac]	Percent of point counts[d]	Logistic Regression Model?
Cerulean Warbler	30	II	46.8	36.1	yes
Swainson's Warbler	25	IV	1.9	1.2	no
Louisiana Waterthrush	25	III	11.6	15.7	yes
Worm-eating Warbler	24	IV	12.5	21.7	yes
Kentucky Warbler	22	IV	11.2	26.5	yes
Acadian Flycatcher	22	IV	15.6	81.9	yes
Eastern Wood-pewee	21	III	3.4	1.2	no
Wood Thrush	21	IV	9.1	56.6	yes
Yellow-throated Vireo	21	IV	8.5	20.5	yes
Hooded Warbler	21	IV	8.0	38.5	yes
Black-billed Cuckoo	21	IV	1.9	0.00	no
Scarlet Tanager	19	IV	11.1	47.0	yes
Great Crested Flycatcher	19	IV	1.0	1.2	no
Yellow-billed Cuckoo	19	IV	<1.0	9.6	no
Black-and-white Warbler	19	IV	1.3	41.0	yes

[a] Draft PIF Landbird Conservation Plan: Physiographic Area 22: Ohio Hills (Rosenburg 2000).
[b]Action levels: I=crisis; recovery needed; II=immediate management or policy needed rangewide; III=management to reverse or stabilize populations; IV= long-term planning to ensure stable populations; V=research needed to better define threats; VI=monitor population changes only (Rosenburg 2000).
[c] Percent of population thought to occur in the Ohio Hills area 22 calculated from percent of range area, weighted by BBS relative abundance (Rosenberg 2000).
[d] Percent of forested point counts (n=83) where species occurred in 1999-2000.

Table 6. Mean and standard error (SE) for habitat variables measured at grassland (n=44), shrub/pole (n=33), fragmented forest (n=36), and intact forest (n=49) sampling points.

	Treatment							
	Grassland		Shrub/Pole		Fragmented Forest		Intact Forest	
Variables	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Slope (%)	16.96	2.10	10.16	1.93	33.78	2.28	33.75	2.07
Aspect Code	1.05	0.10	0.78	0.13	1.05	0.12	1.02	0.08
Grass/Forb Height (dm)	7.29	0.27	6.20	0.48	--[a]	--	--	--
Litter Depth (cm)	2.26	0.19	1.64	0.17	--	--	--	--
Elevation (m)	400.93	7.19	378.85	11.53	332.08	7.11	389.58	10.87
Distance to Minor Edge (m)	113.02	16.75	68.14	8.23	38.71	3.88	64.61	11.57
Distance to Habitat Edge (m)	335.46	45.26	79.16	11.06	128.61	12.52	1430.66	145.32
Distance to Forest/Mine Edge (m)	347.35	44.30	253.98	34.46	128.61	12.52	1430.66	145.32
Robel Pole Index	2.93	0.17	4.30	0.27	--	--	--	--
Canopy Height (m)	--	--	4.67	0.45	21.70	0.72	22.90	0.67
<u>Ground Cover (%)</u>								
Water	0.14	0.10	0.15	0.12	1.15	0.32	0.48	0.17
Bareground	7.73	1.18	2.22	0.92	7.71	0.95	7.45	0.59
Litter	8.14	1.54	6.06	1.78	54.24	1.88	48.32	1.75
Woody Debris	0.06	0.04	0.30	0.12	4.20	0.42	4.95	0.41
Moss	1.04	0.38	1.83	0.86	2.01	0.32	2.04	0.34
Green	82.77	2.00	85.86	3.47	30.35	1.74	36.61	1.99
Forb Cover	23.63	2.39	21.89	2.86	--	--	--	--
Grass Cover	45.05	2.71	43.70	5.26	--	--	--	--
Shrub Cover	14.13	2.72	22.99	3.23	--	--	--	--
<u>Stem Densities (no./ha)</u>								
<2.5 cm	777.70	207.52	2590.91	351.50	2034.72	119.64	1670.92	100.40
>2.5-6 cm	73.15	18.79	993.37	151.95	6439.24	537.40	7122.45	741.86
>8-23 cm	0.85	0.43	113.26	20.71	374.65	37.20	304.08	14.32
>23-38 cm	0.00	0.00	27.65	6.29	93.23	5.60	94.13	5.11
>38-53 cm	0.00	0.00	3.98	1.65	32.29	3.32	31.89	2.60
>53-68 cm	0.00	0.00	1.70	0.87	11.28	1.69	7.91	1.22
>68 cm	0.00	0.00	0.00	0.00	4.34	0.93	3.57	0.73
<u>Canopy Cover (%)</u>								
>0.5-3 m	--	--	29.70	2.94	54.90	2.33	47.63	2.33
>3-6 m	--	--	22.88	2.86	66.63	2.42	54.67	2.06
>6-12 m	--	--	14.37	2.59	63.06	2.38	65.46	1.24
>12-18 m	--	--	2.84	0.86	56.01	2.68	63.34	2.07
>18-24 m	--	--	0.11	0.08	41.39	2.97	51.28	3.06
>24 m	--	--	0.00	0.00	16.15	2.48	18.06	2.14
Structural Diversity Index	--	--	3.85	0.29	11.58	0.23	11.37	0.22

[a] Variables were not measured in this treatment.

Table 7. Two-way ANOVA results comparing habitat variables among treatments and mines.

	Factor Levels															
	Treatment			Waller-Duncan[a]				Mine			Waller-Duncan[b]			Treatment x Mine		
Variables	F	df	P	GR	SH	FR	IN	F	df	P	Can.	Dal.	Hob.	F	df	P
Slope (%)	39.79	3	<0.01	B	C	A	A	26.55	2	<0.01	B	A	A	5.26	5	<0.01
Aspect Code	2.07	3	0.11					0.05	2	0.95				1.90	5	0.10
Elevation (m)	24.94	3	<0.01	A	B	C	A	106.18	2	<0.01	A	B	C	4.63	5	<0.01
Grass Height (dm)	3.82	1	0.06					20.78	2	<0.01	C	B	A	4.26	1	0.04
Litter Depth (cm)	3.56	1	0.06					25.07	2	<0.01	C	B	A	2.31	1	0.13
Distance to minor edge (m)	4.69	3	<0.01	A	B	B	B	0.35	2	0.70				2.08	5	0.07
Distance to habitat edge (m)	647.34	3	<0.01	B	C	C	A	184.31	2	<0.01	B	A	C	185.51	5	<0.01
Distance to mine/forest edge (m)	537.85	3	<0.01	B	C	D	A	142.67	2	<0.01	B	A	C	172.57	5	<0.01
Robel Pole Index	20.66	1	<0.01					11.09	2	<0.01	A	B	C	0.00	1	0.94
Canopy Height (m)	222.33	2	<0.01	--	B	A	A	1.02	2	0.36				7.66	3	<0.01
<u>Ground Cover (%):</u>																
Water	5.87	3	<0.01	C	C	A	B	1.26	2	0.28				0.40	5	0.85
Bareground	14.55	3	<0.01	A	B	A	A	3.91	2	0.02	AB	A	B	2.30	5	0.05
Litter	208.5	3	<0.01	C	C	A	B	4.14	2	0.02	C	A	B	9.24	5	<0.01
Woody Debris	121.45	3	<0.01	B	B	A	A	2.41	2	0.09				0.95	5	0.45
Moss	4.61	3	<0.01	B	B	A	A	0.24	2	0.79				0.95	5	0.45
Green	119.75	3	<0.01	B	A	C	C	2.18	2	0.12				1.63	5	0.15
Forb	0.07	1	0.79					4.99	2	0.01	A	A	B	3.56	1	0.06
Grass	0.15	1	0.70					22.22	2	<0.01	B	B	A	4.93	1	0.03
Shrub	3.54	1	0.06					14.68	2	<0.01	A	B	B	4.52	1	0.04
<u>Stem Density (no./ha)</u>:																
<2.5 cm	51.56	3	<0.01	B	A	A	A	4.39	2	0.01				5.80	5	<0.01
>2.5-8 cm	196.94	3	<0.01	C	B	A	A	2.90	2	0.06				2.07	5	0.07
>8-23 cm	514.48	3	<0.01	C	B	A	A	3.28	2	0.04				1.09	5	0.37
>23-38 cm	276.56	3	<0.01	C	B	A	A	0.00	2	0.99				0.31	5	0.91
>38-53 cm	189.33	3	<0.01	C	B	A	A	0.71	2	0.49				3.26	5	<0.01
>53-68 cm	31.73	3	<0.01	C	C	A	B	0.87	2	0.42				1.88	5	0.10
>68 cm	13.35	3	<0.01	B	B	A	A	2.25	2	0.11				1.56	5	0.17

Table 7. Continued.

	Factor Levels															
	Treatment			Waller-Duncan[a]				Mine			Waller-Duncan[b]			Treatment x Mine		
Variables	F	df	P	GR	SH	FR	IN	F	df	P	Can.	Dal.	Hob.	F	df	P
Canopy Cover (%):																
0.5-3 m	24.15	2	<0.01	--	C	A	B	0.98	2	0.38				1.69	3	0.17
>3-6 m	69.44	2	<0.01	--	C	A	B	0.10	2	0.91				3.68	3	0.01
>6-12 m	144.61	2	<0.01	--	B	A	A	0.02	2	0.98				1.85	3	0.14
>12-18 m	259.89	2	<0.01	--	C	B	A	0.82	2	0.44				0.65	3	0.58
>18-24 m	154.75	2	<0.01	--	C	B	A	1.95	2	0.15				1.82	3	0.15
>24 m	30.83	2	<0.01	--	B	A	A	1.41	2	0.25				2.58	3	0.06
Structural Diversity Index	262.81	2	<0.01	--	B	A	A	0.09	2	0.91				2.38	3	0.07

[a] Waller-Duncan k-ratio t-test. Treatments with different letters differ at P<0.05 ('A' indicates highest value). GR=grassland; SH=shrub/pole; FR=fragmented forest; IN=intact forest.
[b] Waller-Duncan k-ratio t-test. Mines with different letters differ at P<0.05 ('A' indicates highest value). Can.=Cannelton; Dal.=Daltex; Hob.=Hobet.

Table 8. ANOVA results comparing habitat variables among mines within individual treatments for variables with treatment x mine interactions.

	Treatment/Mine																						
	Grassland			Waller-Duncan[a]			Shrub/pole			Waller-Duncan		Fragmented Forest			Waller-Duncan			Intact Forest			Waller-Duncan		
Variables	F	df	P	Can.	Dal.	Hob.	F	df	P	Can.	Hob.	F	df	P	Can.	Dal.	Hob.	F	df	P	Can.	Dal.	Hob.
Slope (%)	2.30	2	0.11	B	A	AB	120.21	1	<0.01	B	A	6.40	2	<0.01	B	A	A	4.72	2	0.01	B	B	A
Aspect Code	1.84	2	0.17				2.93	1	0.09	B	A	0.47	2	0.63				1.03	2	0.36			
Elevation (m)	19.53	2	<0.01	A	A	B	127.50	1	<0.01			14.40	2	<0.01	A	B	C	37.36	2	<0.01	A	B	C
Distance to habitat edge (m)	15.69	2	<0.01	B	A	B	3.40	1	0.07	A	B	3.60	2	0.04	AB	B	A	445.12	2	<0.01	A	A	B
Distance to forest/mine edge (m)	13.72	2	<0.01	B	A	B	11.33	1	<0.01	B	A	3.60	2	0.04	AB	B	A	445.12	2	<0.01	A	A	B
Grass Height (dm)	5.42	2	<0.01	B	B	A	31.76	1	<0.01	B	A	--	--	--				--	--	--			
Canopy Height (m)	--	--	--				1.21	1	0.28			7.29	2	<0.01	A	B	B	3.17	2	0.05	AB	A	B
Ground Cover (%):																							
Bareground	3.75	2	0.03	AB	A	B	0.77	1	0.39			4.00	2	0.03	A	B	B	0.59	2	0.56			
Litter	12.35	2	<0.01	C	B	A	6.24	1	0.02	A	B	1.92	2	0.16				5.72	2	<0.01	B	A	B
Grass	9.73	2	<0.01	B	B	A	25.30	1	<0.01	B	A	--	--	--									
Shrub	13.11	2	<0.01	AB	B	C	5.95	1	0.02	A	B	--	--	--									
Stem Density (no./ha):																							
<2.5cm	5.81	2	<0.01	B	A	A	0.00	1	0.98			2.07	2	0.14				0.07	2	0.93			
>38-53cm	--	--	--				3.47	1	0.07	A	B	1.36	2	0.27				5.16	2	<0.01	B	A	A
Canopy Cover (%):																							
>3-6m	--	--	--				2.63	1	0.11			0.28	1	0.76				6.00	2	<0.01	A	A	B
	--	--	--																				
Structural Diversity Index	--	--	--				1.38	1	0.25			0.33	1	0.72				3.30	2	0.05	AB	A	B

[a] Waller-Duncan k-ratio t-test. Mines with different letters differ at P<0.05 ('A' indicates highest value). Can.=Cannelton; Dal.= Daltex; Hob.=Hobet.

Table 9. ANOVA results comparing habitat variables among treatments at individual mines for variables with treatment x mine interactions.

	Mine/treatment																			
	Cannelton			Waller-Duncan[a]				Daltex			Waller-Duncan			Hobet			Waller-Duncan			
Variables	F	df	P	GR	SH	FR	IN	F	df	P	GR	FR	IN	F	df	P	GR	SH	FR	IN
Slope (%)	39.47	3	<0.01	B	C	A	A	1.77	2	0.19				22.80	3	<0.01	B	B	A	A
Aspect Code	4.06	3	0.01	A	B	A	AB	1.00	2	0.38				0.10	3	0.96				
Elevation (m)	11.28	3	<0.01	AB	B	C	A	9.18	2	<0.01	A	B	A	11.93	3	<0.01	A	BC	C	B
Distance to habitat edge (m)	759.76	3	<0.01	B	B	B	A	209.89	2	<0.01	B	C	A	18.43	3	<0.01	B	C	B	A
Distance to forest/mine edge (m)	660.78	3	<0.01	B	B	B	A	209.89	2	<0.01	B	C	A	8.04	3	<0.01	BC	BA	C	A
Grass Height (dm)	4.25	1	0.05					--	--	--				0.01	1	0.91				
Canopy Height (m)	97.45	1	<0.01	--	B	A	A	--	--	--				123.98	2	<0.01	--	B	A	A
Ground Cover (%):																				
Bareground	7.33	3	<0.01	A	B	A	A	1.58	2	0.22				8.94	3	<0.01	B	C	AB	A
Litter	50.67	3	<0.01	C	B	A	A	173.58	2	<0.01	B	A	A	101.76	3	<0.01	C	D	A	B
Grass	3.70	1	0.07					--	--	--				1.64	1	0.21				
Shrub	0.03	1	0.86					--	--	--				12.34	1	<0.01				
Stem Densities (no./ha):																				
<2.5cm	50.28	3	<0.01	B	A	A	A	13.42	2	<0.01	B	A	A	8.48	3	<0.01	B	A	A	A
>38-53cm	39.03	3	<0.01	D	C	A	B	91.33	2	<0.01	B	A	A	134.64	3	<0.01	B	B	A	A
Canopy Cover (%):																				
>3-6m	29.42	2	<0.01	--	B	A	A							35.47	2	<0.01	--	C	B	A
Structural Diversity Index	117.12	2	<0.01	--	B	A	A							194.46	2	<0.01	--	C	A	B

[a] Waller-Duncan k-ratio t-test. Treatments with different letters differ at P<0.05 ('A' indicates highest value). GR=grassland; SH=shrub/pole; FR=fragmented forest; IN=intact forest.

Table 10. Mean distance from subplot centers to minor edge types within treatments, and the percentage of subplots within each treatment that were closest to that edge type.

	Grassland			Shrub/pole			Fragmented Forest			Intact Forest		
	Distance (m)			Distance (m)			Distance (m)			Distance (m)		
Minor Edge Type	Mean	SE	Percent	Mean	SE	Percent	Mean	SE	Percent	Mean	SE	Percent
Paved road	40.00	0.00	0.63	--	--	0.00	--	--	0.00	--	--	0.00
Open-canopy road	105.97	14.71	40.51	76.10	6.02	73.23	54.03	4.56	24.65	57.10	7.37	10.26
Partially-open canopy road	--	--	0.00	--	--	0.00	12.72	3.78	12.68	58.96	7.12	48.21
Stream	--	--	0.00	--	--	0.00	35.99	3.80	47.89	34.77	4.01	31.79
Natural gap/wildlife opening	--	--	0.00	--	--	0.00	34.00	7.97	3.52	11.50	8.50	1.03
Valley fill	118.80	16.97	55.70	36.36	6.46	19.69	38.40	13.38	3.52	--	--	0.00
Grassland	--	--	0.00	--	--	0.00	77.50	2.50	1.41	--	--	0.00
Forest	44.00	16.99	3.16	75.71	13.38	5.51	--	--	0.00	--	--	0.00
Pond	--	--	0.00	10.00	5.00	1.57	--	--	0.00	--	--	0.00
Combination	--	--	0.00	--	--	0.00	35.00	7.45	6.34	239.71	28.91	8.72

Table 11. Comparison of species found to be “probable” or “confirmed” breeders in southwestern West Virginia by the West Virginia Breeding Bird Atlas (WV BBA) or expected to be there by the West Virginia Gap Analysis Lab (Gap), and those observed during this study during surveys and/or incidentally (x=observed during breeding season, m=assumed to be migrating).

			This Study				
Species	WV BBA	Gap	Grassland	Shrub/ pole	Fragmented Forest	Intact Forest	Pond
Forest Interior Species							
Acadian Flycatcher	x	x		x	x	x	
Black-throated Blue Warbler		x					
Black-throated Green Warbler	x	x				x	x
Blue-headed Vireo	x	x			x	x	
Canada Warbler		x					
Cerulean Warbler	x	x		x	x	x	
Eastern Wood-pewee	x	x				x	
Great Crested Flycatcher	x	x				x	
Kentucky Warbler	x	x			x	x	
Louisiana Waterthrush	x	x			x	x	
Ovenbird	x	x		x	x	x	
Pileated Woodpecker	x	x			x	x	
Scarlet Tanager	x	x		x	x	x	x
Summer Tanager	x	x			x	x	
Swainson’s Warbler	x	x			x		
Veery		x				x	
Winter Wren	x	x					
Wood Thrush	x	x			x	x	
Worm-eating Warbler	x	x			x	x	
Yellow-throated Warbler	x	x			x	x	
Interior-edge Species							
American Redstart	x	x			x	x	
American Robin	x	x			x	x	x
Black-and-white-Warbler	x	x			x	x	
Black-billed Cuckoo	x	x	x	x	x		
Black-capped Chickadee	x	x			x	x	
Blue-gray Gnatcatcher	x	x			x	x	
Carolina Chickadee	x	x	x	x	x	x	x
Carolina Wren	x	x		x	x	x	
Common Raven	x	x	x				x
Dark-eyed Junco		x			x		
Downy Woodpecker	x	x		x	x	x	x
Eastern Phoebe	x	x	x	x		x	x
Eastern Towhee	x	x	x	x		x	x
Hairy Woodpecker	x	x		x	x	x	
Hooded Warbler	x	x		x	x	x	
Least Flycatcher		x					
Northern Flicker	x	x	x	x	x	x	
Northern Parula	x	x		x	x	x	
Palm Warbler							m

Table 11. Continued.

Species	WV BBA	Gap	This Study: Grassland	Shrub/ pole	Fragmented Forest	Intact Forest	Pond
Pine Warbler	x	x					
Red-bellied Woodpecker	x	x			x	x	
Red-eyed Vireo	x	x	x	x	x	x	x
Red-headed Woodpecker		x					
Rose-breasted Grosbeak		x					
Ruby-throated Hummingbird	x	x	x	x	x	x	
Ruffed Grouse	x	x			x	x	
Tufted Titmouse	x	x		x	x	x	
Whip-poor-will	x	x				x	
White-breasted Nuthatch	x	x		x	x	x	
Wild Turkey	x	x	x	x	x	x	x
Yellow-billed Cuckoo	x	x	x	x	x	x	x
Yellow-throated Vireo	x	x			x	x	x
<u>Edge Species</u>							
American Crow	x	x			x		
American Goldfinch	x	x	x	x	**x**	x	x
American Woodcock	x	x			x	x	x
Baltimore Oriole	x	x	x		x		x
Blue Grosbeak		x	x	x	x		x
Blue Jay	x	x	x		x	x	x
Blue-winged Warbler	x	x	x	x	x	x	x
Brown Thrasher	x	x	x	x			x
Brown-headed Cowbird	x	x				x	
Cedar Waxwing	x	x	x	x	x		
Chestnut-sided Warbler		x					
Chipping Sparrow	x	x		x			
Common Grackle	x	x					
Common Yellowthroat	x	x	x	x			x
Eastern Bluebird	x	x	x	x			x
Eastern Kingbird	x	x	x				
Field Sparrow	x	x	x	x			x
Golden-winged Warbler	x	x		x			x
Gray Catbird	x	x		x			x
House Wren	x	x					
Indigo Bunting	x	x	x	x	x	x	x
Mourning Dove	x	x	x	x			x
Northern Bobwhite	x	x	x				
Northern Cardinal	x	x	x	x	x	x	x
Northern Mockingbird	x	x		x			
Orchard Oriole	x	x	x	x			x
Prairie Warbler	x	x	x	x			x
Purple Finch				x			
Song Sparrow	x	x	x	x	x		x
Warbling Vireo	x	x					
White-eyed Vireo	x	x		x	x		
Yellow Warbler	x	x	x	x			x

Table 11. Continued.

			This Study				
Species	WV BBA	Gap	Grassland	Shrub/ pole	Fragmented Forest	Intact Forest	Pond
Yellow-breasted Chat	x	x	x	x	x		x
Grassland Species							
Bobolink			x				m
Dickcissel			x				x
Eastern Meadowlark	x	x	x	x			x
Grasshopper Sparrow		x	x	x			x
Henslow's Sparrow		x	x				x
Horned Lark		x	x				x
Red-winged Blackbird	x	x	x	x	x		x
Ring-necked Pheasant			x				
Vesper Sparrow			x				
Willow Flycatcher		x	x				x
Wetland Species							
American Black Duck		x					
American Bittern							x
Blue-winged Teal		x					m
Canada Goose	x	x	x		x		x
Common Merganser							m
Double-crested Cormorant						m	
Great Blue Heron							x
Green Heron	x	x					x
Hooded Merganser		x					
Mallard	x	x	x				x
Spotted Sandpiper		x					m
Swamp Sparrow		x					
Wood Duck	x	x			x		x
Greater Yellowlegs							**m**
Lesser Yellowlegs							m
Least Sandpiper							m
Pied-billed Grebe							m
Solitary Sandpiper							m
White-rumped Sandpiper							m
Green-winged Teal							m
Yellow-crowned Night-heron						m	
Other Species							
Bank Swallow		x					
Barn Swallow	x	x	x		x		x
Belted Kingfisher	x	x			x	x	
Chimney Swift	x	x	x		x		x
Cliff Swallow		x	x				
Common Nighthawk	x	x	m				
European Starling	x		x				
House Finch	x	x					

Table 11. Continued.

Species	WV BBA	Gap	This Study Grassland	Shrub/ pole	Fragmented Forest	Intact Forest	Pond
House Sparrow	x						
Killdeer	x	x	x				x
Northern Rough-winged Swallow	x	x	x				x
Purple Martin	x	x					
Tree Swallow	x	x	x		x		x
Rock Dove	x						

Table 12. Bird species observed (means with standard errors in parentheses) during 50-m radius point count surveys on reclaimed MTMVF areas in grassland, shrub/pole, fragmented forests, and intact forest treatments in Boone, Fayette, Kanawha, and Logan Counties, West Virginia, 1999-2000.

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		ANOVA Results[a]	
Species	1999	2000	1999	2000	1999	2000	1999	2000	F	P
Forest Interior Species										
Acadian Flycatcher	0.00	0.00	0.17	0.03	0.96	0.86	1.11	1.32	4.87	0.03
	(0.00)	(0.00)	(0.17)	(0.03)	(0.15)	(0.11)	(0.12)	(0.12)		
Black-throated Green	0.00	0.00	0.00	0.00	0.00	0.17	0.06	0.17	0.21	0.65
Warbler	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.04)	(0.06)		
Blue-headed Vireo	0.00	0.00	0.00	0.00	0.25	0.19	0.44	0.36	2.86	0.09
	(0.00)	(0.00)	(0.00)	(0.00)	(0.09)	(0.08)	(0.12)	(0.08)		
Cerulean Warbler	0.00	0.00	0.00	0.03	0.21	0.31	0.36	0.36	1.22	0.27
	(0.00)	(0.00)	(0.00)	(0.03)	(0.08)	(0.10)	(0.11)	(0.09)		
Eastern Wood-pewee	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.02)		
Great Crested Flycatcher	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)		
Kentucky Warbler	0.00	0.00	0.17	0.00	0.29	0.25	0.28	0.26	0.00	0.97
	(0.00)	(0.00)	(0.17)	(0.00)	(0.11)	(0.08)	(0.09)	(0.08)		
Louisiana Waterthrush	0.00	0.00	0.00	0.00	0.08	0.19	0.17	0.06	1999:0.58	1999: 0.45
	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.07)	(0.07)	(0.04)	2000:3.33	2000: 0.07
Ovenbird	0.00	0.00	0.00	0.03	0.54	0.61	1.00	1.34	18.03	<0.01
	(0.00)	(0.00)	(0.00)	(0.03)	(0.10)	(0.10)	(0.13)	(0.17)		
Pileated Woodpecker	0.00	0.03	0.00	0.00	0.17	0.08	0.00	0.06	1999:6.96	1999: 0.01
	(0.00)	(0.03)	(0.00)	(0.00)	(0.08)	(0.05)	(0.00)	(0.04)	2000:0.11	2000: 0.74
Scarlet Tanager	0.00	0.00	0.00	0.09	0.21	0.31	0.11	0.68	1999:1.22	1999: 0.27
	(0.00)	(0.00)	(0.00)	(0.05)	(0.08)	(0.10)	(0.07)	(0.12)	2000:6.03	2000: 0.02
Summer Tanager	0.00	0.00	0.00	0.00	0.13	0.08	0.11	0.13	0.08	0.78
	(0.00)	(0.00)	(0.00)	(0.00)	(0.07)	(0.05)	(0.05)	(0.05)		
Swainson's Warbler	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)		
Wood Thrush	0.00	0.00	0.00	0.00	0.79	0.36	0.44	0.64	0.08	0.77
	(0.00)	(0.00)	(0.00)	(0.00)	(0.18)	(0.09)	(0.11)	(0.12)		
Worm-eating Warbler	0.00	0.00	0.00	0.00	0.08	0.19	0.19	0.17	0.25	0.62
	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.07)	(0.08)	(0.06)		

Table 12. Continued.

Species	Grassland 1999	Grassland 2000	Shrub/pole 1999	Shrub/pole 2000	Fragmented Forest 1999	Fragmented Forest 2000	Intact Forest 1999	Intact Forest 2000	ANOVA Results[a] F	ANOVA Results[a] P
Yellow-throated Warbler	0.00	0.00	0.00	0.00	0.04	0.17	0.08	0.09	0.14	0.71
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.07)	(0.06)	(0.04)		
Interior-edge Species										
American Redstart	0.00	0.00	0.50	0.06	0.25	0.25	0.53	0.77	13.21	<0.01
	(0.00)	(0.00)	(0.22)	(0.04)	(0.11)	(0.07)	(0.09)	(0.13)		
American Robin	0.00	0.00	0.00	0.03	0.04	0.00	0.00	0.02		
	(0.00)	(0.00)	(0.00)	(0.03)	(0.04)	(0.00)	(0.00)	(0.02)		
Black-and-white Warbler	0.00	0.00	0.00	0.03	0.29	0.28	0.22	0.34	0.00	0.98
	(0.00)	(0.00)	(0.00)	(0.03)	(0.09)	(0.09)	(0.07)	(0.07)		
Black-capped Chickadee	0.00	0.00	0.00	0.00	0.04	0.00	0.03	0.02		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.00)	(0.03)	(0.02)		
Blue-gray Gnatcatcher	0.00	0.00	0.00	0.00	0.04	0.00	0.03	0.11		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.00)	(0.03)	(0.09)		
Carolina Chickadee	0.00	0.03	0.00	0.27	0.42	0.42	0.42	0.28	0.57	0.45
	(0.00)	(0.03)	(0.00)	(0.10)	(0.12)	(0.12)	(0.12)	(0.08)		
Carolina Wren	0.00	0.00	0.17	0.03	0.38	0.19	0.44	0.06	0.23	0.63
	(0.00)	(0.00)	(0.17)	(0.03)	(0.12)	(0.07)	(0.11)	(0.04)		
Dark-eyed Junco	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.00)	(0.00)	(0.00)		
Downy Woodpecker	0.00	0.00	0.00	0.18	0.08	0.28	0.06	0.00	1999: 0.17	1999: 0.68
	(0.00)	(0.00)	(0.00)	(0.08)	(0.06)	(0.09)	(0.04)	(0.00)	2000:12.33	2000:<0.01
Eastern Phoebe	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.04		
	(0.00)	(0.00)	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)	(0.03)		
Eastern Towhee	0.03	0.08	0.50	0.76	0.00	0.00	0.00	0.02		
	(0.03)	(0.04)	(0.34)	(0.11)	(0.00)	(0.00)	(0.00)	(0.02)		
Hairy Woodpecker	0.00	0.00	0.00	0.09	0.00	0.06	0.11	0.09	2.11	0.15
	(0.00)	(0.00)	(0.00)	(0.05)	(0.00)	(0.04)	(0.05)	(0.05)		
Hooded Warbler	0.00	0.00	0.33	0.03	0.17	0.14	0.42	0.57	13.07	<0.01
	(0.00)	(0.00)	(0.21)	(0.03)	(0.08)	(0.07)	(0.10)	(0.10)		
Northern Flicker	0.00	0.03	0.00	0.06	0.08	0.00	0.06	0.02		
	(0.00)	(0.03)	(0.00)	(0.04)	(0.06)	(0.00)	(0.06)	(0.02)		
Northern Parula	0.00	0.00	0.00	0.03	0.17	0.36	0.14	0.11	1999:0.01	1999: 0.92
	(0.00)	(0.00)	(0.00)	(0.03)	(0.10)	(0.09)	(0.06)	(0.05)	2000:7.19	2000: <0.01
Red-bellied Woodpecker	0.00	0.00	0.00	0.00	0.04	0.08	0.08	0.09	1999:0.39	1999: 0.53
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.05)	(0.05)	(0.04)	2000:0.00	2000: 0.98

Table 12. Continued.

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		ANOVA Results[a]	
Species	1999	2000	1999	2000	1999	2000	1999	2000	F	P
Red-eyed Vireo	0.00	0.03	0.50	0.42	1.00	1.72	0.92	1.38	3.30	0.07
	(0.00)	(0.03)	(0.22)	(0.10)	(0.12)	(0.14)	(0.13)	(0.11)		
Ruby-throated	0.00	0.03	0.00	0.06	0.08	0.11	0.11	0.04		
Hummingbird[b]	(0.00)	(0.03)	(0.00)	(0.04)	(0.06)	(0.07)	(0.05)	(0.03)		
Tufted Titmouse	0.00	0.00	0.00	0.09	0.13	0.28	0.17	0.23	0.00	0.99
	(0.00)	(0.00)	(0.00)	(0.05)	(0.07)	(0.08)	(0.06)	(0.06)		
White-breasted Nuthatch	0.00	0.00	0.00	0.03	0.08	0.19	0.22	0.15	0.39	0.53
	(0.00)	(0.00)	(0.00)	(0.03)	(0.08)	(0.07)	(0.08)	(0.05)		
Yellow-billed Cuckoo	0.00	0.03	0.33	0.06	0.04	0.14	0.08	0.00	1999:0.39	1999: 0.53
	(0.00)	(0.03)	(0.21)	(0.04)	(0.04)	(0.06)	(0.05)	(0.00)	2000:7.40	2000: <0.01
Yellow-throated Vireo	0.00	0.00	0.00	0.00	0.13	0.22	0.08	0.11	1.81	0.71
	(0.00)	(0.00)	(0.00)	(0.00)	(0.07)	(0.07)	(0.05)	(0.05)		
Edge Species										
American Crow[b]	0.00	0.00	0.00	0.09	0.13	0.00	0.00	0.00		
	(0.00)	(0.00)	(0.00)	(0.05)	(0.09)	(0.00)	(0.00)	(0.00)		
American Goldfinch	0.37	0.25	2.67	0.55	0.08	0.14	0.00	0.02	1999:3.16	1999:0.08
	(0.14)	(0.07)	(1.73)	(0.14)	(0.06)	(0.09)	(0.00)	(0.02)	2000:2.04	2000:0.16
Baltimore Oriole	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Blue Grosbeak	0.00	0.15	0.00	0.06	0.00	0.00	0.00	0.00		
	(0.00)	(0.07)	(0.00)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)		
Blue Jay[b]	0.03	0.00	0.00	0.00	0.08	0.08	0.03	0.11		
	(0.03)	(0.00)	(0.00)	(0.00)	(0.06)	(0.06)	(0.03)	(0.05)		
Blue-winged Warbler	0.10	0.00	1.17	0.48	0.04	0.00	0.06	0.00		
	(0.06)	(0.00)	(0.17)	(0.11)	(0.04)	(0.00)	(0.04)	(0.00)		
Brown Thrasher	0.10	0.08	0.17	0.06	0.00	0.00	0.00	0.00		
	(0.07)	(0.04)	(0.17)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)		
Brown-headed Cowbird	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.15	3.42	0.07
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.06)	(0.05)		
Cedar Waxwing[b]	0.00	0.13	0.00	0.33	0.00	0.00	0.00	0.00		
	(0.00)	(0.09)	(0.00)	(0.13)	(0.00)	(0.00)	(0.00)	(0.00)		
Chipping Sparrow	0.00	0.00	0.17	0.27	0.00	0.00	0.00	0.00		
	(0.00)	(0.00)	(0.17)	(0.08)	(0.00)	(0.00)	(0.00)	(0.00)		

Table 12. Continued.

	Treatment								ANOVA Results[a]	
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest			
Species	1999	2000	1999	2000	1999	2000	1999	2000	F	P
Common Yellowthroat	0.37	0.15	0.50	0.79	0.00	0.00	0.00	0.00		
	(0.10)	(0.07)	(0.34)	(0.12)	(0.00)	(0.00)	(0.00)	(0.00)		
Eastern Bluebird	0.00	0.03	0.00	0.06	0.00	0.00	0.00	0.00		
	(0.00)	(0.03)	(0.00)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)		
Field Sparrow	0.37	0.68	1.00	1.27	0.00	0.00	0.00	0.00		
	(0.12)	(0.16)	(0.26)	(0.21)	(0.00)	(0.00)	(0.00)	(0.00)		
Golden-winged Warbler	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00		
	(0.00)	(0.00)	(0.00)	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)		
Gray Catbird	0.00	0.00	0.17	0.15	0.00	0.00	0.00	0.00		
	(0.00)	(0.00)	(0.17)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)		
Indigo Bunting	0.80	0.98	0.83	1.70	0.17	0.19	0.03	0.06	6.68	0.01
	(0.16)	(0.13)	(0.31)	(0.19)	(0.08)	(0.07)	(0.03)	(0.04)		
Mourning Dove	0.07	0.08	0.00	0.09	0.00	0.00	0.00	0.00		
	(0.07)	(0.04)	(0.00)	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)		
Northern Bobwhite[b]	0.03	0.08	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.03)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Northern Cardinal	0.00	0.03	0.50	0.24	0.08	0.17	0.00	0.04		
	(0.00)	(0.03)	(0.22)	(0.08)	(0.06)	(0.08)	(0.00)	(0.04)		
Orchard Oriole	0.00	0.05	0.00	0.18	0.00	0.00	0.00	0.00		
	(0.00)	(0.03)	(0.00)	(0.09)	(0.00)	(0.00)	(0.00)	(0.00)		
Prairie Warbler	0.10	0.23	0.67	1.15	0.00	0.00	0.00	0.00		
	(0.06)	(0.08)	(0.21)	(0.15)	(0.00)	(0.00)	(0.00)	(0.00)		
Song Sparrow	0.20	0.23	0.00	0.09	0.04	0.03	0.00	0.00		
	(0.10)	(0.09)	(0.00)	(0.05)	(0.04)	(0.03)	(0.00)	(0.00)		
White-eyed vireo	0.07	0.08	0.33	0.45	0.00	0.03	0.00	0.00		
	(0.05)	(0.04)	(0.21)	(0.10)	(0.00)	(0.03)	(0.00)	(0.00)		
Yellow Warbler	0.30	0.08	0.33	0.27	0.00	0.03	0.00	0.00		
	(0.09)	(0.04)	(0.21)	(0.11)	(0.00)	(0.03)	(0.00)	(0.00)		
Yellow-breasted Chat	0.23	0.15	0.67	1.33	0.00	0.06	0.00	0.00		
	(0.08)	(0.06)	(0.21)	(0.16)	(0.00)	(0.04)	(0.00)	(0.00)		
Grassland Species										
Bobolink	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		

Table 12. Continued.

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		ANOVA Results[a]	
Species	1999	2000	1999	2000	1999	2000	1999	2000	F	P
Dickcissel	0.20	0.18	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.12)	(0.08)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Eastern Meadowlark	0.63	0.58	0.00	0.06	0.00	0.00	0.00	0.00		
	(0.17)	(0.13)	(0.00)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)		
Grasshopper Sparrow	2.23	2.95	0.33	0.27	0.00	0.00	0.00	0.00		
	(0.19)	(0.22)	(0.33)	(0.09)	(0.00)	(0.00)	(0.00)	(0.00)		
Henslow's Sparrow	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Horned Lark	0.33	0.23	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.09)	(0.08)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Red-winged Blackbird	1.37	0.73	0.00	0.36	0.00	0.03	0.00	0.00		
	(0.28)	(0.21)	(0.00)	(0.16)	(0.00)	(0.03)	(0.00)	(0.00)		
Vesper Sparrow	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Willow Flycatcher	0.13	0.15	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.06)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Other Species										
American Kestrel[b]	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Barn Swallow[b]	0.00	0.05	0.00	0.03	0.00	0.00	0.00	0.00		
	(0.00)	(0.03)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)		
Belted Kingfisher[b]	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.00)		
Chimney Swift[b]	0.00	0.18	0.00	0.30	0.00	0.00	0.00	0.00		
	(0.00)	(0.15)	(0.00)	(0.12)	(0.00)	(0.00)	(0.00)	(0.00)		
Cliff Swallow[b]	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Cooper's Hawk[b]	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00		
	(0.00)	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)		
European Starling[b]	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.00)	(0.40)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Killdeer[b]	0.13	0.08	0.17	0.00	0.00	0.00	0.00	0.00		
	(0.06)	(0.04)	(0.17)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		

Table 12. Continued.

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		ANOVA Results[a]	
Species	1999	2000	1999	2000	1999	2000	1999	2000	F	P
Mallard[b]	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.07)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Northern Rough-winged	0.00	0.48	0.00	0.03	0.00	0.00	0.00	0.00		
Swallow[b]	(0.00)	(0.15)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)		
Tree Swallow[b]	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.00)	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Turkey Vulture[b]	0.03	0.05	0.00	0.00	0.00	0.00	0.03	0.00		
	(0.03)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.00)		
Unknown Bird[b]	0.07	0.10	0.17	0.24	0.21	0.11	0.11	0.15		
	(0.05)	(0.05)	(0.17)	(0.08)	(0.08)	(0.05)	(0.05)	(0.05)		
Unknown Sparrow[b]	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Unknown Swallow[b]	0.50	0.00	0.33	0.00	0.00	0.00	0.00	0.00		
	(0.26)	(0.00)	(0.33)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Unknown Woodpecker[b]	0.00	0.00	0.00	0.00	0.08	0.11	0.06	0.02		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.05)	(0.04)	(0.02)		

[a] ANOVA results testing for differences in species abundances between fragmented and intact forest. Only species observed at >5% of point counts were analyzed.

[b] Not used in subsequent analyses of songbird richness, similarity, or total abundance.

Table 13. Comparison of bird densities (birds/ha) in grassland habitats of the United States.

	Study									
	This study	Allaire (1979)	Wray (1982)	DeVault et al. (in review)	Warren & Anderson (unpub. data)	Vickery et al. (1999)	Wiens (1973)	Wiens (1973)	Norment et al. (1999)	Frawley and Best (1991)
Location	SW West Virg.	E. Kent.	N.West Virg.	SW Ind.	NE West Virg. (high elev.)	Maine	Western U.S.	Western U.S.	W. New York	Iowa
Survey Method[a]	PC	ST/SM	TF	RPC	ST	SM	TF	TF	PC	SM
Habitat[b]	MTM	MTM	SM	SM	PA/WM	GR	GR-grazed	GR-ungrazed	GR/PA	AF – unmowed
Species	Density[c]									
Bobolink	0.00-0.03	0.00-0.00	nr	0.00-0.01	0.42	0.00-0.15	nr	nr	0.00-6.37	nr
Dickcissel	0.12-0.25	0.00-0.00	nr	0.09-0.34	0.00	0.00-0.70	0.81	nr	0.00-0.00	0.01
Eastern Meadowlark	0.50-0.70	0.07-0.38	nr	0.39-0.79	0.13	0.00-0.15	0.88	nr	0.00-0.64	nr
Grasshopper Sparrow	2.49-2.80	0.17-0.40	1.23-1.53	0.25-0.51	0.02	0.00-0.35	0.38-0.74	0.19-1.54	0.00-0.00	0.01
Horned Lark	0.21-0.33	0.02-0.19	0.23-0.55	0.04-0.05	0.00	0.00-0.25	0.18-1.97	0.49-1.20	0.00-0.01	nr
Red-winged Blackbird	0.83-1.17	0.12-0.33	nr	0.67-1.29	0.19	nr	nr	nr	0.00-0.02	0.40
Savannah Sparrow	0.00-0.00	0.00-0.00	0.65-1.10	0.00-0.01	0.22	0.00-0.35	nr	nr	0.00-3.82	nr
Vesper Sparrow	0.00-0.00	0.00-0.00	0.87-0.97	0.00-0.00	0.00	0.20-0.45	0.54	nr	0.00-0.00	0.10
Total Abundance	10.27-10.54	0.35-1.06	nr	nr	nr	nr	nr	nr	0.00-10.19	nr
Richness	1-12	2-5	nr	nr	nr	nr	4-6	3-10	0-4	8

[a] PC=point count; ST=strip transect; SM=spot mapping; RPC=roadside point count; TF=territory flush. Note: territory flush and spot mapping are meaures of territory density, not bird density.
[b] MTM=mountaintop mining/valley fill, SM=surface mine, GR=natural grassland, PA=pasture, WM=wet meadow; AF=alfalfa field.
[c] Range represents minimum and maximum values reported; single values indicate an average value; nr=not reported.

Table 14. Species abundance, total abundance, richness, and similarity in the shrub/pole treatment in areas that were relatively young (13-25 years old; n=27) and in areas that were older (>26 year old; n=6) in 2000 compared to Denmon's (1998) study in early successional habitats of West Virginia.

	Treatment				
	Young Shrub/pole		Old Shrub/pole		
Species	Mean	SE	Mean	SE	Denmon (1998)
Acadian Flycatcher	0.04	0.04	0.00	0.00	0.09
American Goldfinch	0.41	0.14	1.17	0.31	0.29
American Redstart	0.07	0.05	0.00	0.00	0.24
American Robin	0.00	0.00	0.17	0.17	0.34
Black-and-white Warbler	0.04	0.04	0.00	0.00	0.10
Blue Grosbeak	0.07	0.05	0.00	0.00	0.00
Blue-winged Warbler	0.44	0.11	0.67	0.33	0.24
Brown Thrasher	0.07	0.05	0.00	0.00	0.03
Carolina Chickadee	0.15	0.07	0.83	0.40	0.11
Carolina Wren	0.04	0.04	0.00	0.00	0.06
Cerulean Warbler	0.04	0.04	0.00	0.00	0.00
Chipping Sparrow	0.30	0.09	0.17	0.17	0.24
Common Yellowthroat	0.89	0.13	0.33	0.21	0.50
Downy Woodpecker	0.22	0.10	0.00	0.00	0.07
Eastern Bluebird	0.07	0.05	0.00	0.00	0.03
Eastern Meadowlark	0.07	0.05	0.00	0.00	0.00
Eastern Phoebe	0.11	0.06	0.33	0.21	0.00
Eastern Towhee	0.63	0.11	1.33	0.21	0.91
Field Sparrow	1.37	0.24	0.83	0.31	0.66
Golden-winged Warbler	0.11	0.06	0.00	0.00	0.09
Grasshopper Sparrow	0.30	0.10	0.17	0.17	0.03
Gray Catbird	0.19	0.08	0.00	0.00	0.33
Hairy Woodpecker	0.11	0.06	0.00	0.00	0.01
Hooded Warbler	0.04	0.04	0.00	0.00	0.06
Indigo Bunting	1.78	0.19	1.33	0.56	1.07
Mourning Dove	0.07	0.05	0.17	0.17	0.00
Northern Cardinal	0.19	0.08	0.50	0.22	0.31
Northern Flicker	0.07	0.05	0.00	0.00	0.01
Northern Parula	0.04	0.04	0.00	0.00	0.00
Orchard Oriole	0.22	0.11	0.00	0.00	0.03
Ovenbird	0.04	0.04	0.00	0.00	0.23
Prairie Warbler	1.15	0.16	1.17	0.48	0.33
Red-eyed Vireo	0.41	0.11	0.50	0.22	1.39
Red-winged Blackbird	0.44	0.19	0.00	0.00	0.06

Table 14. Continued.

	Treatment				
	Young Shrub/pole		Old Shrub/pole		
Species	Mean	SE	Mean	SE	Denmon (1998)
Scarlet Tanager	0.07	0.05	0.17	0.17	0.06
Song Sparrow	0.11	0.06	0.00	0.00	0.26
Tufted Titmouse	0.11	0.06	0.00	0.00	0.14
White-breasted Nuthatch	0.04	0.04	0.00	0.00	0.01
White-eyed Vireo	0.52	0.11	0.17	0.17	0.46
Yellow Warbler	0.33	0.13	0.00	0.00	0.37
Yellow-billed Cuckoo	0.04	0.04	0.17	0.17	0.01
Yellow-breasted Chat	1.37	0.19	1.17	0.31	0.54
Richness	9.52	0.39	8.67	0.49	9.80
Total Abundance	12.78	0.68	11.33	1.17	13.40
Species Shared[a]	18				
Jaccard Index[a]	0.45				
Renkonen Index[a]	0.65				

[a] Comparing young and old shrub areas only.

Table 15. Comparison of abundances of common songbird species in different areas of intact forest in the mixed mesophytic forest region.

	This Study	Allaire (1979)	Demeo (1999)	Wood et al. (1998)	Anderson & Shugart (1974)
Location	SW West Virg.	E. Kent.	N. Cen.. West Virg.	N. Cen. West Virg.	E. Tenn.
Survey Method[a]	PC	ST	PC	PC	SM[b]
Habitat[c]	MF	MF	MF	MF	PF/MF
Species			Abundance[d]		
Acadian Flycatcher	1.11-1.32	0.80-0.94	0.50	0.77	Rare
American Redstart	0.53-0.77	0.40-0.74	0.54	0.61	nr
Black-and-white Warbler	0.22-0.34	0.20-0.33	0.39	0.09	nr
Black-throated Green Warbler	0.06-0.17	0.60-0.74	0.58	0.91	nr
Blue-headed Vireo	0.36-0.44	nr	0.30	0.29	nr
Carolina Chickadee	0.28-0.42	0.20-0.53	nr	nr	Very common
Carolina Wren	0.06-0.44	0.07-0.20	nr	nr	Rare
Cerulean Warbler	0.36	0.60-0.74	0.13	0.07	Rare
Downy Woodpecker	0.00-0.06	0.13-0.33	nr	0.13	Common
Hairy Woodpecker	0.09-0.11	0.00-0.07	nr	0.05	Rare
Hooded Warbler	0.42-0.57	0.40-0.80	0.28	0.61	Common
Indigo Bunting	0.03-0.06	nr	nr	0.18	Rare
Kentucky Warbler	0.26-0.28	0.27-0.67	nr	0.05	Rare
Louisiana Waterthrush	0.06-0.17	0.00-0.13	0.07	0.00	nr
Northern Parula	0.11-0.14	0.07-0.13	nr	0.02	nr
Ovenbird	1.00-1.34	0.60-0.67	nr	0.29	Rare
Pileated Woodpecker	0.00-0.06	0.00-0.07	nr	0.05	nr
Red-bellied Woodpecker	0.08-0.09	0.07-0.33	nr	nr	Common
Red-eyed Vireo	0.92-1.38	0.87-1.34	1.41	1.70	Very common
Scarlet Tanager	0.11-0.68	0.13-0.27	0.49	0.54	Commmon
Summer Tanager	0.11-0.13	0.13-0.20	nr	nr	Rare
Tufted Titmouse	0.17-0.23	0.33-0.60	nr	0.00	Very common
White-breasted Nuthatch	0.15-0.22	0.00-0.20	nr	0.14	Common
Wood Thrush	0.44-0.64	0.13-0.53	0.38	0.57	Rare
Worm-eating Warbler	0.17-0.19	0.53-0.87	0.07	0.00	nr
Yellow-billed Cuckoo	0.00-0.08	0.07-0.13	nr	0.00	Common
Yellow-throated Vireo	0.08-0.11	0.00-0.27	nr	0.04	nr
Yellow-throated Warbler	0.08-0.09	0.13-0.20	nr	0.00	nr
Total Abundance	8.53-10.47	9.69-12.25	8.00-8.99	8.28	nr
Richness	30-39	31-32	nr	43	nr

[a] PC=point count; ST=strip transect; SM=spot mapping. Actual abundance values are reported, not densities.

[b] A variation of the spot-mapping method; only relative abundance was reported.

[c] MF=mature forest; PF=pole forest.

[d] Range represents minimum and maximum values reported; single values indicate an average value; nr=abundances not reported although species do occur in that area.

Table 16. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Cerulean Warbler and Louisiana Waterthrush at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Cerulean Warbler						Louisiana Waterthrush					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	0.98	0.08	1.17	0.13			1.03	0.08	1.15	0.16		
Slope (%)	31.75	2.02	37.28	2.15	4.08	0.04+	33.08	1.71	37.21	3.74		
Elevation (m)	376.11	9.44	361.90	14.52			376.76	8.94	341.36	15.48		
Distance to mine (m)	979.76	146.84	916.64	194.49			994.39	128.28	765.79	282.99		
Distance to closest minor edge (m)	61.98	10.52	39.11	4.73			54.74	8.27	48.07	6.52		
Canopy Height (m)	21.70	0.62	22.62	0.79			22.04	0.53	22.04	1.88		
Ground Cover (%)												
Water	0.90	0.24	0.52	0.22			0.81	0.20	0.54	0.29		
Litter	51.04	1.65	50.44	2.22			49.96	1.47	55.18	4.25		
Bareground	7.41	0.67	7.82	0.84			7.94	0.58	5.63	1.10	4.99	0.02-
Woody Debris	4.44	0.33	4.96	0.57			4.49	0.31	5.36	0.83		
Green	33.70	1.73	34.40	2.39			34.77	1.56	29.82	3.31		
Moss	2.18	0.29	1.77	0.40			1.80	0.25	3.21	0.59	6.45	0.01+
Stem Densities (no./ha)												
<2.5 cm	1826.97	99.45	1821.57	131.93			1877.20	85.95	1560.27	198.10		
>2.5-8 cm	6742.48	619.66	6990.93	781.41			7272.45	547.62	4604.91	725.28	5.28	0.02-
>8-23 cm	345.02	22.42	314.72	30.62			325.00	16.71	379.46	68.11		
>23-38 cm	96.76	4.46	88.51	6.79			94.01	4.28	92.41	8.81		
>38-53 cm	33.45	2.75	29.64	2.90			31.95	2.28	32.59	4.73		
>53-68 cm	9.61	1.31	8.87	1.61			9.60	1.10	8.04	2.49		
>68 cm	3.59	0.65	4.44	1.09			3.79	0.66	4.46	0.99		
Canopy Cover (%)												
0.5-3 m	52.31	2.14	47.90	2.81			49.63	1.82	56.16	5.59		
>3-6 m	60.28	2.01	58.79	3.05			59.96	1.83	58.57	5.49		
>6-12 m	62.73	1.56	67.42	1.93	4.19	0.04+	64.12	1.38	66.07	4.87		
>12-18 m	59.10	2.22	62.22	2.53			59.49	1.80	64.02	5.78		
>18-24 m	45.25	2.88	50.28	3.41			47.10	2.43	47.05	5.99		
>24 m	16.27	2.08	18.95	2.56			17.46	1.76	16.16	4.48		
Structural Diversity Index	11.46	0.19	11.45	0.28			11.37	0.17	11.93	0.85		

Table 17. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Worm-eating Warbler and Kentucky Warbler at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Worm-eating Warbler						Kentucky Warbler					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	1.14	0.08	0.73	0.10	10.78	<0.01-	1.02	0.08	1.12	0.11		
Slope (%)	34.58	1.69	31.10	3.46			33.05	1.87	35.68	2.53		
Elevation (m)	374.57	8.97	359.10	17.53	2.77	0.10-	383.23	9.51	337.78	12.44	8.48	<0.01-
Distance to mine (m)	996.20	137.73	828.48	215.34			1028.68	139.65	762.82	208.64		
Distance to closest minor edge (m)	54.66	8.02	50.31	14.49			53.11	8.25	55.07	13.37		
Canopy Height (m)	21.91	0.56	22.46	1.01			21.83	0.58	22.60	0.89		
Ground Cover (%)												
Water	0.69	0.19	1.00	0.37			0.87	0.22	0.49	0.25		
Litter	51.92	1.53	47.25	2.49	3.92	0.05-	7.74	0.60	7.07	1.09		
Bareground	7.88	0.61	6.50	0.99			50.69	1.45	51.20	2.94		
Woody Debris	4.27	0.33	5.81	0.62	8.11	<0.01+	4.54	0.33	4.89	0.65		
Green	33.04	1.58	36.94	2.95			34.01	1.55	33.80	3.08		
Moss	1.98	0.28	2.19	0.43			2.00	0.28	2.12	0.44		
Stem Densities (no./ha)												
<2.5 cm	1801.44	93.74	1901.56	143.12			1908.27	95.03	1600.54	131.49	2.72	0.10-
>2.5-8 cm	6791.83	595.59	6967.19	710.55			7268.65	608.55	5658.97	665.27		
>8-23 cm	324.04	19.47	366.25	43.67			355.34	22.40	276.36	25.39	3.61	0.06-
>23-38 cm	95.29	4.61	88.75	5.60			94.46	4.26	91.85	8.00		
>38-53 cm	33.75	2.49	26.56	2.90			30.75	2.51	35.60	3.30		
>53-68 cm	9.52	1.20	8.75	1.89			9.07	1.23	10.05	1.75		
>68 cm	4.23	0.66	2.81	1.15			3.13	0.59	5.98	1.33		
Canopy Cover (%)												
0.5-3 m	51.60	1.97	47.81	3.40			51.63	2.04	48.21	3.10		
>3-6 m	59.88	1.97	59.25	3.31			59.86	1.92	59.40	3.55		
>6-12 m	64.81	1.36	63.25	2.84			63.23	1.45	67.72	2.27	4.39	<0.04+
>12-18 m	61.69	1.89	55.50	3.52	2.43	0.10-	60.52	1.90	59.46	3.62		
>18-24 m	48.92	2.41	41.13	5.15			47.30	2.55	46.52	4.55		
>24 m	16.85	1.81	18.56	3.58			17.22	1.95	17.34	2.86		
Structural Diversity Index	11.54	0.19	11.20	0.26			11.48	0.18	11.39	0.35		

Table 18. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Wood Thrush and Acadian Flycatcher at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Wood Thrush						Acadian Flycatcher					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	P	Mean	SE	Mean	SE	χ^2	P
Aspect Code	1.04	0.10	1.05	0.09			0.85	0.18	1.09	0.07		
Slope (%)	31.86	2.53	35.23	1.87			33.94	3.58	33.72	1.70		
Elevation (m)	387.24	9.89	358.35	11.67	3.62	0.06-	385.06	17.80	367.65	8.94	6.70	0.01-
Distance to mine (m)	1049.47	180.64	885.26	153.19			711.22	239.19	1013.67	132.67	4.20	0.04+
Distance to closest minor edge (m)	58.52	11.58	49.88	8.63			80.72	23.55	47.36	6.53		
Canopy Height (m)	22.10	0.70	21.99	0.68			20.93	1.07	22.30	0.54		
Ground Cover (%)												
Water	0.71	0.29	0.81	0.21			0.94	0.61	0.72	0.16		
Litter	49.80	2.21	51.61	1.61			51.48	3.04	50.67	1.47		
Bareground	8.28	0.86	7.01	0.65			5.16	0.96	8.12	0.59	7.17	<0.01+
Woody Debris	4.80	0.46	4.51	0.39			5.47	0.85	4.44	0.31		
Green	33.99	2.48	33.93	1.60			34.77	3.00	33.77	1.58		
Moss	2.23	0.43	1.88	0.26			2.11	0.73	2.01	0.24		
Stem Densities (no./ha)												
<2.5 cm	1937.50	120.18	1738.28	104.05			2287.11	134.30	1717.84	87.54	3.41	0.06-
>2.5-8 cm	7456.93	760.06	6352.21	622.08			9048.83	1039.30	6319.29	528.80		
>8-23 cm	337.33	30.48	331.38	21.99			442.97	56.79	308.70	16.78	2.91	0.09-
>23-38 cm	86.15	5.93	99.61	4.72	2.98	0.08+	100.78	9.91	92.12	4.04		
>38-53 cm	32.94	3.20	31.38	2.67			34.38	5.65	31.52	2.16		
>53-68 cm	11.15	1.68	7.94	1.22			8.20	1.95	9.60	1.17		
>68 cm	4.05	0.91	3.78	0.74			1.95	0.94	4.35	0.66	1.21	0.21+
Canopy Cover (%)												
0.5-3 m	52.80	2.75	49.09	2.15			47.19	3.91	51.52	1.90		
>3-6 m	62.64	2.50	57.50	2.25			55.86	4.00	60.63	1.85		
>6-12 m	66.28	1.45	63.02	1.86			60.70	2.16	65.31	1.42		
>12-18 m	60.24	2.58	60.23	2.25			60.39	4.28	60.20	1.84		
>18-24 m	44.49	3.29	49.09	2.99			39.45	5.96	48.86	2.33		
>24 m	15.07	2.56	18.93	2.06			14.22	3.81	17.95	1.78		
Structural Diversity Index	11.30	0.26	11.58	0.20			10.69	0.38	11.64	0.17	3.08	0.08+

Table 19. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Hooded Warbler and Yellow-throated Vireo at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Hooded Warbler						Yellow-throated Vireo					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	1.00	0.09	1.13	0.11			1.03	0.07	1.11	0.19	13.21	<0.01+
Slope (%)	33.04	2.09	34.91	2.17			32.98	1.77	36.91	2.80	5.20	0.02+
Elevation (m)	358.47	9.26	391.56	14.09			370.03	9.44	374.53	13.42	9.20	<0.01+
Distance to mine (m)	780.70	136.97	1248.30	203.05			1040.72	134.30	620.81	213.49	9.05	<0.01-
Distance to closest minor edge (m)	55.17	8.25	51.09	12.70			55.09	8.64	47.84	5.13		
Canopy Height (m)	21.25	0.67	23.28	0.63			22.40	0.56	20.59	0.88		
Ground Cover (%)												
Water	0.77	0.24	0.76	0.23			0.75	0.17	0.81	0.54		
Litter	8.03	0.70	6.82	0.77			7.61	0.56	7.35	1.37		
Bareground	52.16	1.74	48.71	1.97			49.83	1.38	54.78	3.53	6.46	0.01-
Woody Debris	4.30	0.33	5.15	0.55	2.61	0.10+	4.60	0.34	4.78	0.59		
Green	32.38	1.78	36.44	2.21			34.89	1.58	30.22	2.90		
Moss	2.02	0.32	2.05	0.34			2.06	0.28	1.91	0.44		
Stem Densities (no./ha)												
<2.5 cm	1914.66	108.99	1683.71	106.21			1779.41	83.39	2007.35	210.97		
>2.5-8 cm	6185.70	570.01	7853.22	842.86	5.19	0.02+	6784.01	563.97	7029.41	895.41		
>8-23 cm	348.68	26.89	310.80	19.03			333.64	20.65	335.29	37.69		
>23-38 cm	92.67	4.39	95.45	6.86			93.29	4.33	95.59	7.56		
>38-53 cm	31.25	2.84	33.33	2.80			30.61	2.23	37.87	4.81	2.62	0.10+
>53-68 cm	9.98	1.28	8.33	1.67			9.28	1.18	9.56	1.87		
>68 cm	3.97	0.71	3.79	0.98			3.86	0.64	4.04	1.31		
Canopy Cover (%)												
0.5-3 m	53.25	1.89	46.70	3.14			50.59	1.88	51.18	4.11		
>3-6 m	62.98	2.10	54.62	2.60			58.71	1.95	63.82	3.07		
>6-12 m	63.53	1.58	65.87	1.97			63.29	1.37	69.04	2.57	7.55	0.01+
>12-18 m	58.39	2.13	63.14	2.71			59.01	1.91	65.15	3.33		
>18-24 m	45.19	2.97	50.08	3.27			46.97	2.51	47.57	4.83		
>24 m	15.91	2.15	19.36	2.41			18.53	1.77	12.13	3.73		
Structural Diversity Index	11.50	0.19	11.39	0.28			11.38	0.18	11.76	0.32		

Table 20. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Black-and-white Warbler and Scarlet Tanager at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Black-and-white Warbler						Scarlet Tanager					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	P	Mean	SE	Mean	SE	χ^2	P
Aspect Code	1.04	0.08	1.05	0.12	3.64	0.06+	1.10	0.09	0.98	0.11		
Slope (%)	32.56	2.16	35.57	2.01			30.77	1.99	37.30	2.25	8.62	<0.01+
Elevation (m)	370.14	10.18	372.12	13.03			356.13	10.31	388.38	11.99		
Distance to mine (m)	1022.10	158.37	858.70	170.12	2.95	0.09+	696.48	140.22	1263.70	182.72	9.16	<0.01+
Distance to closest minor edge (m)	58.47	9.79	46.39	9.48			59.46	12.10	46.77	5.30		
Canopy Height (m)	21.89	0.63	22.26	0.78			21.62	0.70	22.53	0.67		
Ground Cover (%)												
Water	0.96	0.26	0.48	0.18			0.76	0.25	0.77	0.23	3.10	0.08+
Litter	7.65	0.62	7.43	0.93			50.73	2.00	50.93	1.67		
Bareground	51.40	1.65	49.96	2.19			8.23	0.67	6.76	0.82	4.89	0.03-
Woody Debris	4.29	0.41	5.15	0.41			4.57	0.42	4.71	0.42		
Green	33.38	1.67	34.82	2.45			33.64	2.02	34.33	1.92		
Moss	2.01	0.26	2.06	0.45	6.35	0.06+	1.88	0.27	2.21	0.41		
Stem Densities (no./ha)												
<2.5 cm	1736.52	101.48	1957.72	123.94	10.04	<0.01-	1938.18	103.07	1691.51	119.66		
>2.5-8 cm	5866.42	474.94	8283.09	931.56	5.19	<0.01+	6770.38	482.07	6907.05	894.79		
>8-23 cm	326.96	19.73	344.49	34.44			344.43	25.99	321.63	24.91		
>23-38 cm	93.87	4.80	93.57	6.13			91.71	4.85	96.15	5.91		
>38-53 cm	32.97	2.61	30.70	3.31			29.35	2.80	35.26	2.94	6.48	0.01+
>53-68 cm	9.44	1.36	9.19	1.52			10.33	1.38	8.17	1.49		
>68 cm	3.06	0.59	5.15	1.10			3.94	0.81	3.85	0.82		
Canopy Cover (%)												
0.5-3 m	51.25	2.17	49.89	2.79			48.78	2.38	52.98	2.42		
>3-6 m	59.71	2.36	59.78	2.32	3.74	0.05-	59.54	2.44	59.97	2.32		
>6-12 m	62.87	1.65	66.80	1.79			63.70	1.73	65.32	1.76		
>12-18 m	59.80	2.09	60.88	2.85			55.60	2.35	65.71	2.12	6.95	<0.01+
>18-24 m	46.47	3.15	48.01	2.96			42.80	2.98	52.15	3.17		
>24 m	16.23	2.09	18.79	2.55			17.74	2.32	16.67	2.24		
Structural Diversity Index	11.43	0.20	11.50	0.26			11.24	0.21	11.72	0.24		

Table 21. Means and standard errors (SE) of songbird abundance (birds/point count) by habitat guild and nesting guild on reclaimed MTMVF areas in grassland, shrub/pole, fragmented forest, and intact forest treatments in Boone, Fayette, Kanawha, and Logan Counties, West Virginia, 1999-2000. Treatments with the same letter within rows are not significantly different (Waller-Duncan k-ratio t-test, $P \leq 0.05$).

	Treatment													
	Grassland			Shrub/pole			Fragmented Forest			Intact Forest			ANOVA Results	
Guild	1999		2000	1999		2000	1999		2000	1999		2000	F	P
Habitat														
Interior	0.20	D	0.03	1.00	C	0.36	2.67	B	3.33	4.17	A	5.70	318.66	<0.01
	(0.10)		(0.03)	(0.45)		(0.10)	(0.32)		(0.28)	(0.26)		(0.33)		
Interior-	0.03	D	0.33	1.50	C	2.45	3.08	A	3.33	2.58	B	2.77	182.32	<0.01
edge	(0.03)		(0.10)	(0.43)		(0.21)	(0.29)		(0.20)	(0.24)		(0.16)		
Edge	2.43	B	2.78	6.67	A	6.45	0.33	C	0.50	0.14	D	0.23	148.24	<0.01
	(0.39)		(0.31)	(1.48)		(0.46)	(0.12)		(0.14)	(0.07)		(0.06)		
Grass	4.33	A	4.10	0.33	B	0.67	0.00	C	0.03	0.00	C	0.00	472.39	<0.01
	(0.35)		(0.26)	(0.33)		(0.17)	(0.00)		(0.03)	(0.00)		(0.00)		
Nest														
Ground	3.60	A	3.75	2.50	B	2.27	1.46	C	1.44	1.97	C	2.11	31.88	<0.01
	(0.31)		(0.23)	(0.22)		(0.15)	(0.20)		(0.18)	(0.19)		(0.18)		
Shrub	3.27	B	3.30	5.50	A	6.27	0.42	C	0.61	0.44	C	0.64	111.27	<0.01
	(0.40)		(0.33)	(1.52)		(0.47)	(0.12)		(0.14)	(0.11)		(0.11)		
Subcanopy	0.00	C	0.13	1.67	B	0.94	3.00	A	2.42	3.06	A	2.96	204.39	<0.01
	(0.00)		(0.06)	(0.33)		(0.14)	(0.28)		(0.16)	(0.24)		(0.21)		
Canopy	0.03	B	0.00	0.00	B	0.15	0.79	A	2.17	0.92	A	2.64	1999: 15.09	1999: <0.01
	(0.03)	C	(0.00)	(0.00)	C	(0.06)	(0.16)	B	(0.21)	(0.15)	A	(0.19)	2000: 158.67	2000: <0.01
Cavity	0.00	C	0.10	0.00	B	0.76	0.88	A	1.19	0.94	A	0.87	29.70	<0.01
	(0.00)		(0.05)	(0.00)		(0.15)	(0.16)		(0.17)	(0.16)		(0.12)		
Total	8.07	C	8.28	12.17	A	12.52	7.58	BC	9.19	8.53	B	10.47	8.72	<0.01
Abundance	(0.59)		(0.41)	(1.40)		(0.59)	(0.63)		(0.51)	(0.54)		(0.47)		
Richness	5.08	C	5.17	9.36	A	9.17	7.56	B	6.71	7.91	B	7.03	22.70	<0.01
	(0.35)		(0.42)	(0.34)		(0.60)	(0.43)		(0.51)	(0.30)		(0.45)		

Table 22. Jaccard and Renkonen similarity indices comparing songbird community composition among grassland, shrub/pole, fragmented forest, and intact forest treatments in 1999 and 2000.

Comparisons	Species shared		Jaccard		Renkonen	
	1999	2000	1999	2000	1999	2000
Grassland/Intact	2	8	0.04	0.14	0.01	0.02
Grassland/Fragment	4	12	0.08	0.22	0.04	0.07
Shrub/Intact	9	21	0.20	0.37	0.17	0.12
Shrub/Fragment	11	24	0.24	0.44	0.19	0.19
Grassland/Shrub	12	23	0.40	0.48	0.33	0.42
Fragment/Intact	29	29	0.74	0.64	0.78	0.70

[a] Jaccard indices only examine the number of species shared while the Renkonen indices also take into account the proportion of each species present in each sample (in both cases the scale ranges from 0 = no similarity and 1 = complete similarity).

Table 23. Nesting success of birds on MTMVF areas by mine, nesting guild, and species.

	Year	N	Observation Days	Incubation Survival	Brooding Survival	Total Survival
Mine						
Daltex	1999	1	4.5	0.030	-----	0.030
Hobet	1999	10	66.5	0.135	0.191	0.026
Daltex	2000	13	135.5	0.546	1.000	0.546
Hobet	2000	8	88.5	0.681	1.000	0.681
Cannelton	2000	4	13.5	0.018	1.000	0.018
Combined	1999	11	71.0	0.160	0.258	0.041
Combined	2000	25	237.5	0.527	1.000	0.527
Nesting Guilds						
Shrub	1999	2	11.5	0.101	-----	0.101
Ground	1999	8	52.5	0.166	0.222	0.037
Shrub	2000	3	54.0	1.000	1.000	1.000
Ground	2000	18	158.0	0.329	1.000	0.329
Miscellaneous[a]	2000	2	20.0	1.000	1.000	1.000
Years Combined						
Shrub	99/00	5	65.5	0.488	1.000	0.488
Ground	99/00	26	210.5	0.262	0.774	0.203
Miscellaneous	99/00	2	20.0	1.000	1.000	1.000
Species						
Barn Swallow	99/00	1	4.5	-----	1.000	1.000
Eastern Bluebird	99/00	1	15.5	1.000	1.000	1.000
Eastern Meadowlark	99/00	1	16.0	1.000	1.000	1.000
Field Sparrow	99/00	2	12.0	0.180	0.134	0.024
Grasshopper Sparrow	99/00	19	172.0	0.397	0.917	0.364
Horned Lark	99/00	2	4.5	0.008	0.000	0.000
Indigo Bunting	99/00	2	11.5	0.083	-----	0.083
Killdeer	99/00	3	35.0	0.230	-----	-----
Mourning Dove	99/00	2	6.0	0.003	-----	0.003
Red-winged Blackbird	99/00	3	54.0	1.000	1.000	1.000

[a] Eastern Bluebird and Barn Swallow.

Table 24. Comparison of grassland bird nest survival on reclaimed MTMVF areas with previous studies.

Species	No. Nests (years)	Nest Density[b]	Nest Survival	Location	Grassland Type[a]	Study
Grasshopper Sparrow	19 (2)	~0.06/ha	0.36	West Virginia	MTMVF	This study
	51 (3)	0.11/ha	0.07	West Virginia	Surface mines	Wray (1982)
	38 (3)	nr	0.41	Missouri	CRP field- warm/cool season grasses	McCoy et al. (1999)
	12 (1)	0.06/ha	0.41	Illinois	Airport grasslands	Kershner & Bollinger (1996)
	14 (3)	nr	0.11	North Dakota	WPA	Koford (1999)
	38 (3)	nr	0.28	North Dakota	CRP fields	Koford (1999)
	13 (3)	nr	0.12	Minnesota	CRP fields	Koford (1999)
	12 (3)	0.25/ha	~0.25[c]	Oklahoma	Tallgrass prairie	Rohrbaugh et al. (1999)
Eastern Meadowlark	1 (2)	<0.01/ha	1.00	West Virginia	MTMVF	This study
	12 (3)	nr	0.67	New York	Pasture/cool season grass	Norment et al. (1999)
	32 (3)	nr	0.30	Missouri	CRP fields- warm/cool season grasses	McCoy et al. (1999)
	105 (1)	0.56/ha	0.14	Illinois	Airport grasslands	Kershner & Bollinger (1996)
	42 (3)	0.86/ha	~0.25[b]	Oklahoma	Undisturbed tallgrass prairie	Rohrbaugh et al. (1999)
	7 (1)	nr	0.62	West Virginia	Pastures/wet meadows	Warren & Anderson, (unpub. data)
Horned Lark	2 (2)	~0.01/ha	0.00	West Virginia	MTMVF	This study
	47 (2)	0.23/ha	0.05	West Virginia	Surface mines	Wackenhut (1980)
	3 (1)	0.02/ha	1.00	Illinois	Airport grasslands	Kershner & Bollinger (1996)
Red-winged Blackbird	3 (2)	~0.01/ha	1.00	West Virginia	MTMVF	This study
	145 (6)	1.41/ha	0.48	Illinois	Cool season grasslands	Warner (1994)
	70 (3)	nr	0.11	North Dakota	CRP fields	Koford (1999)
	9 (3)	nr	0.17	North Dakota	WPA	Koford (1999)
	25 (3)	nr	0.01	Minnesota	CRP fields	Koford (1999)
	63 (2)	5.66/ha	0.08	Iowa	Grassed waterways	Bryan & Best (1994)
	238 (3)	nr	0.28	Missouri	CRP fields - warm/cool season grasses	McCoy et al. (1999)
	11 (1)	0.06/ha	0.06	Illinois	Airport grasslands	Kershner & Bollinger (1996)
	15 (1)	nr	0.42	West Virginia	Pastures/wet meadows	Warren & Anderson, (unpub. data)

Table 24. Continued.

Species	No. Nests (years)	Nest Density	Nest Survival	Location	Grassland Type[a]	Study
Savannah Sparrow	0 (2)	----	----	West Virginia	MTMVF	This study
	41(3)	0.24/ha	0.22	West Virginia	Surface mines	Wray (1982)
	58 (3)	nr	0.76	New York	Pasture/cool season grass	Norment et al. (1999)
	12 (1)	0.02/ha	0.23	Illinois	Airport grasslands	Kershner & Bollinger (1996)
	4 (3)	nr	0.15	North Dakota	CRP fields	Koford (1999)
	4 (3)	nr	0.22	North Dakota	WPA	Koford (1999)
	12 (3)	nr	0.02	Minnesota	CRP fields	Koford (1999)
	30 (3)	nr	0.25	Minnesota	WPA	Koford (1999)
	17 (1)	nr	0.36	West Virginia	Pastures/wet meadows	Warren & Anderson, (unpub. data)
Dickcissel	0 (2)	----	----	West Virginia	MTMVF	This study
	14 (6)	0.14/ha	0.14	Illinois	Cool season grassland	Warner (1994)
	27 (2)	2.76/ha	0.22	Iowa	Grassed waterways	Bryan & Best (1994)
	87 (3)	nr	0.30	Missouri	CRP field- warm/cool season grasses	McCoy et al. (1999)
	87 (3)	0.60/ha	~0.25[b]	Oklahoma	Tallgrass prairie	Rohrbaugh et al. (1999)

[a] MTMVF = mountaintop mining/valley fill; CRP = conservation reserve program; WPA = waterfowl production area.
[b] nr=not reported.
[c]Survival rates were presented in a figure and estimates are approximate.

Table 25. Means and standard errors of habitat variables surrounding successful (n=11) and unsuccessful (n=4) nests of Grasshopper Sparrows on MTMVF areas in 2000.

	Successful		Unsuccessful		Combined	
Variable	Mean	SE	Mean	SE	Mean	SE
Aspect Code	1.5	0.4	3.2	0.8	2.0	0.4
Slope (%)	4.8	2.2	16.0	10.0	7.8	3.2
Overhead Cover (%)	47.5	10.3	28.8	10.5	42.5	8.2
Side Cover (%)	85.1	4.7	74.3	23.3	82.2	6.6
Distance to Minor Edge (m)	22.8	7.4	36.3	3.8	26.4	5.7
Lespedeza Cover (%)	5.8	3.7	0.3	0.3	4.3	2.7
Ground Cover (%)						
Green	81.4	4.1	88.8	9.7	83.3	3.9
Grass	43.2	6.0	47.5	8.3	44.3	4.8
Forb	35.9	5.6	37.5	14.5	36.3	5.3
Shrub	2.3	1.0	0.0	0.0	1.7	0.8
Litter	0.0	0.0	0.0	0.0	0.0	0.0
Wood	0.0	0.0	0.0	0.0	0.0	0.0
Bareground	18.6	4.1	6.3	4.7	15.3	3.5
Moss	0.0	0.0	5.0	5.0	1.3	1.3
Water	0.0	0.0	0.0	0.0	0.0	0.0
Robel Pole Index						
nest	2.5	0.3	2.2	0.4	2.4	0.2
1m	2.5	0.3	2.6	0.3	2.5	0.2
3m	2.7	0.2	2.2	0.4	2.6	0.2
5m	2.3	0.2	2.6	0.4	2.4	0.2
Grass Height (dm)						
nest	4.6	1.0	3.8	1.4	4.4	0.8
1m	5.3	0.6	5.3	0.9	5.3	0.5
3m	5.5	0.5	6.2	0.8	5.7	0.4
5m	4.8	0.5	7.2	0.3	5.5	0.4
10m	5.3	0.3	7.6	0.6	5.9	0.4
Litter depth (cm)						
nest	2.0	0.3	0.5	0.3	1.6	0.3
1m	2.0	0.5	1.3	0.4	1.8	0.4
3m	1.8	0.4	0.8	0.2	1.5	0.3
5m	2.2	0.4	1.8	0.3	2.1	0.3

Table 26. Seasonal mean abundance (no./survey), species richness, and standard errors (SE) of raptors during broadcast surveys across in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in 2000.

	Grassland						Shrub/pole					
	Winter		Summer		Migration		Winter		Summer		Migration	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Overall Abundance	0.33	0.25	1.10	0.30	0.67	0.16	0.21	0.12	0.23	0.10	0.46	0.27
Overall Richness	0.08	0.06	0.08	0.04	0.10	0.04	0.17	0.10	0.06	0.05	0.06	0.04
American Kestrel	0.00	0.00	0.04	0.03	0.13	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Peregrine Falcon	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Cooper's Hawk	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Accipiter spp.[a]	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00
Northern Harrier	0.08	0.06	0.04	0.03	0.13	0.05	0.00	0.00	0.02	0.02	0.00	0.00
Red-tailed Hawk	0.00	0.00	0.08	0.04	0.06	0.04	0.04	0.04	0.02	0.02	0.00	0.00
Red-shouldered Hawk	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.04	0.03
Eastern Screech Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Barred Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Turkey Vulture	0.25	0.25	0.94	0.29	0.31	0.14	0.08	0.08	0.19	0.09	0.44	0.27
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[a] Either Sharp-shinned Hawk or Cooper's Hawk.

Table 26. Continued.

	Fragmented Forest						Intact Forest					
	Winter		Summer		Migration		Winter		Summer		Migration	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Overall Abundance	0.21	0.10	0.21	0.08	0.13	0.06	0.25	0.12	0.17	0.08	0.16	0.07
Overall Richness	0.08	0.06	0.06	0.04	0.06	0.05	0.13	0.09	0.08	0.04	0.05	0.04
American Kestrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peregrine Falcon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cooper’s Hawk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accipiter spp.[a]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Harrier	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-tailed Hawk	0.17	0.10	0.06	0.03	0.02	0.02	0.04	0.04	0.02	0.02	0.05	0.04
Red-shouldered Hawk	0.00	0.00	0.02	0.02	0.06	0.04	0.04	0.04	0.08	0.05	0.11	0.07
Eastern Screech Owl	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Barred Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00
Turkey Vulture	0.04	0.04	0.10	0.07	0.00	0.00	0.17	0.10	0.02	0.02	0.00	0.00
Unknown	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00

[a] Either Sharp-shinned Hawk or Cooper’s Hawk.

Table 27. Abundance and richness of raptor species observed on roadside surveys in grassland, shrub/pole, and fragmented forest treatments on each of the 3 MTMVF areas in 2000.

	Hobet			Cannelton			Daltex	
Species	Grass	Shrub/ pole	Fragmented Forest	Grass	Shrub/ pole	Fragmented Forest	Grass	Fragmented Forest
Overall Abundance	11	7	2	2	1	7	14	11
Overall Richness	3	2	1	2	1	3	4	1
American Kestrel	3	0	0	0	0	0	5	0
Peregrine Falcon	0	0	0	0	0	0	1	0
Northern Harrier	0	0	0	1	1	0	0	0
Broad-winged Hawk	0	0	0	0	0	1	0	0
Red-tailed Hawk	2	1	0	1	0	4	1	0
Turkey Vulture	6	6	2	0	0	2	6	11
Unknown[a]	0	0	0	0	0	0	1	0

[a] Unknown is either a Red-tailed Hawk or Turkey Vulture.

Table 28. Seasonal observations of raptor species (w=winter, s=summer, m=migration) on the 3 mines in each of the 4 treatments (GR=grassland, SH=shrub/pole, FR=fragmented forest, IN=intact forest), compared to species expected based on habitat requirements and West Virginia Breeding Bird Atlas (WV BBA) records.

	WV BBA	Expected in WV from habitat requirements[a]				Observations on the 3 mines[b]										
						Hobet				Daltex			Cannelton			
Species	Record	GR	SH	FR	IN	GR	SH	FR	IN	GR	FR	IN	GR	SH	FR	IN
American Kestrel	s	wsm	wsm	wm	wm	wsm		m		sm			s	sm		
Peregrine Falcon				m	m					sm			s[c]m			
Northern Harrier		m				wsm				wm			wsm	sm		
Broad-winged Hawk	s				sm	s						s			sm	
Red-shouldered Hawk	s				wsm	s	wsm	s	sm	s	m	s		ws	sm	wsm
Red-tailed Hawk	s	s	s	wsm	wsm	sm	wsm	wsm	wsm	sm	ws	sm	sm	wsm	sm	
Rough-legged Hawk				wm	wm	w		w								
Cooper's Hawk	s	s	s	sm	sm	m				m		s	m			
Sharp-shinned Hawk	s		s	sm	sm	s								w		
Accipiter spp.[d]	s	s	s	sm	sm			s			w					
Barred Owl	s		s	wsm	wsm			s	s			s		w		
Eastern Screech Owl	s		s	wsm	wsm		m	s			sm					
Short-eared Owl		wm								w						
Turkey Vulture	s	wsm	wsm	wsm	s	sm	wsm	s	wsm	sm	ws		wsm	sm	wsm	

[a]Buckelew and Hall (1994), Hall (1983), and West Virginia GAP analysis data.
[b]Includes observations from broadcast surveys and roadside surveys in 2000, and incidental sightings for 1999 and 2000
[c]Unconfirmed sighting.
[d]Either Sharp-shinned Hawk or Cooper's Hawk.

Table 29. Similarity indices comparing raptor community composition among treatments for all seasons in 2000.

Comparison	Species shared	Jaccard[a]	Renkonen
Grassland/Intact	2	0.25	0.08
Grassland/Fragment	2	0.25	0.11
Fragment/Intact	3	0.60	0.12
Shrub/Intact	3	0.43	0.09
Shrub/Fragment	4	0.67	0.10
Shrub/Grassland	3	0.33	0.29

[a]The Jaccard index only examines the number of species shared while the Renkonen index takes into account the proportion of each species present in each sample (in all cases the scale ranges from 0=no similarity and 1=complete similarity).

Table 30. Mammal species expected (Exp) to occur in grassland, shrub/pole, fragmented forest and intact forest treatments and reclaimed-mine ponds based on WV GAP analysis data, personal communication by M. E. Hight (2000), and Whitaker and Hamilton (1998) compared to species observed (Obs) via several methods including Sherman live trapping (s), pitfall trapping (p), and incidental sighting (i).

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		Pond[a]	
Species	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
Order Insectivora										
Hairy-tailed mole *Parascalops breweri*			x		x	i	x			
Masked Shrew *Sorex cinereus*	x	p, s	x	p	x	p, s	x	p		
Pygmy shrew *Sorex hoyi*	x	p	x	p	x	p	x	p		
Short-tailed shrew *Blarina brevicauda*	x	p, s	x	p	x	p, s	x	p, s	x	
Smoky shrew *Sorex fumeus*		p	x	p	x	p	x	p		
Order Rodentia										
Allegheny woodrat *Neotoma magister*				s			x			
Beaver *Castor canadensis*			x		x	i	x		x	
Eastern chipmunk *Tamias striatus*		s	x		x	s	x	s		
Eastern fox squirrel *Sciurus niger*	x				x		x			
Eastern gray squirrel *Sciurus carolinensis*	x				x		x			
Golden mouse *Ochrotomys nuttalli*			x		x		x			
Groundhog *Marmota monax*	x	i	x		x		x			
House mouse *Mus musculus*	x	p, s								s
Meadow vole *Microtus pennsylvanicus*	x	p, s	x	p, s	x	p	x			
Muskrat *Ondatra zibethicus*	x				x		x		x	

Table 30. Continued.

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		Pond[a]	
Species	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
Peromyscus species *P. leucopus/maniculatus*	x	p, s	x	p, s	x	p, s	x	p, s		s
Red squirrel *Tamiasciurus hudsonicus*			x		x		x			
Southern bog lemming *Synaptomys cooperi*	x	p, s	x	p, s	x	p	x	p	x	s
Southern flying squirrel *Glaucomys volans*			x		x		x			
Southern red-backed vole *Clethrionomys gapperi*			x		x		x			
Woodland jumping mouse *Napaeozapus insignis*		p	x		x	p, s	x	s		
Woodland vole *Microtus pinetorum*			x	p	x	p	x	s		
<u>Order Carnivora</u>										
Black bear *Ursus americanus*	x	i	x	i	x	i	x	i	x	
Bobcat *Lynx rufus*			x		x	i	x		x	
Coyote *Canis latrans*	x	i	x	i	x	i	x		x	
Gray fox *Urocyon cinereoargenteus*	x		x		x		x		x	
Least weasel *Mustela nivalis*			x		x		x			
Long-tailed weasel *Mustela frenata*			x		x		x			
Mink *Mustela vison*					x		x			
Raccoon *Procyon lotor*	x		x	i	x	i	x	i	x	i
Red fox *Vulpes vulpes*	x	i	x		x	i	x		x	
Striped skunk *Mephitis mephitis*	x		x	i	x		x			

Table 30. Continued.

	Treatment									
	Grassland		Shrub/pole		Fragment ed Forest		Intact Forest		Pond[a]	
Species	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
Other										
Eastern cottontail *Sylvilagus floridanus*	x	s, i	x	i	x	i	x	i	x	i
Virginia opossum *Didelphis virginiana*			x		x	i	x	i	x	
White-tailed deer *Odocoileus virginianus*	x	i	x	i	x	i	x	i	x	i
Wild boar *Sus scrofa*			x		x		x			i

[a] Ponds were not considered a treatment because they were distributed throughout the reclaimed areas, overlapping both grassland and shrub/pole treatments.

Table 31. Average mammalian species richness (# species/transect), relative abundance (mammals/100 trap nights), and standard errors (SE) in grassland,shrub/pole, fragmented forest, and intact forest treatments and reclaimed-mine ponds in 1999 and 2000. Means were compared among treatments within years; means followed by different letters are significantly different (*P*=0.05) from each other. An absence of letters beside the means indicates that they were not subjected to statistical analysis due to small sample size.

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		Pond[a]	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Species Richness										
1999	1.7 A (n=16)[b]	0.18	-[c]	-	1.8 A (n=16)	0.25	2.3 A (n=16)	0.19	-	-
2000	1.4 A (n=20)	0.13	1.5 A (n=12)	0.15	1.4 A (n=20)	0.15	1.4 A (n=20)	0.13	1.1 (n=56)	0.09
Relative Abundance										
Total										
1999	16.1 A	1.66	-	-	12.6 A	0.94	14.5 A	1.87	-	-
2000	21.8 A	2.38	20.2 A	2.74	7.5 B	1.07	7.9 B	1.83	8.9	1.05
Peromyscus species										
1999	13.9 A	1.30	-	-	10.8 A	0.69	11.3 A	1.59	-	-
2000	20.4 A	2.58	18.9 A	2.52	6.0 B	0.78	6.6 B	1.66	7.8	1.02
House mouse										
1999	1.9	0.83	-	-	0.0	0.00	0.0	0.00	-	-
2000	1.0	0.59	0.0	0.00	0.0	0.00	0.0	0.00	0.5	0.22
Woodland jumping mouse										
1999	0.0	0.00	-	-	0.7	0.39	0.0	0.00	-	-
2000	0.0	0.00	0.0	0.00	1.0	0.58	0.5	0.27	0.0	0.00
Meadow vole										
1999	0.1	0.08	-	-	0.0	0.00	0.0	0.00	-	-
2000	0.0	0.00	0.3	0.17	0.0	0.00	0.0	0.00	0.1	0.06
Short-tailed shrew										
1999	0.3 A	0.27	-	-	0.9 AB	0.38	2.1 B	0.62	-	-
2000	0.0	0.00	0.0	0.00	0.2	0.12	0.0	0.00	0.0	0.00
Eastern chipmunk										
1999	0.0 A	0.00	-	-	0.1 A	0.08	0.9 B	0.31	-	-
2000	0.1 A	0.07	0.0 A	0.00	0.1 A	0.06	0.8 B	0.35	0.0	0.00
Eastern woodrat										
1999	0.0	0.00	-	-	0.0	0.00	0.0	0.00	-	-
2000	0.0	0.00	1.2	0.67	0.0	0.00	0.0	0.00	0.1	0.09
Southern bog lemming										
1999	0.0	0.00	-	-	0.0	0.00	0.0	0.00	-	-
2000	0.1	0.09	0.1	0.10	0.0	0.00	0.0	0.00	0.3	0.13

Table 31. Continued.

	Treatment									
	Grassland		Shrub/pole		Fragmented Forest		Intact Forest		Pond[a]	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Relative Abundance										
Masked shrew										
1999	0.0	0.00	-	-	0.1	0.08	0.1	0.10	-	-
2000	0.0	0.00	0.0	0.00	0.1	0.06	0.0	0.00	0.0	0.00
Virginia Opossum										
1999	0.0	0.00	-	-	0.3	0.30	0.0	0.00	-	-
2000	0.1	0.09	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Eastern cottontail										
1999	0.1	0.06	-	-	0.0	0.00	0.0	0.00	-	-
2000	0.3	0.20	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00

[a] Data were not included in the statistical analysis because the trapping methods were different from those used in the other three treatments.

[b] n= the number of “surveys” where a “survey” is a single transect trapped for 3 nights (or 2 nights for ponds).

[c] The shrub/pole treatment and ponds were not sampled in 1999.

Table 32. Similarity indices comparing small mammal community composition among treatments in 1999 and 2000.

	Species Shared		Jaccard[a]		Renkonen	
Comparison	1999	2000	1999	2000	1999	2000
Grassland/Intact	2	2	0.25	0.29	0.79	0.83
Grassland/Fragment	2	2	0.22	0.22	0.86	0.81
Fragment/Intact	4	2	0.57	0.33	0.87	0.86
Shrub/Intact	-[b]	1	-	0.17	-	0.83
Shrub/Fragment	-	1	-	0.13	-	0.80
Shrub/Grassland	-	2	-	0.25	-	0.93

[a] The Jaccard index only examines the number of species shared while the Renkonen index takes into account the proportion of each species present in each sample (in all cases the scale ranges from 0 = no similarity to 1 = complete similarity).

[b] A dash indicates that comparisons were not possible since “Shrub” treatment was not sampled in 1999.

Table 33. A comparison of the small mammal abundances found on our study with those of other studies. These comparisons should be interepreted with caution, however, because none occurred on MTMVF areas and sampling methods differed.

							Abundance (per 100 trap nights)				
Study	Location	Duration	Study Area	Trap Type	Years Since Reclamation	Correction[a] Employed?	Total	*Peromyscus*[b] species	House mouse	Meadow vole	Short-tailed shrew
Grassland Studies											
Our study	Southern W. Va.	1999-2000	MTM[c]	Live	5-15	Yes	18.9	17.1	1.4	0.1	0.1
Our study	Southern W. Va.	1999-2000	MTM[c]	Live	5-15	No	13.4	12.0	1.2	0.0	0.1
Verts (1957)	Southern Ill.	1954	SM[c]	Snap	4-15	No	nr[d]	14.7	nr[d]	nr[d]	nr[d]
Voight and Glenn-Lewin (1979)	Southern Iowa	1975-1976	SM[c]	Snap	14-24	No	12.6	10.9	0.0	0.5	0.2
Mindell (1978)	Northern W. Va.	1977-1978	SM[c]	Snap	2-6	No	5.1	0.7	0.1	4.1	0.2
Forren (1981)	Northern W Va.	1980	SM[c]	Snap	4-9	No	4.1	0.2	nr[d]	2.3	1.5
Sly (1976)	Ind.	1969	SM[c]	Snap	5-12	No	6.0	5.3	0.05	0.05	0.1
Kirkland (1976)	Central New York	1973	SM[c]	Live	1-20	No	3.2	2.7	0.0	0.02	0.02
Clark et al. (1998)	Southeastern Okl.	1991	GR[c]	Snap	na[e]	No	16.9	3.7	1.6	nr[d]	0.1
Sietman et al. (1994)	East-central Kan.	1991	GR[c]	Live	na[e]	No	4.8	1.9	0.0	0.0	0.0
Denmon (1998)	W. Va.	1996-1997	ES[c]	Snap	5-20	Yes	2.7	1.0	0.0	0.3	0.7
Shrub/pole Studies											
Our study	Southern W. Va.	2000	MTM[c]	Live	16-32	Yes	20.2	18.9	0.0	0.3	0.0
Our study	Southern W. Va.	2000	MTM[c]	Live	16-32	No	14.1	13.2	0.0	0.2	0.0
Verts (1957)	Southern Ill.	1954	SM[c]	Snap	16-22	No	nr[d]	7.6	nr[d]	nr[d]	nr[d]
Denmon (1998)	W. Va.	1996-1997	ES[c]	Snap	21-30	Yes	3.4	2.7	0.0	0.3	0.2

[a] Refers to correction for sprung traps used in abundance calculations. One-half a trap night is subtracted for each sprung trap in order to more accurately reflect trapping effort (Nelson and Clark 1973). We calculated our abundances with and without the correction since some of the studies to which we compared our results employed the correction while some did not. We assumed that other studies did not employ a correction if they did not state in their methods that they did so.

[b] Includes white-footed mice (*Peromyscus leucopus*) and deer mice (*Peromyscus maniculatus*)

[c] MTM = Reclaimed mountaintop mine/valleyfill
SM = Reclaimed strip mine
GR = Natural grassland
ES = Land in early successional stage following mining or logging operations.

[d] nr = Value not reported

[e] na = Not applicable

Table 34. Species expected (Exp) to occur on in grassland, shrub/pole, fragmented forest, and intact forest treatments in our study area in southwestern West Virgini,a based on Green and Pauley (1987) and personal communication with T. Pauley, compared to those actually observed (Obs) in drift fence surveys (a), stream searches (s), and from incidental sightings (i).

	Grassland		Shrub/ pole		Fragmented Forest		Intact Forest	
Species	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
Terrestrial species								
Salamanders								
Cumberland Plateau Salamander (*Plethodon kentucki*)					x		x	a
Four-toed Salamander (*Hemidactylium scutatum*)					x		x	
Green Salamander (*Aneides aeneus*)					x		x	
Jefferson Salamander (*Ambystoma jeffersonianum*)					x		x	
Longtail Salamander (*Eurycea longicauda*)	x		x		x	a	x	
Marbled Salamander (*Ambystoma opacum*)					x		x	
Ravine Salamander (*Plethodon richmondi*)					x		x	
Redback Salamander (*Plethodon cinereus*)					x		x	a
Red Eft (*Notophthalmus viridescens*) [a]		a		a	x	a	x	a
Slimy Salamander (*Plethodon glutinosus*)					x	a	x	a
Spotted Salamander (*Ambystoma maculatum*)					x	a	x	
Wehrle’s Salamander (*Plethodon wehrlei*)					x		x	
Toads and frogs								
Eastern American Toad (*Bufo americanus*)	x	a	x	a		a		a
Eastern Spadefoot (*Scaphiopus holbrookii*)					x		x	
Fowler’s Toad (*Bufo woodhouseii*)			x					
Gray Treefrog (*Hyla chrysoscelis*)				i	x		x	
Mountain Chorus Frog (*Pseudacris brachyphona*)					x		x	
Northern Peeper (*Pseudacris crucifer*)					x	a	x	
Wood Frog (*Rana sylvatica*)					x		x	a
Lizards								
Broadhead Skink (*Eumeces laticeps*)					x		x	
Five-lined Skink (*Eumeces fasciatus*)	x		x	a	x	a	x	a
Ground Skink (*Scincella lateralis*)					x		x	a
Northern Coal Skink (*Eumeces anthracinus*)	x		x		x		x	
Northern Fence lizard (*Sceloporus undulatus*)	x	a		a		i		
Snakes								
Black King Snake (*Lampropeltis getulus*)	x		x		x		x	
Black Rat Snake (*Elaphe obsoleta*)	x	a	x	a	x	a	x	i
Eastern Earth Snake (*Virginia valeriae*)	x		x		x		x	
Eastern Garter Snake (*Thamnophis sirtalis*)	x	a	x	a	x	a	x	a
Eastern Hognose (*Heterodon platirhinos*)	x	a		a				
Eastern Milk Snake (*Lampropeltis triangulum*)	x		x	a	x	a	x	a
Eastern Smooth Green Snake (*Opheodrys vernalis*)	x			i				i
Eastern Worm Snake (*Carphophis amoenus*)	x		x		x		x	a
Northern Black Racer (*Coluber constrictor*)	x	a	x	a		i		i
Northern Brown Snake (*Storeria dekayi*)	x		x		x		x	
Northern Copperhead (*Agkistrodon contortrix*)				a	x	a	x	a
Northern Redbelly Snake (*Storeria occipitomaculata*)	x		x		x	a	x	a
Northern Ringneck Snake (*Diadophis punctatus*)					x		x	i
Rough Green Snake (*Opheodrys aestivus*)	x		x		x		x	

Table 34. Continued.

Species	Grassland		Shrub/ pole		Fragmented Forest		Intact Forest	
	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
Timber Rattlesnake (*Crotalus horridus*)				i	x	I	x	
Turtles								
Eastern Box Turtle (*Terrapene carolina*)	x		x	a	x	a	x	a
Aquatic species								
Salamanders								
Appalachian Seal Salamander (*Desmognathus monticola*)					x	s	x	a
Dusky Salamander spp. (*D.fuscus* or *D.ochrophaeus*)					x		x	
Eastern Hellbender (*Cryptobranchus alleganiensis*)					x		x	
Midland Mud Salamander (*Pseudotriton montanus*)					x		x	
Mudpuppy (*Necturus maculosus*)	x		x		x		x	
Northern Dusky Salamander (*Desmognathus fuscus*)					x	s	x	s
Northern Red Salamander (*Pseudotriton ruber*)	x		x		x		x	
Red-spotted Newt (*Notophthalmus viridescens*)	x	a	x	a	x	a	x	a
Southern Two-lined Salamander (*Eurycea cirrigera*)					x		x	i
Spring Salamander (*Gyrinophilus porphyriticus*)					x		x	i
Toads and frogs								
Bullfrog (*Rana catesbeiana*)	x		x	a	x	a	x	
Green Frog (*Rana clamitans*)	x	a	x	a	x	a	x	a
Northern Leopard Frog (*Rana pipiens*)	x		x		x		x	
Pickerel frog (*Rana palustris*)	x	a	x	a	x	a	x	a
Snakes								
Northern Water Snake (*Nerodia sipedon*)	x	a	x	a	x	i	x	
Queen Snake (*Regina septemvittata*)					x		x	
Turtles								
Common Snapping Turtle (*Chelydra serpentina*)	x	i	x	i	x	i	x	
Eastern Spiny Softshell Turtle (*Trionyx spiniferus*)	x		x	i	x		x	
Midland Painted Turtle (*Chrysemys picta*)	x		x		x		x	
Stinkpot (*Sternotherus odoratus*)	x		x		x		x	

[a] Juvenile form of red-spotted newt; not included as a separate species in calculations of species richness.

Table 35. Herpetofaunal species richness and relative abundance in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in southwestern West Virginia, March - September, 2000.

	Treatment			
	Grassland	Shrub/pole	Fragmented Forest	Intact Forest
Species Richness				
No. species	13	14	16	15
Mean	0.21	0.28	0.29	0.22
SE	0.04	0.03	0.04	0.03
Overall Abundance				
No. individuals	91	109	110	59
Mean	0.52	0.61	0.63	0.34
SE	0.19	0.15	0.13	0.06

Table 36. Herpetofaunal community similarity between pairs of treatments on reclaimed MTMVF areas in southwestern West Virginia, March - September, 2000.

Comparisons	No. species shared	Jaccard[a] index	Renkonen index
Grassland/Shrub	11	0.69	0.65
Grassland/Fragment	9	0.45	0.58
Grassland/Intact	6	0.27	0.43
Shrub/Fragment	10	0.50	0.55
Shrub/Intact	7	0.32	0.56
Fragment/Intact	10	0.48	0.61

[a]The Jaccard index only examines the number of species shared while the Renkonen index takes into account the proportion of each species present in each sample (in all cases the scale ranges from 0=no similarity and 1=complete similarity).

Table 37. Number of individuals and species of herpetofauna groups captured in drift fence arrays in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in southwestern West Virginia, March - September, 2000.

	Grassland				Shrub/pole				Fragmented Forest				Intact Forest			
	Individuals		Species		Individuals		Species		Individuals		Species		Individuals		Species	
Taxonomic Group	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Salamanders	5	5.7	2	15.4	5	4.6	1	7.1	25	23.1	4	25.0	17	29.3	4	26.7
Toads and frogs	63	71.6	3	23.1	68	63.0	4	28.6	65	60.2	5	31.3	31	53.4	4	26.7
Lizards	2	2.3	1	7.7	2	1.9	2	14.3	3	2.8	1	6.3	2	3.4	2	13.3
Snakes	17	19.3	6	46.2	33	30.6	7	50.0	13	12.0	5	31.3	6	10.3	4	26.7
Turtles	1	1.1	1	7.7	0	0.0	0	0.0	2	1.9	1	6.3	2	3.4	1	6.7

Table 38. Number of individuals (# indivs) of herpetofauna species captured in drift fence arrays and percent of points at which a species was captured in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in southwestern West Virginia, March - September, 2000.

	Grassland		Shrub/pole		Fragmented Forest		Intact Forest	
Species	# indivs	% of points	# indivs	% of points	# indivs	% of points	# indivs	% of points
Salamanders								
Appalachian Seal Salamander							1	33
Cumberland Plateau Salamander							4	66
Longtail Salamander					2	33		
Redback Salamander							2	33
Red-spotted Newt	4	100	5	100	19	100	10	100
Slimy Salamander					3	33		
Spotted Salamander	1	33			1	33		
Toads and frogs								
Bullfrog			2	66	1	33		
Eastern American Toad	7	66	27	100	3	66	14	100
Green Frog	39	100	25	100	26	66	4	100
Northern Spring Peeper					3	66		
Pickerel Frog	17	100	14	66	32	100	12	66
Unidentified Frog	2	33	1	33			1	33
Wood Frog							1	33
Lizards								
Five-lined Skink			1	33	3	33	1	33
Ground Skink							1	33
Northern Fence Lizard	2	66	1	33				
Snakes								
Black Rat Snake	6	66	4	66	1	33		
Eastern Garter Snake	3	33	5	66	7	66	2	33
Eastern Hognose	1	33	1	33				
Eastern Milk Snake	1	33	2	33	1	33		
Eastern Worm Snake							1	33
Northern Black Racer	5	66	14	100				
Northern Copperhead			6	66	3	66	2	66
Northern Redbelly Snake					1	33	1	33
Northern Water Snake	1	33	1	33				
Turtles								
Eastern Box Turtle	1	33			2	66	2	33
Unknown	1	33			2	33		

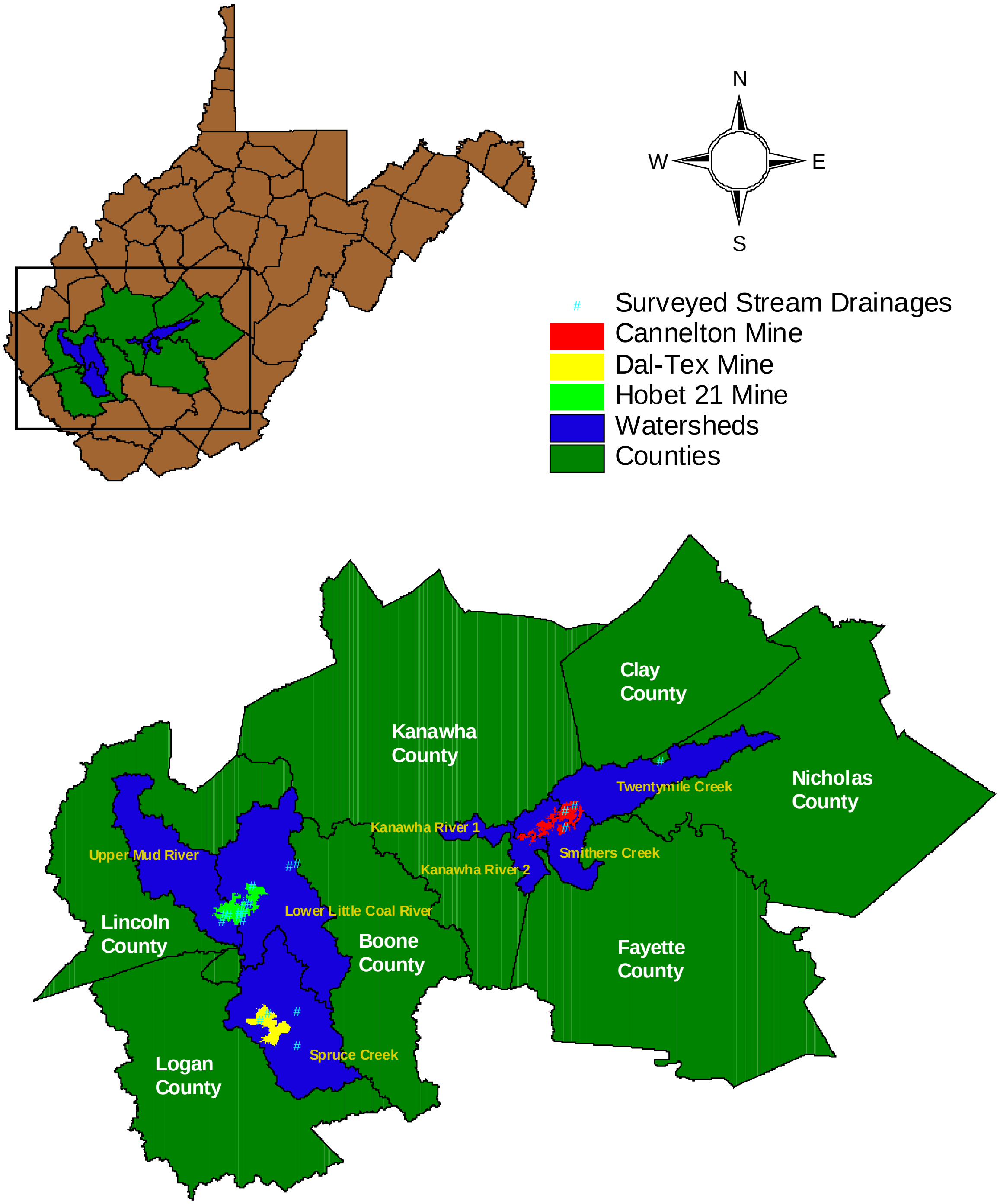

Figure 1. Location of mountaintop removal mine sites within watersheds in southern West Virginia.

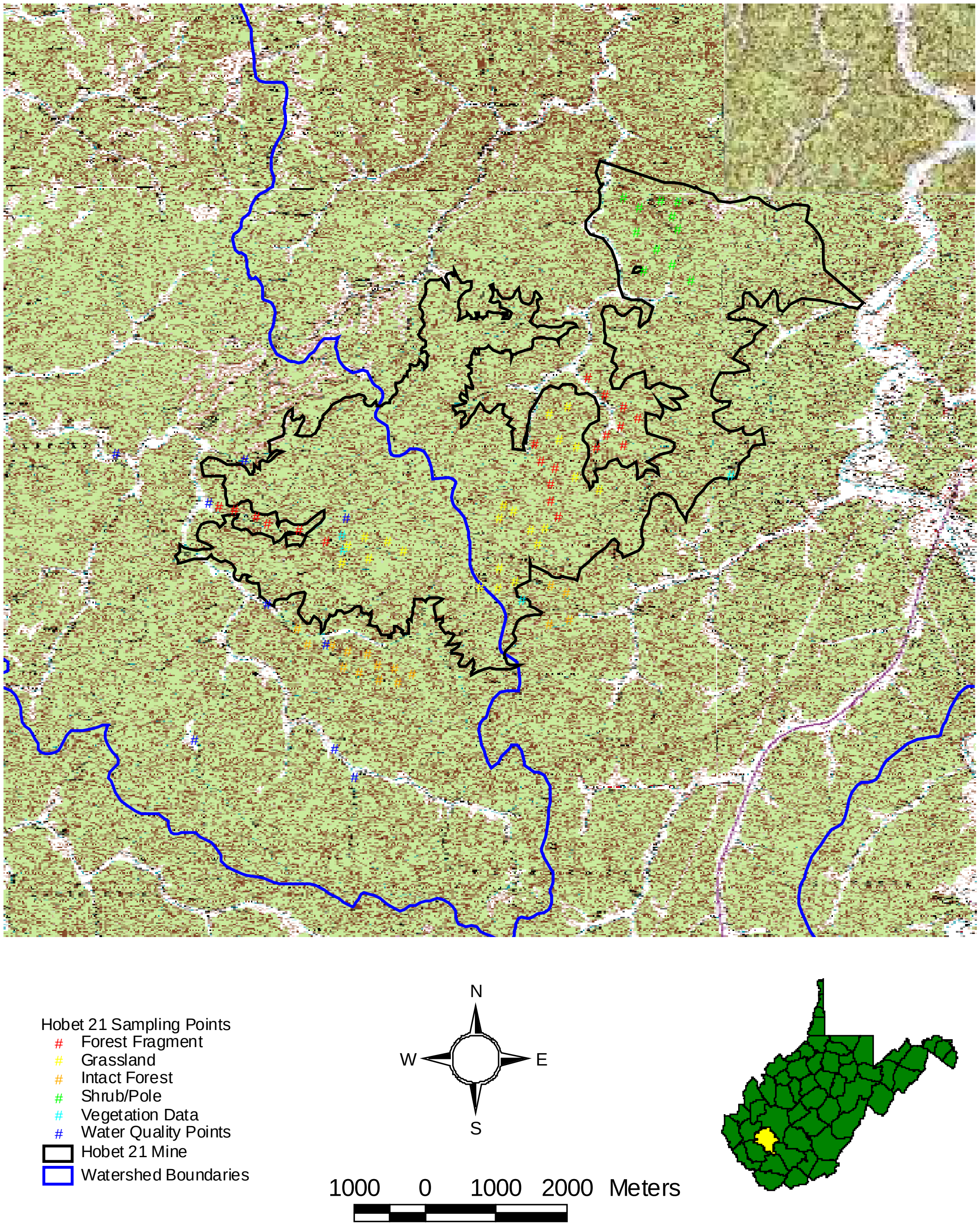

Figure 2. Topographic map of Hobet 21 mountaintop removal mine with locations of sampling points in Boone County, West Virginia.

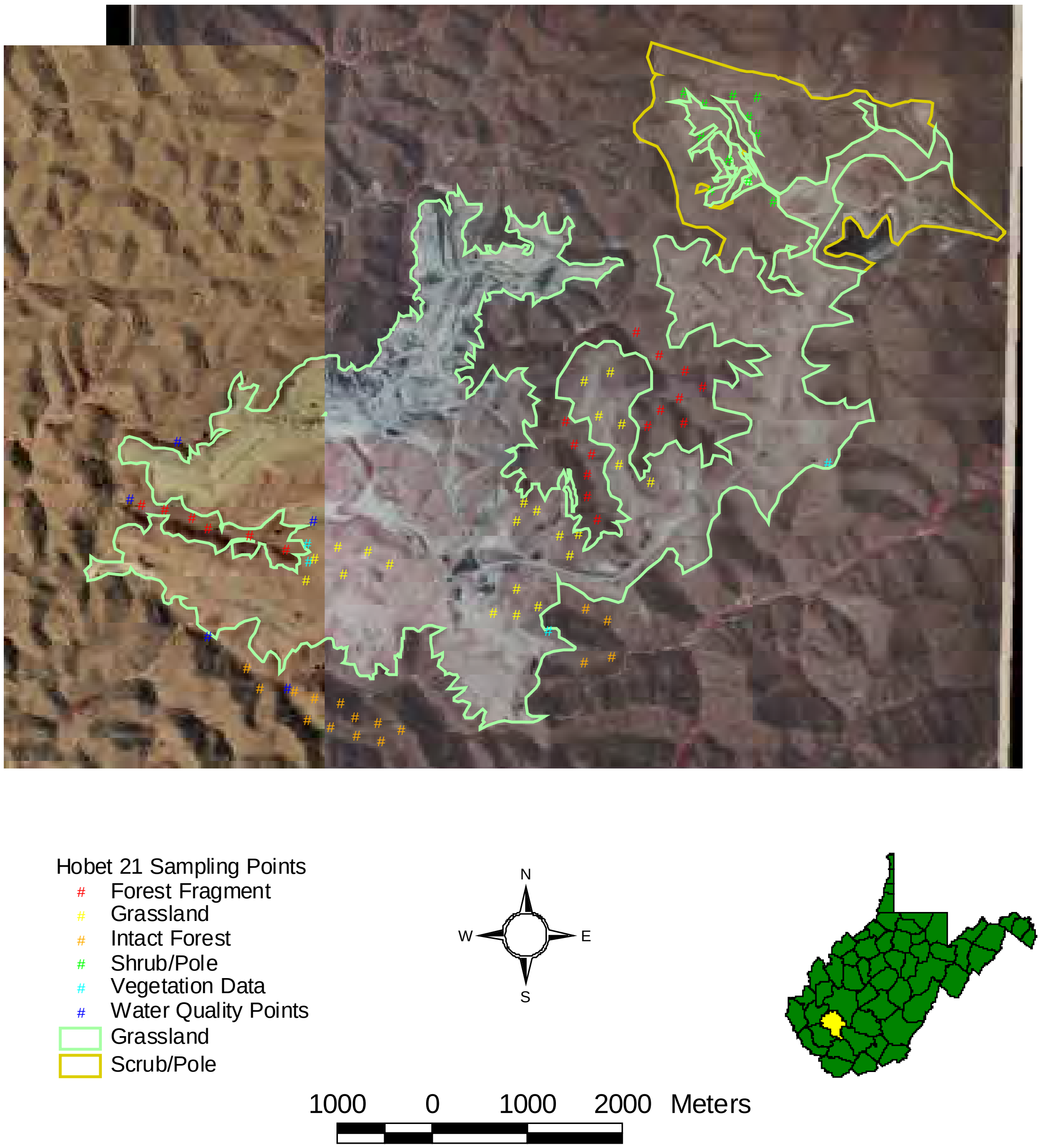

Figure 3. Aerial photograph of Hobet 21 mountaintop removal mine with locations of sampling points in Boone County, West Virginia.

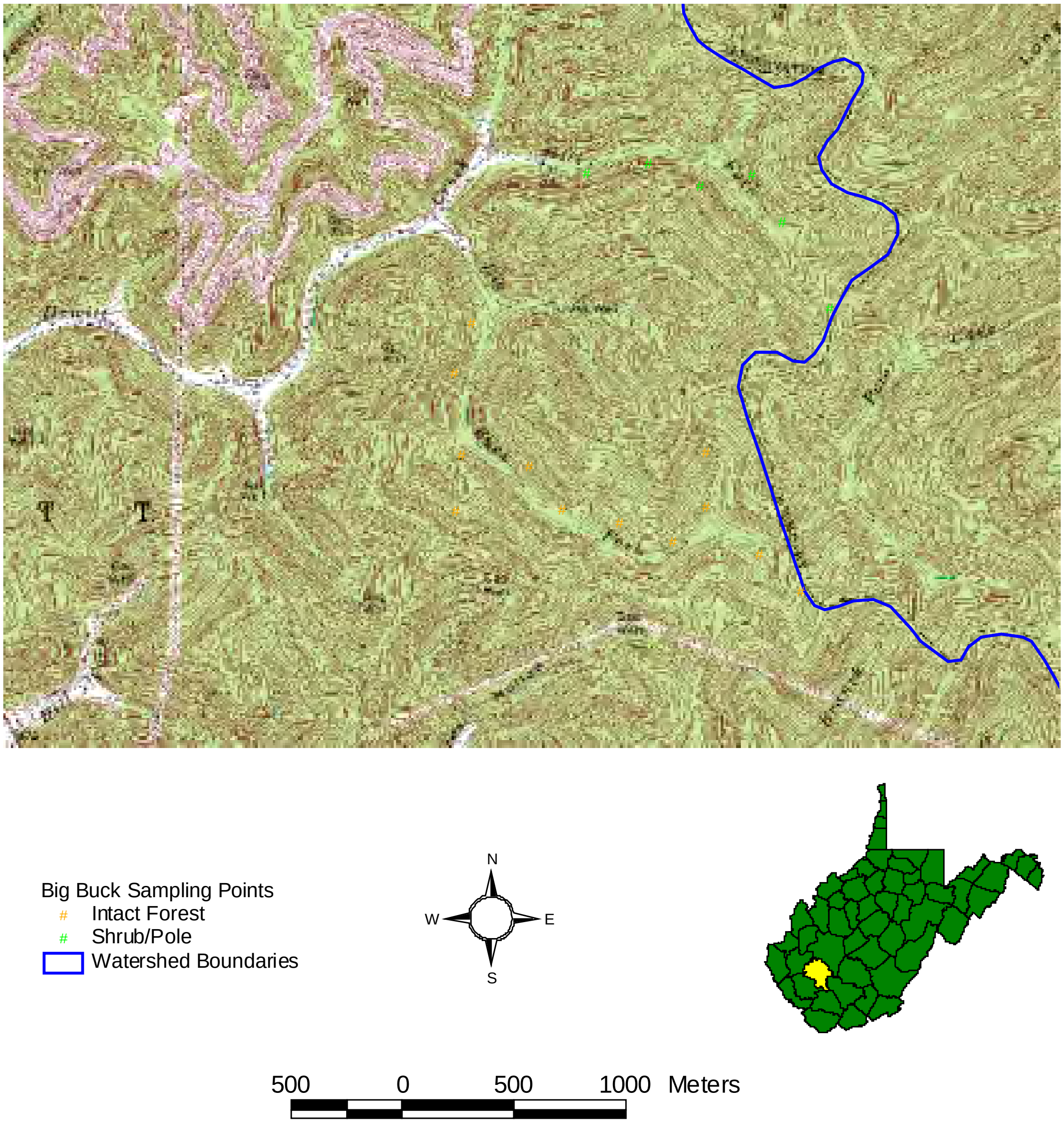

Figure 4. Topographic map of sampling points located along Big Buck Fork (intact forest) and Hill Fork drainages (shrub/pole) in Boone County, West Virginia.

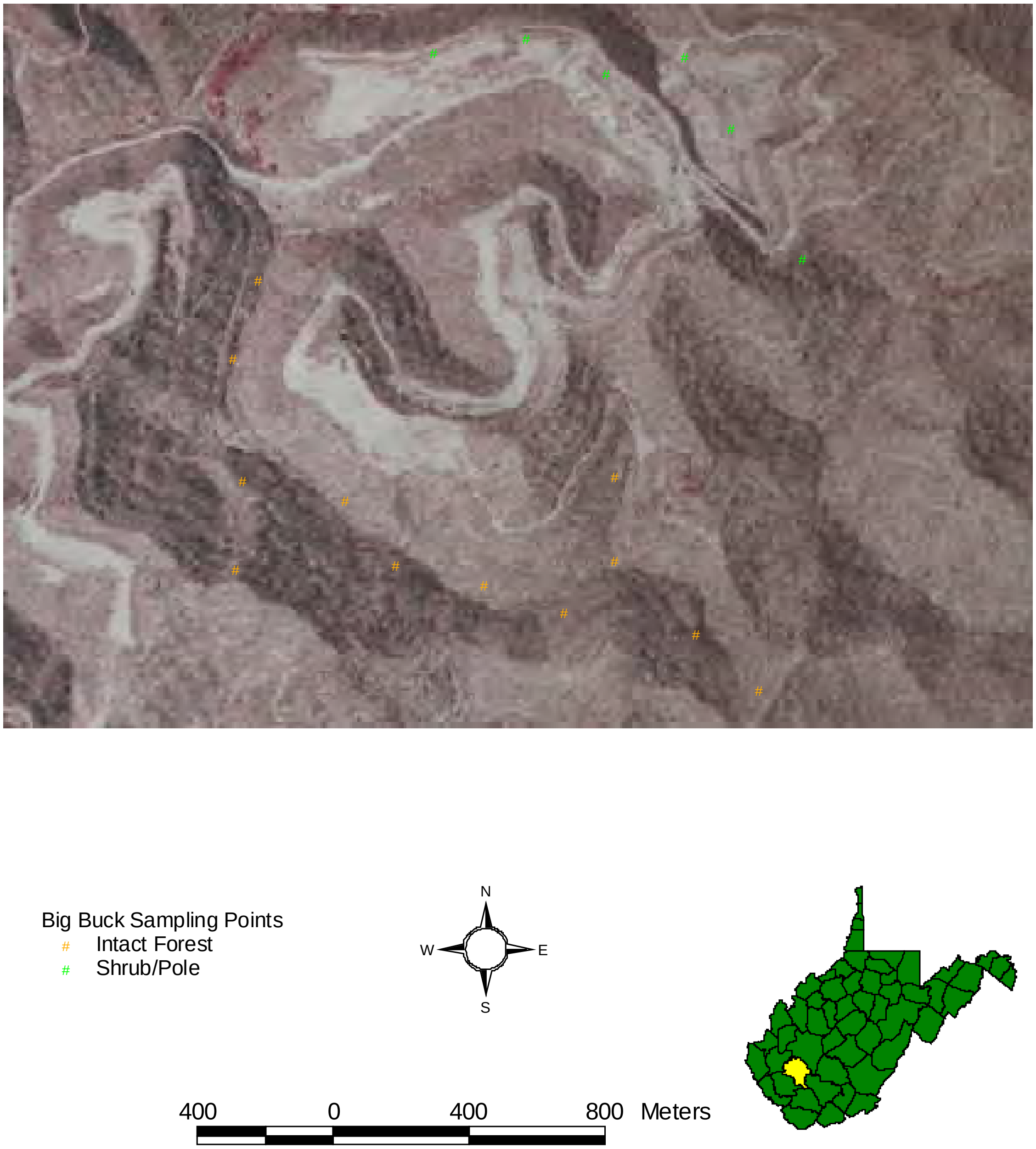

Figure 5. Aerial photograph of sampling points located along Big Buck Fork (intact forest) and Hill Fork drainages (shrub/pole) in Boone County, West Virginia.

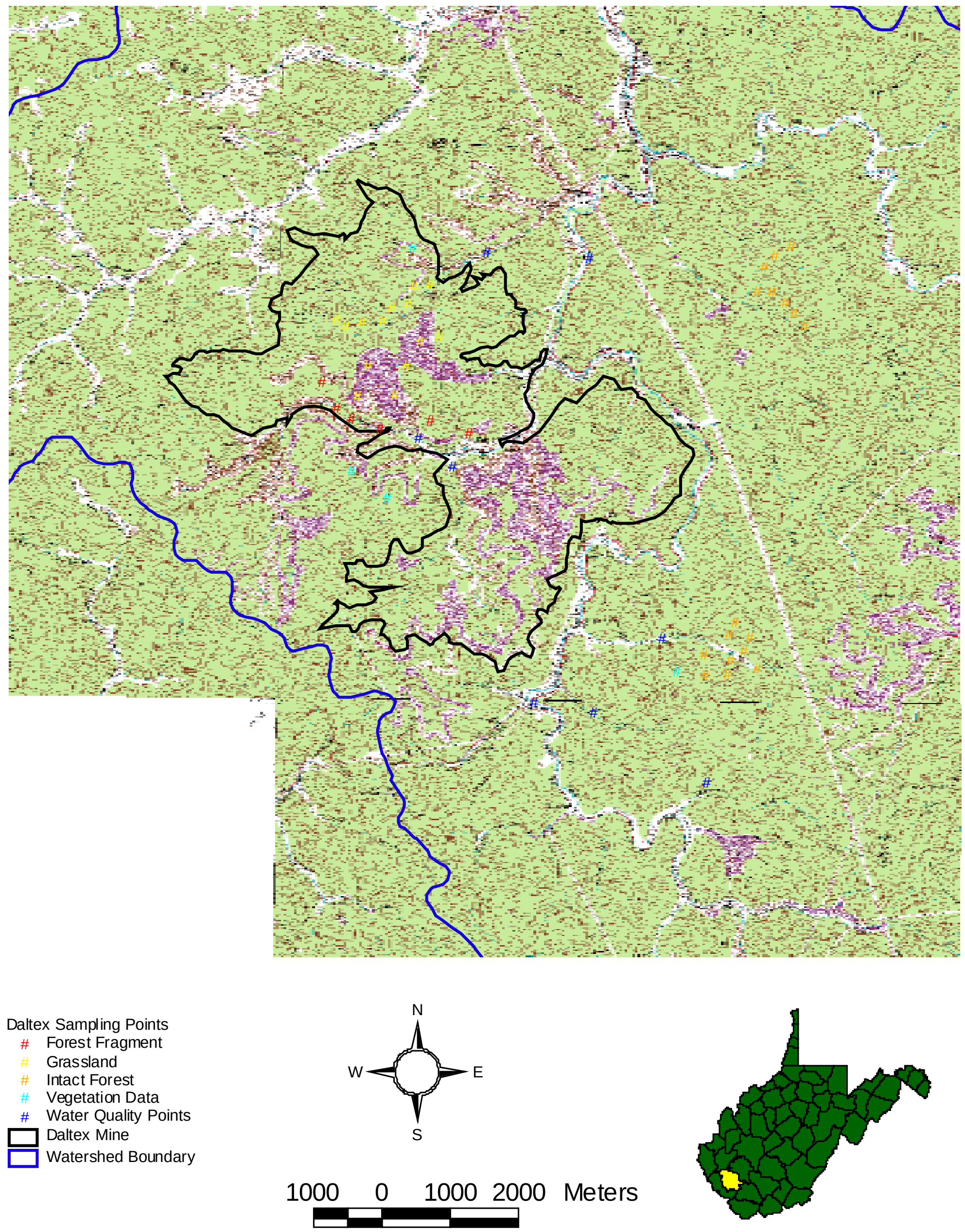

Figure 6. Topographic map of Daltex mountaintop removal mine with locations of sampling points in Logan County, West Virginia.

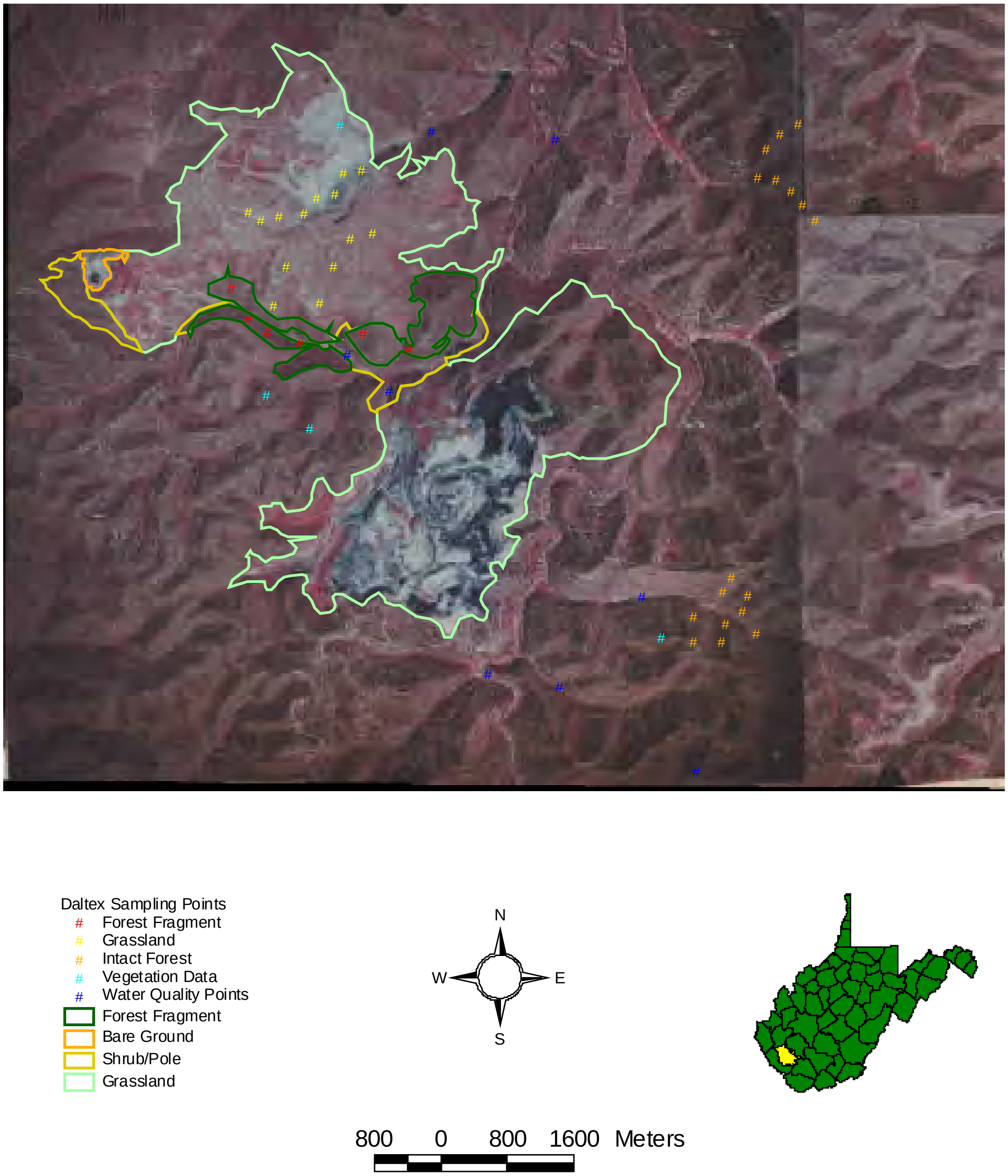

Figure 7. Aerial photograph of Daltex mountaintop removal mine with locations of sampling points in Logan County, West Virginia.

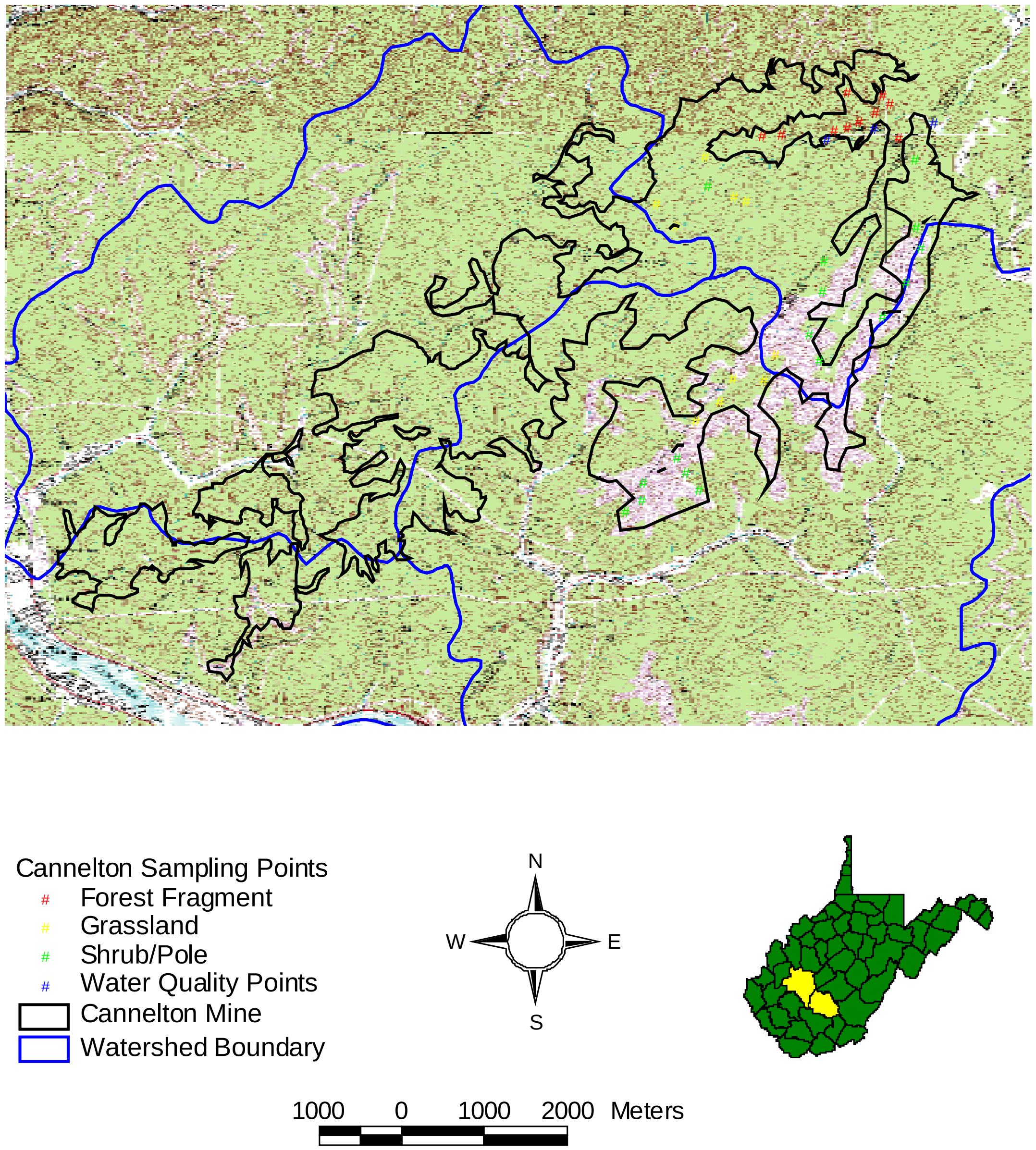

Figure 8. Topographic map of Cannelton mountaintop removal mine with locations of sampling points in Kanawha and Fayette Counties, West Virginia.

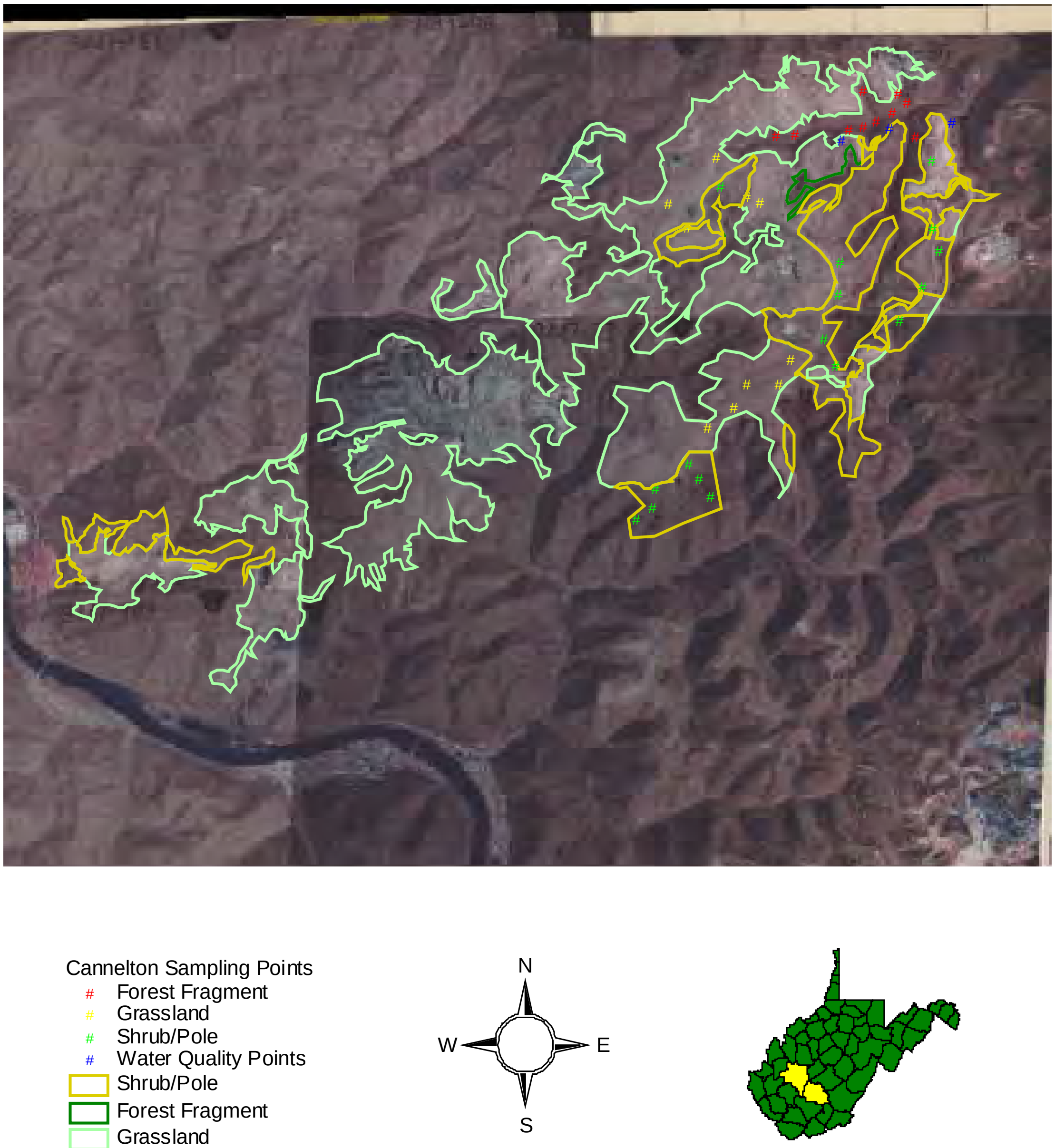

Figure 9. Aerial photograph of Cannelton mountaintop removal mine with locations of sampling points in Kanawha and Fayette Counties, West Virginia.

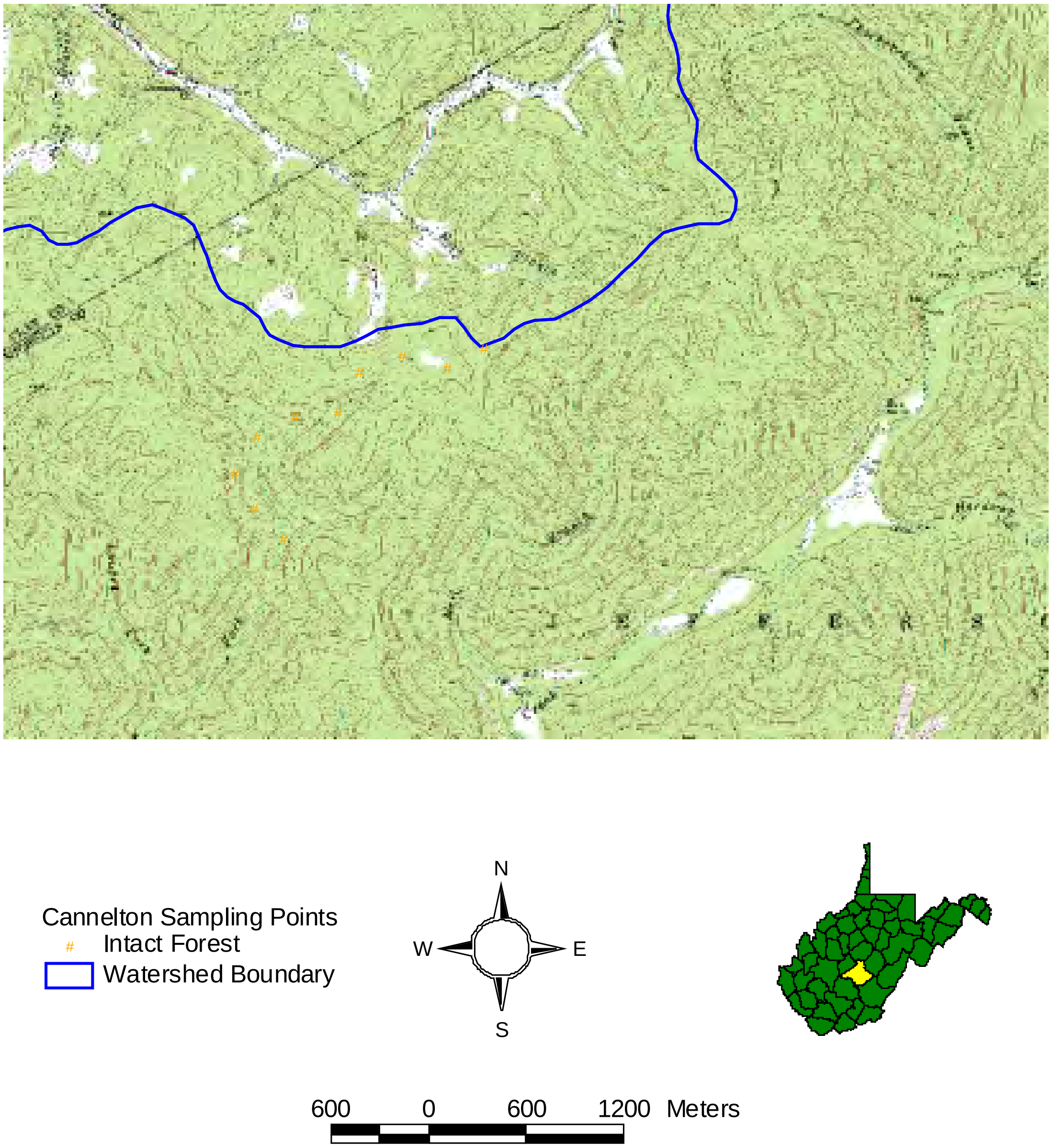

Figure 10. Topographic map of sampling points located along Ash Fork (intact forest) in Nicholas County, West Virginia.

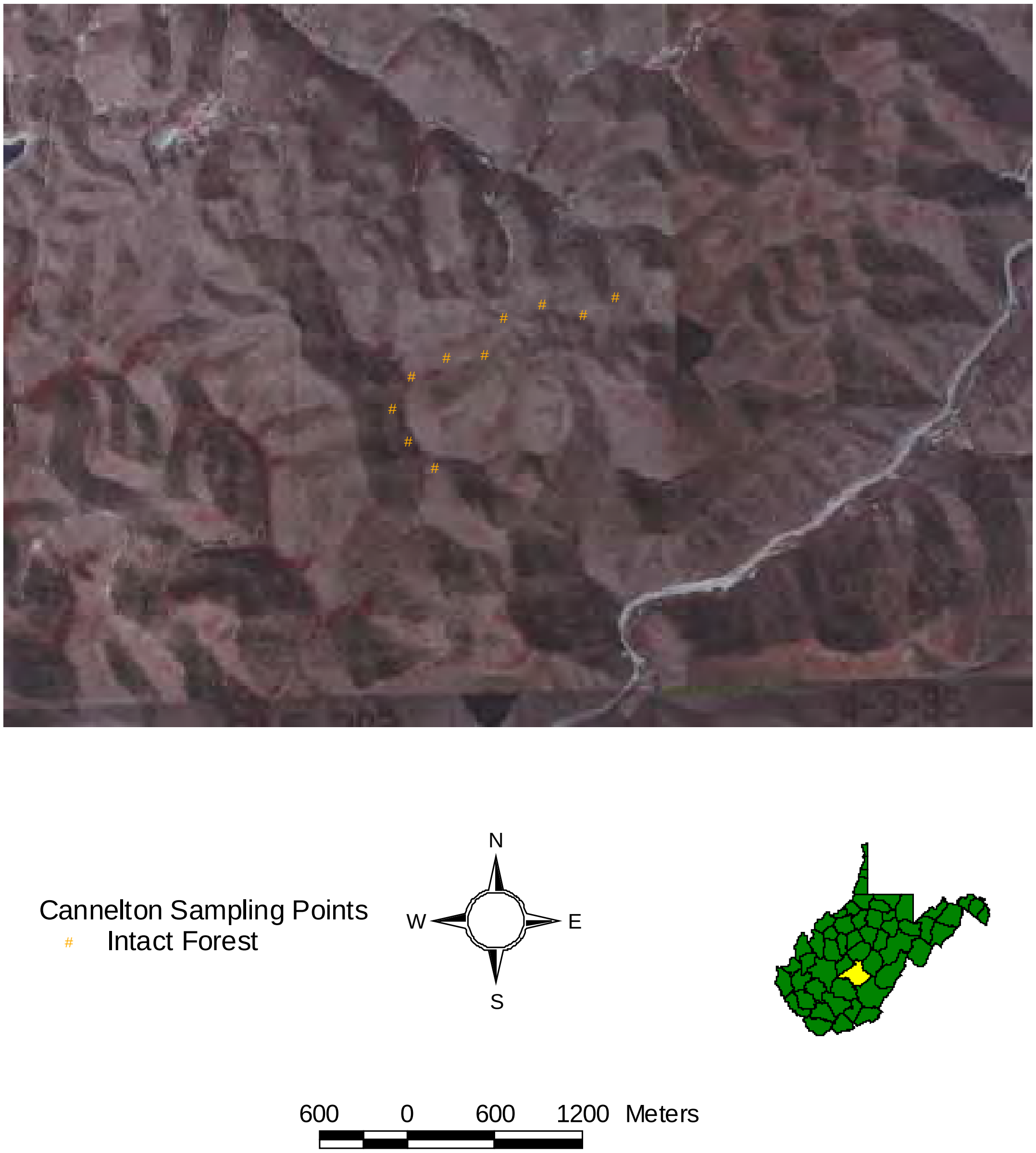

Figure 11. Aerial photograph of sampling points along Ash Fork (intact forest) in Nicholas County, West Virginia.

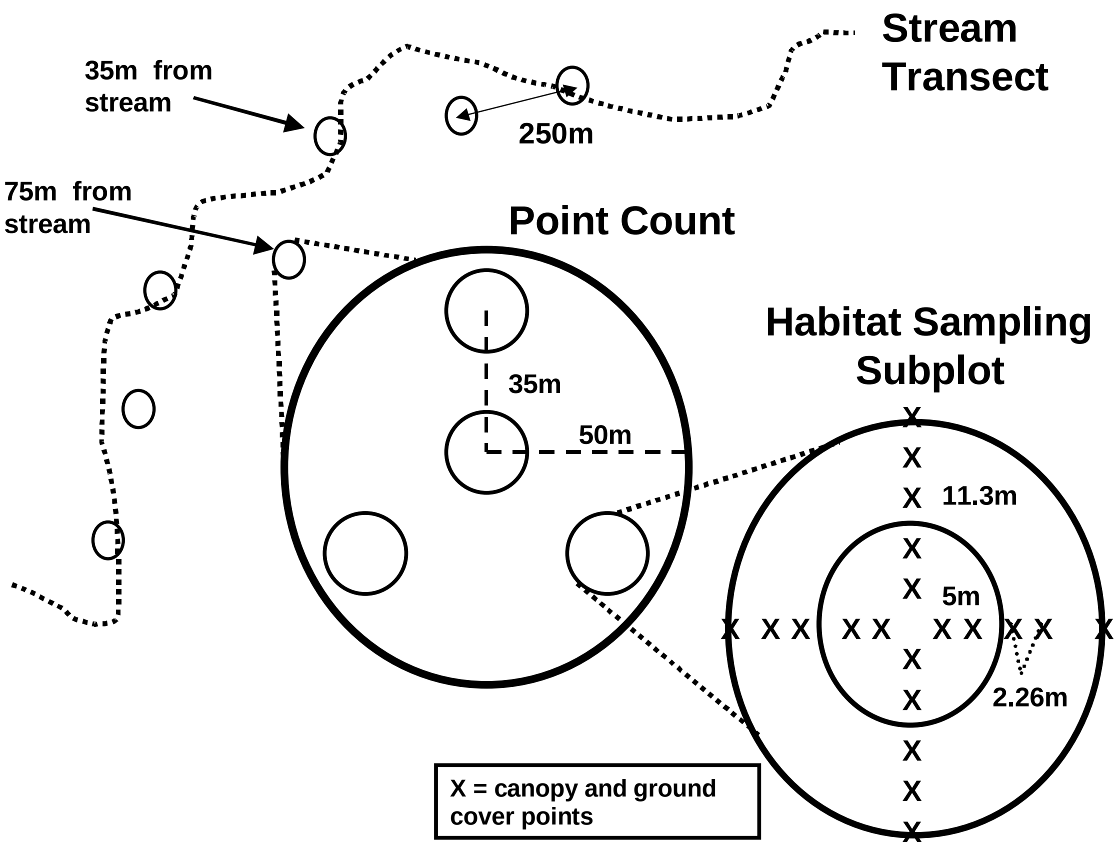

Figure 12. Placement of point count plots along streams and layout of vegetation sampling subplots within the 50-m radius point count plot.

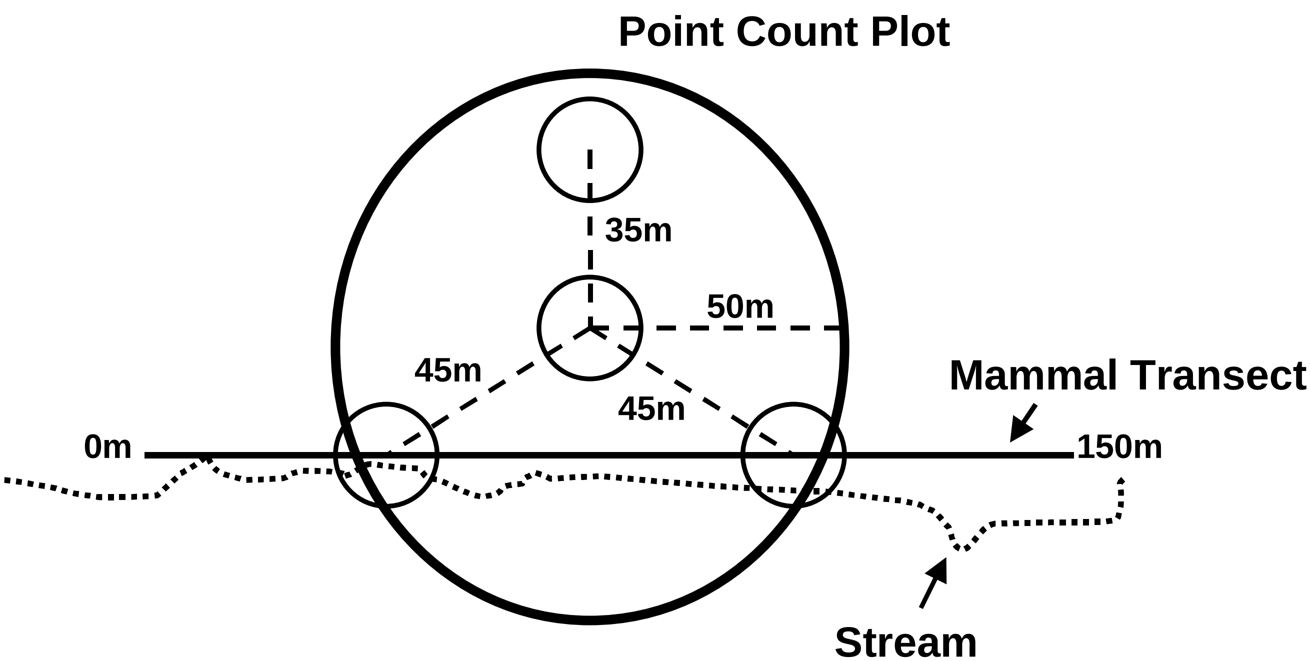

Figure 13. Layout of small mammal transects in relation to the bird point count plot and stream.

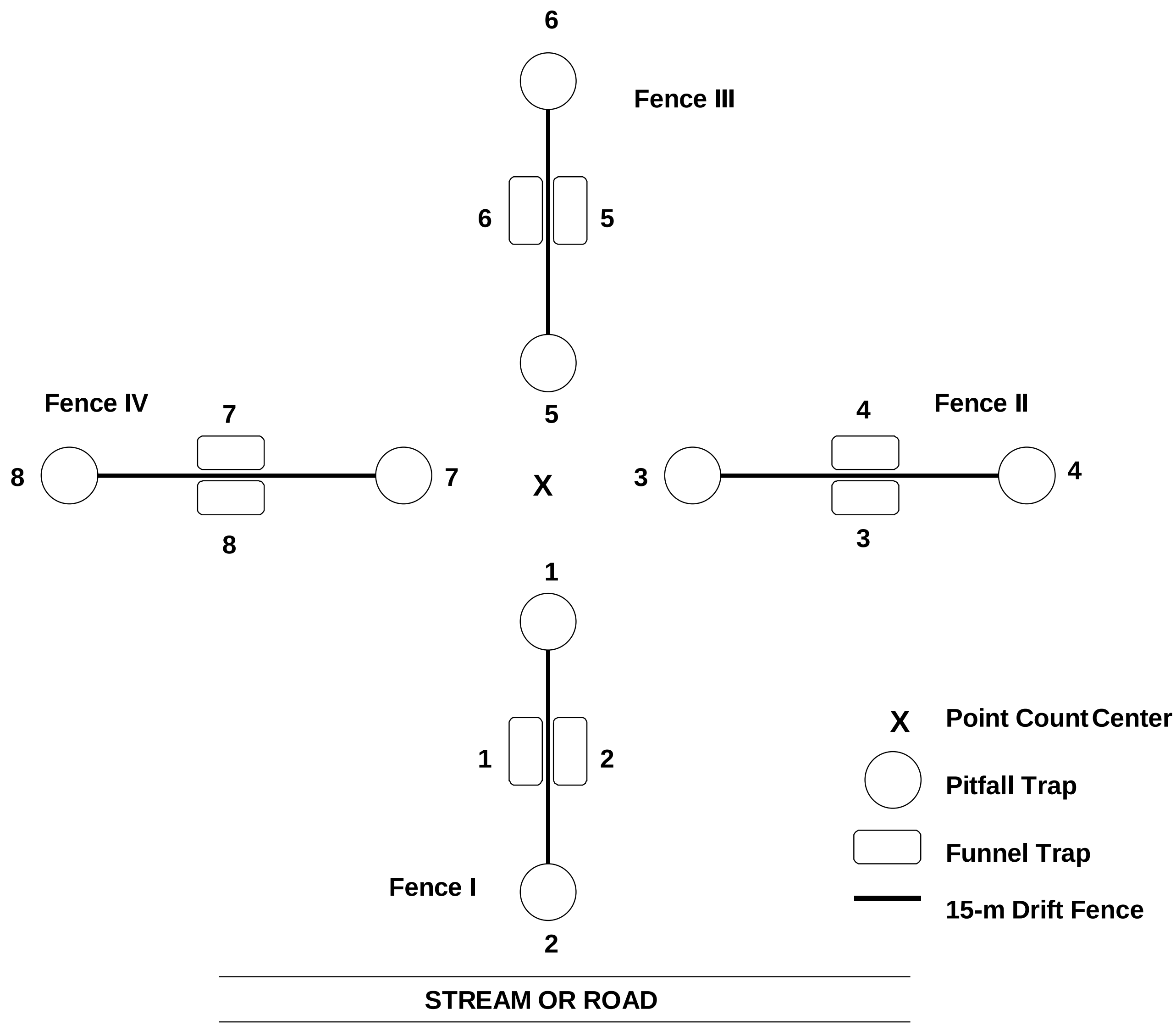

Figure 14. Placement of herpetofaunal drift fence array relative to songbird point count station.

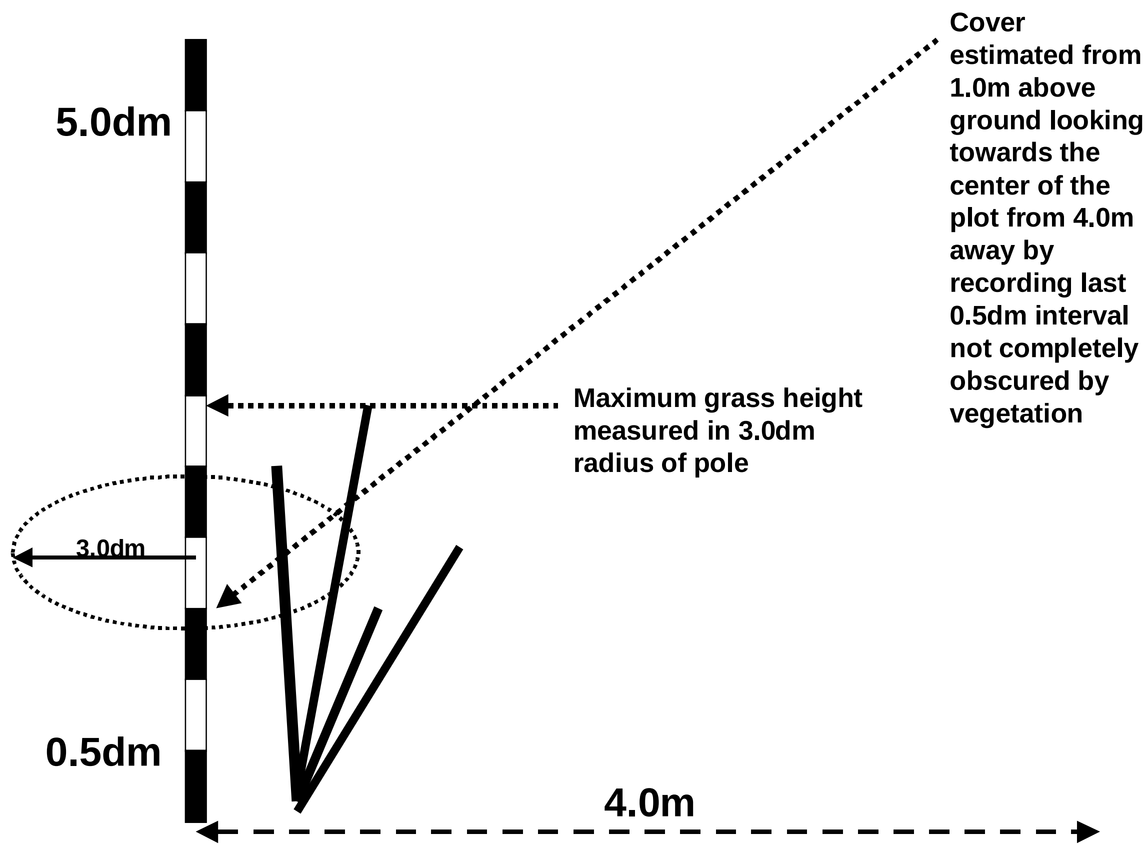

Figure 15. Example of how a Robel pole is used to measure vegetative cover and grass height.

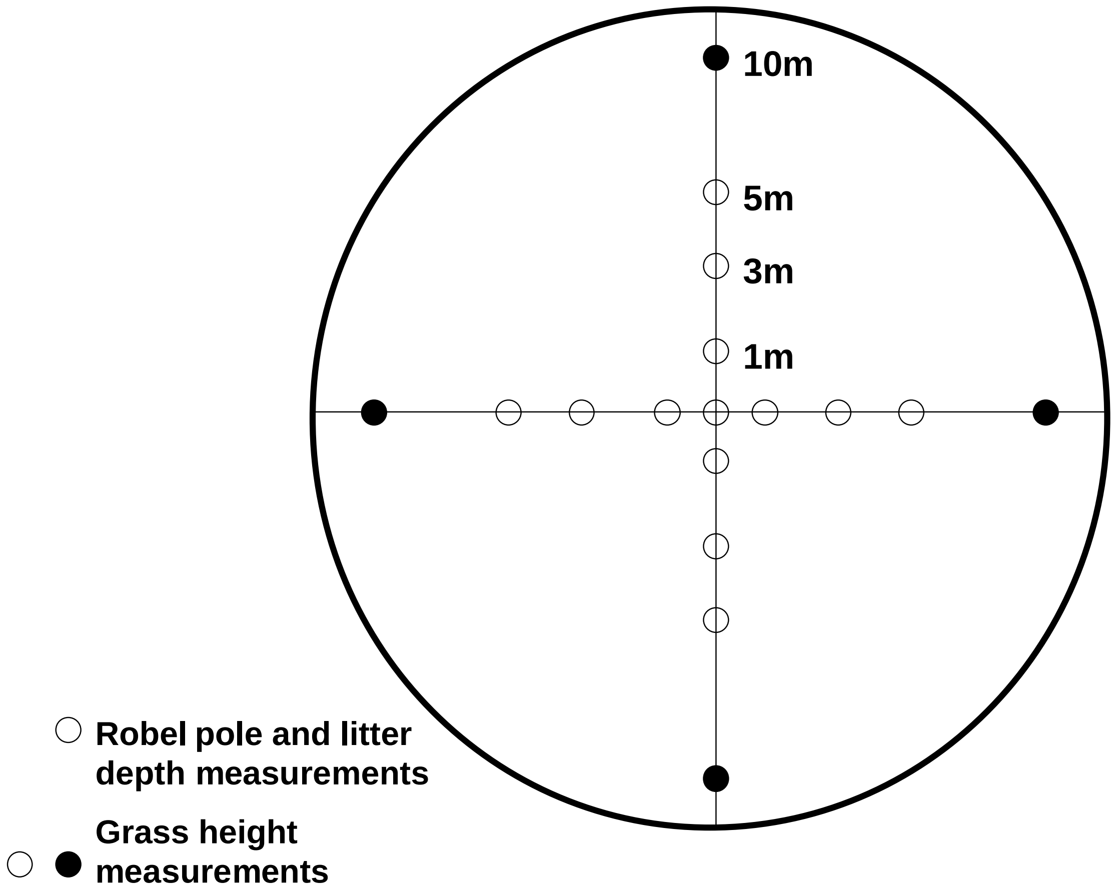

Figure 16. Sampling points on grassland vegetation subplot for vegetative cover and grass height measurements (Robel pole) and litter depth measurements.

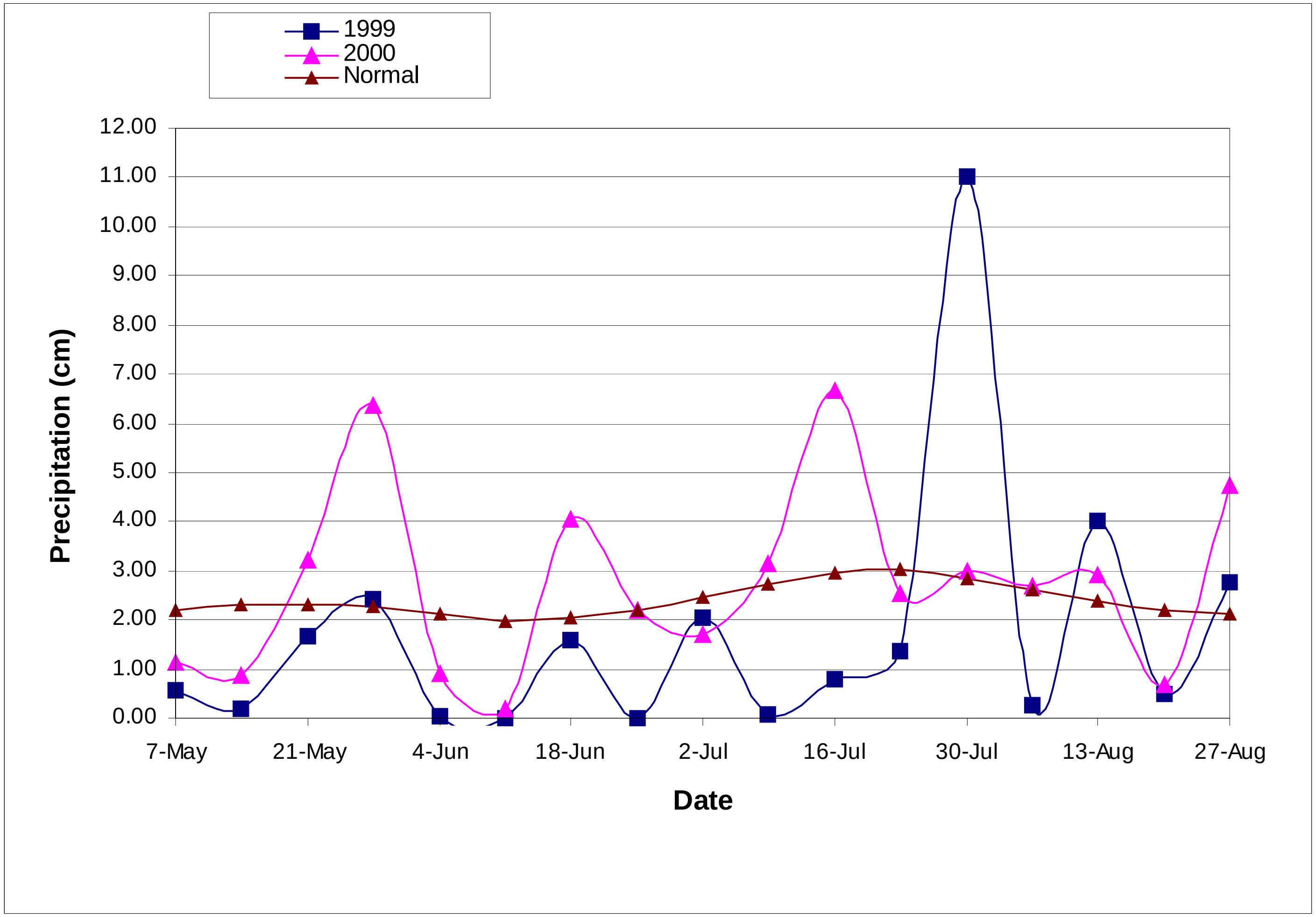

Fig. 17. Weekly precipitation reported in Charleston, West Virginia from May to August in 1999 and 2000. Total precipitation from May to August was 29.2 cm in 1999 and 47.0 cm in 2000.

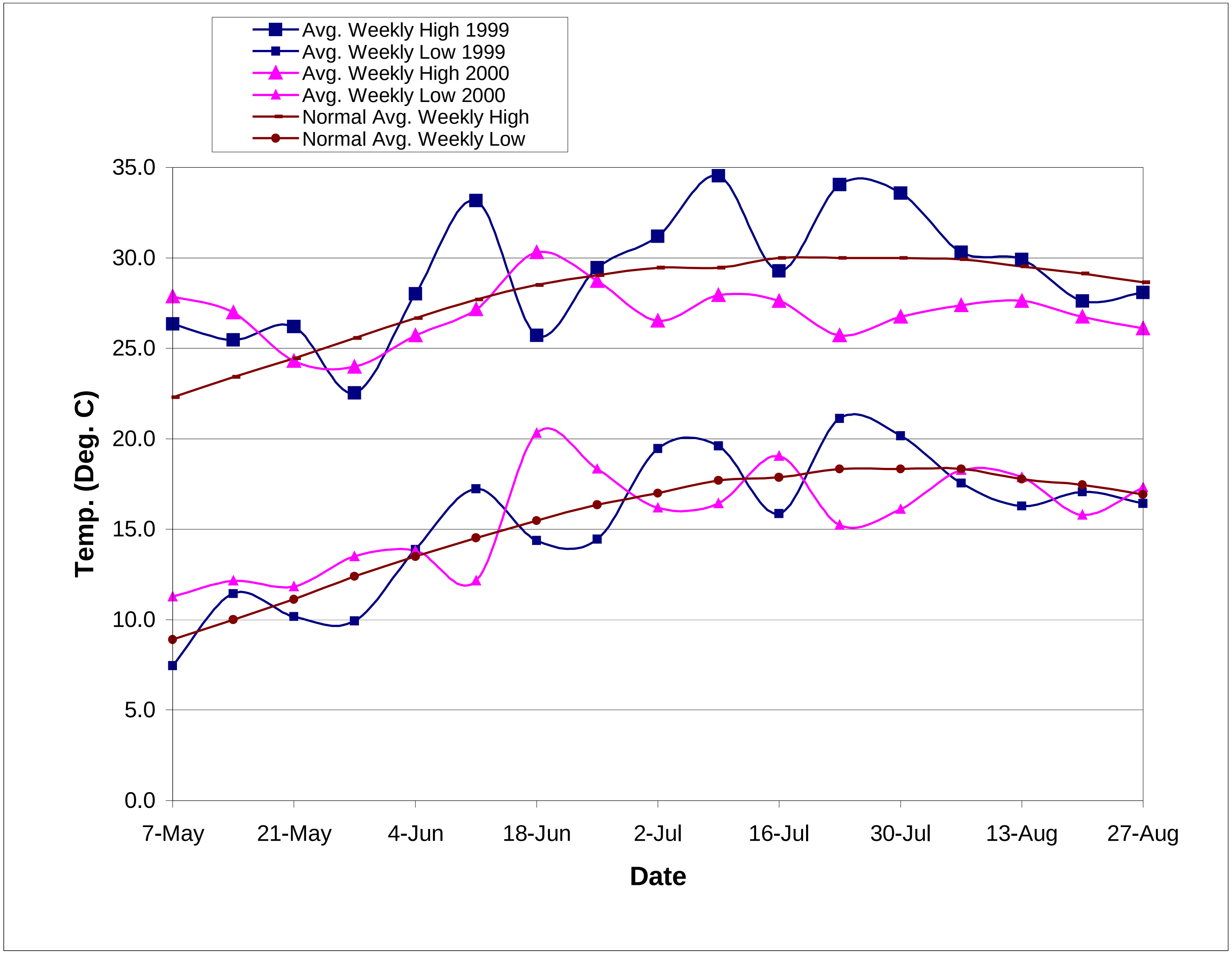

Fig. 18. Average weekly high and low temperatures recorded in Charleston, West Virginia from May to August 1999 and 2000. In 1999 the average high was 29.1 degrees C while the low was 15.4. In 2000, the average high was 26.9 degrees C and the low was 15.9.

Appendix 1. Orders, common names, and scientific names of all bird species mentioned in the text.

Order/Species	Scientific Name
<u>Order Podicepediformes</u>	
Pied-billed Grebe	*Podilymbus podiceps*
<u>Order Pelecaniformes</u>	
Double-crested Cormorant	*Phalacrocorax auritus*
<u>Order Ciconiiformes</u>	
American Bittern	*Botaurus lentiginosus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Casmerodius albus*
Cattle Egret	*Bubulcus ibis*
Green-backed Heron	*Butorides striatus*
Yellow-crowned Night-Heron	*Nycticorax violaceus*
<u>Order Anseriformes</u>	
Mute Swan[*]	*Cygnus olor*
Canada Goose	*Branta canadensis*
Green-winged Teal	*Anas crecca*
American Black Duck	*Anas rubripes*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Blue-winged Teal	*Anas discors*
Northern Shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Common Goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
<u>Order Falconiformes</u>	
Black Vulture	*Coragyps stratus*
Turkey Vulture	*Cathartes aura*

Order/Species	Scientific Name
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperii*
Northern Goshawk	*Accipiter gentilis*
Red-shouldered hawk	*Buteo lineatus*
Broad-winged Hawk	*Buteo platypterus*
Red-tailed Hawk	*Buteo jamaicensis*
Rough-legged Hawk	*Buteo lagopus*
American Kestrel	*Falco sparverius*
Peregrine Falcon	*Falco peregrinus*
<u>Order Galliformes</u>	
Ring-necked Pheasant[*]	*Phasianus colchicus*
Ruffed Grouse	*Bonasa umbellus*
Wild Turkey	*Meleagris gallopavo*
Northern Bobwhite	*Colinus virginianus*
<u>Order Gruiformes</u>	
King Rail	*Rallus elegans*
Sora	*Porzana carolina*
Common Moorhen	*Gallinula chloropus*
American Coot	*Fulica americana*
<u>Order Charadriiformes</u>	
American Golden-plover	*Pluvialis dominica*
Killdeer	*Charadrius vociferous*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Solitary Sandpiper	*Tringa solitaria*
Spotted Sanpiper	*Actitis macularia*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
White-rumped Sandpiper	*Calidris fuscicollis*
Baird's Sandpiper	*Calidris bairdii*
Pectoral Sandpiper	*Calidris melanotos*

Appendix 1. Continued.

Order/Species	Scientific Name
Common Snipe	*Gallinago gallinago*
American Woodcock	*Scolopax minor*
Order Columbiformes	
Rock Dove*	*Columba livia*
Mourning Dove	*Zenaida macroura*
Order Cuculiformes	
Black-billed Cuckoo	*Coccyzus erthropthalmus*
Yellow-billed Cuckoo	*Coccyzus americanus*
Order Strigiformes	
Eastern Screech-Owl	*Otus asio*
Great Horned Owl	*Bulbo virginianus*
Barred Owl	*Strix varia*
Short-eared Owl	*Asio flammeus*
Order Caprimulgiformes	
Common Nighthawk	*Chordeiles minor*
Whip-poor-will	*Caprimulgus vociferus*
Order Apodiformes	
Chimney Swift	*Chaetura pelagica*
Ruby-throated Hummingbird	*Archilocus colubris*
Order Coraciiformes	
Belted Kingfisher	*Ceryle torquata*
Order Piciformes	
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-bellied Woodpecker	*Melanerpes carolinus*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Northern Flicker	*Colaptes auratus*
Pileated Woodpecker	*Dryocopus pileatus*

Order/Species	Scientific Name
Order Passeriformes	
Acadian Flycatcher	*Empidonax virescens*
Willow Flycatcher	*Empidonax traillii*
Least Flycatcher	*Empidonax minimus*
Eastern Phoebe	*Sayornis phoebe*
Great Crested Flycatcher	*Myiarchus crinitus*
Eastern Kingbird	*Tyrannus tyrannus*
Horned Lark	*Eremophila alpestris*
Purple Martin	*Progne subis*
Tree Swallow	*Tachycineta bicolor*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Bank Swallow	*Riparia riparia*
Cliff Swallow	*Petrochelidon pyrrhonota*
Barn Swallow	*Hirundo rustica*
Blue Jay	*Cyanocitta cristata*
American Crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corax*
Black-capped Chickadee	*Poecile atricapilla*
Carolina Chickadee	*Poecile carolinensis*
Tufted Titmouse	*Baeolophus bicolor*
White-breasted Nuthatch	*Sitta carolinensis*
Brown Creeper	*Certhia americana*
Carolina Wren	*Thryothorus ludovicianus*
House Wren	*Troglodytes aedon*
Winter Wren	*Troglodytes troglodytes*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Eastern Bluebird	*Sialia sialis*
Veery	*Catharus fuscescens*
Wood Thrush	*Hylocichla mustelina*
American Robin	*Turdus migratorius*
Gray Catbird	*Dumatella carolinensis*
Northern Mockingbird	*Mimus polyglottos*
Brown Thrasher	*Toxostoma rufum*
European Starling*	*Sturnus vulgaris*
White-eyed Vireo	*Vireo griseus*
Blue-headed Vireo	*Vireo solitarius*

Appendix 1. Continued.

Order/Species	Scientific Name
Warbling Vireo	*Vireo gilvus*
Yellow-throated Vireo	*Vireo flavifrons*
Eastern Wood-Pewee	*Contopus virens*
Red-eyed Vireo	*Vireo olivaceus*
Blue-winged Warbler	*Vermivora pinus*
Golden-winged Warbler	*Vermivora chrysoptera*
Northern Parula	*Parula americana*
Yellow Warbler	*Dendroica petechia*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Black-throated Blue Warbler	*Dendroica caerulescens*
Black-throated Green Warbler	*Dendroica virens*
Yellow-throated Warbler	*Dendroica dominica*
Pine Warbler	*Dendroica pinus*
Prairie Warbler	*Dendroica discolor*
Palm Warbler	*Dendroica palmarum*
Cerulean Warbler	*Dendroica cerulea*
Black-and-white Warbler	*Mniotilta varia*
American Redstart	*Setophaga ruticilla*
Worm-eating Warbler	*Helmitheros vermivorus*
Swainson's Warbler	*Limnothlypis swainsonii*
Ovenbird	*Seiurus aurocapillus*
Louisiana Waterthrush	*Seiurus motacilla*
Kentucky Warbler	*Oporornis formosus*
Common Yellowthroat	*Geothlypis trichas*
Hooded Warbler	*Wilsonia citrina*
Canada Warbler	*Wilsonia canadensis*
Yellow-breasted Chat	*Icteria virens*
Summer Tanager	*Piranga rubra*
Scarlet Tanager	*Piranga olivacea*
Northern Cardinal	*Cardinalis cardinalis*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Blue Grosbeak	*Guiraca caerulea*
Indigo Bunting	*Passerina cyanea*
Dickcissel	*Spiza americana*
Eastern Towhee	*Pipilo erythropthalmus*
Chipping Sparrow	*Spizella passerina*
Field Sparrow	*Spizella pusilla*

Order/Species	Scientific Name
Dark-eyed Junco	*Junco hyemalis*
Bobolink	*Dolichonyx oryzivorus*
Red-winged Blackbird	*Agelaius phoeniceus*
Eastern Meadowlark	*Sturnella magna*
Common Grackle	*Quiscalus quiscula*
Cedar Waxwing	*Bombycilla cedrorum*
Brown-headed Cowbird	*Molothrus ater*
Orchard Oriole	*Icterus spurius*
Baltimore Oriole	*Icterus galbula*
Purple Finch	*Carpodacus purpureus*
House Finch[*]	*Carpodacus mexicanus*
American Goldfinch	*Carduelis tristis*
House Sparrow[*]	*Passer domesticus*

Appendix 2. Common and scientific names of woody plants found on sampling points in grassland, shrub/pole, fragmented forest, and intact forest treatments.

		Treatment										
		Grassland			Shrub/pole		Fragmented Forest			Intact Forest		
Common Name	Scientific Name[a]	Can.	Dal.	Hob.	Can.	Hob.	Can.	Dal.	Hob.	Can.	Dal.	Hob.
American basswood	*Tilia americana*						x	x	x	x	x	x
American beech	*Fagus grandifolia*					x[b]	x	x	x	x	x	x
American chestnut	*Castanea dentata*						x		x	x	x	x
Common elderberry	*Sambucus canadensis*			x				x				
American elm	*Ulmus americana*							x			x	x
American hazelnut	*Corlyus americana*							x	x		x	x
American sycamore	*Platanus occidentalis*				x	x		x	x		x	
Autumn olive	*Elaegnus umbellata*	x	x	x	x			x				
Bicolor lespedeza	*Lespedeza bicolor*	x	x	x		x						
Bitternut hickory	*Carya cordiformis*						x	x	x		x	x
Blackberry/raspberry	*Rubus spp.*	x	x	x	x	x	x	x	x		x	x
Black birch	*Betula lenta*				x	x	x	x	x	x	x	x
Black cherry	*Prunus serotina*				x	x[b]	x		x		x	x
Black gum	*Nyssa sylvatica*				x		x	x	x	x	x	x
Black locust	*Robinia pseudoacacia*		x	x	x	x	x	x	x	x	x	x
Black oak	*Quercus velutina*					x	x	x	x	x	x	x
Blueberry	*Vaccinium spp.*				x		x	x	x			x
Black walnut	*Juglans nigra*							x	x		x	x
Box elder	*Acer negundo*					x						
Buffalo nut	*Pyrularia pubera*						x		x		x	
Chestnut oak	*Quercus prinus*							x	x	x	x	x
Cucumber magnolia	*Magnolia acuminata*					x[b]	x	x	x	x	x	x
Eastern hemlock	*Tsuga canadensis*						x		x	x	x	x
Eastern redbud	*Cercis canadensis*					x[b]	x	x	x		x	x
Eastern red cedar	*Juniperus virginiana*			x								
European black alder	*Alnus glutinosa*			x	x	x						
Flame Azalea	*Rhododendro calendulaceum*						x		x		x	x
Flowering dogwood	*Cornus florida*					x	x	x	x	x	x	x
Green ash	*Fraxinus pennsylvanica*				x	x	x	x	x	x	x	x
Greenbrier	*Smilax spp.*					x	x	x	x	x	x	x

Appendix 2. Continued.

		Treatment										
		Grassland			Shrub/pole		Fragmented Forest			Intact Forest		
Common Name	Scientific Name[a]	Can.	Dal.	Hob.	Can.	Hob.	Can.	Dal.	Hob.	Can.	Dal.	Hob.
Gray dogwood	*Cornus racemosa*							x				x
Hawthorn species	*Crataegus spp.*								x			
Hercule’s club	*Aralia spinosa*										x	
Honeysuckle	*Lonicera spp.*								x			
Ironwood	*Carpinus caroliniana*						x	x	x	x	x	x
Loblolly pine	*Pinus taeda*								x			
Multiflora rose	*Rosa multiflora*		x	x	x	x	x	x	x	x		x
Maple leaf viburnum	*Viburnum acerifolium*						x		x		x	x
Mockernut hickory	*Carya tomentosa*											x
Mountain laurel	*Kalmia latifolia*						x		x	x		x
Musclewood	*Ostyra virginiana*						x	x			x	x
Northern red oak	*Quercus rubra*						x	x	x	x	x	x
Ohio buckeye	*Aesculus glabra*							x				
Persimmon	*Diospyros virginiana*						x	x	x			
Pawpaw	*Asimina triloba*							x	x	x	x	x
Pignut hickory	*Carya glabra*						x	x	x	x	x	x
Pitch pine	*Pinus rigida*				x							
Poison ivy	*Toxicodendron radicans*				x	x	x	x		x	x	x
Princess tree	*Paulownia tomentosa*		x		x							
Red maple	*Acer rubrum*			x	x	x	x	x		x	x	x
Red mulberry	*Morus rubra*										x	
Red pine	*Pinus resinosa*				x							
River birch	*Betula nigra*							x	x			
Rhododendron	*Rhododendron maximum*						x					
Sassafras	*Sassafras albidum*						x	x	x	x	x	x
Scarlet Oak	*Quercus coccinea*						x	x	x		x	x
Scotch pine	*Pinus sylvestris*			x	x							
Serviceberry	*Amelanchier spp.*				x		x	x	x		x	x
Shagbark hickory	*Carya ovata*						x	x	x	x	x	x
Slippery elm	*Ulmus rubra*						x	x	x	x	x	x
Smooth Sumac	*Rhus glabra*				x							
Spicebush	*Lindera benzoin*						x			x	x	x

Appendix 2. Continued.

		Treatment										
		Grassland			Shrub/pole		Fragmented Forest			Intact Forest		
Common Name	Scientific Name[a]	Can.	Dal.	Hob.	Can.	Hob.	Can.	Dal.	Hob.	Can.	Dal.	Hob.
Sourwood	*Oxydendrum arboreum*			x	x	x	x	x	x	x	x	x
Staghorn sumac	*Rhus typhina*					x[b]					x	
Sugar maple	*Acer saccharum*				x	x	x	x	x	x	x	x
Sweetgum	*Liquidambar styraciflua*				x					x	x	x
Tree of heaven	*Ailanthus altissima*				x	x	x	x	x		x	x
Tuliptree	*Liriodendron tulipifera*				x	x[b]	x	x	x	x	x	x
Umbrella magnolia	*Magnolia tripetala*						x	x	x	x	x	x
Virginia Creeper	*Parthenocissus quinquefolia*						x	x	x	x	x	x
Virginia pine	*Pinus virginiana*				x				x			
White ash	*Fraxinus americana*			x		x[b]	x	x	x	x	x	x
White oak	*Quercus alba*						x	x	x	x	x	x
White pine	*Pinus strobus*			x	x	x						
Wild grape	*Vitis spp.*				x					x	x	x
Willow species	*Salix spp.*			x								
Witchhazel	*Hamamelis virginiana*						x	x	x	x	x	x
Wild hydrangea	*Hydrangea arborescens*						x	x	x	x	x	x
Wild rose	*Rosa spp.*										x	
Winged sumac	*Rhus copallina*					x	x		x		x	
Yellow birch	*Betula allegheniensis*							x	x	x	x	x

[a] Nomenclature follows Strausbaugh and Core (1977).
[b] Species only found in the Mud River/Coal River watersheds at the Hill Fork site (a valleyfill associated with a contour mine).

Appendix 3. Mean abundance of songbird species and guilds in grassland, shrub/pole, fragmented forest, and intact forest treatments on the Hobet and Daltex mine sites in 1999.

	Treatment						
	Grasslands		Shrub/pole	Fragmented Forest		Intact Forest	
Species/Guild	Hobet	Daltex	Hobet	Hobet	Daltex	Hobet	Daltex
Forest Interior Species							
Acadian Flycatcher	0.00	0.00	0.17	1.05	0.50	1.00	1.50
Black-throated Green Warbler	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Blue-headed Vireo	0.00	0.00	0.00	0.20	0.50	0.39	0.63
Cerulean Warbler	0.00	0.00	0.00	0.20	0.25	0.39	0.25
Eastern Wood-pewee	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Great Crested Flycatcher	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kentucky Warbler	0.00	0.00	0.17	0.30	0.25	0.18	0.63
Louisiana Waterthrush	0.00	0.00	0.00	0.10	0.00	0.18	0.13
Ovenbird	0.00	0.00	0.00	0.65	0.00	0.93	1.25
Pileated Woodpecker	0.00	0.00	0.00	0.20	0.00	0.00	0.00
Scarlet Tanager	0.00	0.00	0.00	0.25	0.00	0.04	0.38
Summer Tanager	0.00	0.00	0.00	0.10	0.25	0.11	0.13
Swainson's Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood Thrush	0.00	0.00	0.00	0.85	0.50	0.43	0.50
Worm-eating Warbler	0.00	0.00	0.00	0.10	0.00	0.18	0.25
Yellow-throated Warbler	0.00	0.00	0.00	0.05	0.00	0.11	0.00
Interior-edge Species							
American Redstart	0.00	0.00	0.50	0.25	0.25	0.46	0.75
American Robin	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Black-and-white Warbler	0.00	0.00	0.00	0.30	0.25	0.29	0.00
Black-capped Chickadee	0.00	0.00	0.00	0.05	0.00	0.04	0.00
Blue-gray Gnatcatcher	0.00	0.00	0.00	0.05	0.00	0.04	0.00
Carolina Chickadee	0.00	0.00	0.00	0.40	0.50	0.43	0.38
Carolina Wren	0.00	0.00	0.17	0.35	0.50	0.36	0.75
Dark-eyed Junco	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Downy Woodpecker	0.00	0.00	0.00	0.05	0.25	0.04	0.13
Eastern Phoebe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Towhee	0.05	0.00	0.50	0.00	0.00	0.00	0.00
Hairy Woodpecker	0.00	0.00	0.00	0.00	0.00	0.14	0.00

Appendix 3. Continued.

	Treatment						
	Grasslands		Shrub/pole	Fragmented Forest		Intact Forest	
Species/Guild	Hobet	Daltex	Hobet	Hobet	Daltex	Hobet	Daltex
Hooded Warbler	0.00	0.00	0.33	0.20	0.00	0.29	0.88
Northern Flicker	0.00	0.00	0.00	0.10	0.00	0.07	0.00
Northern Parula	0.00	0.00	0.00	0.20	0.00	0.14	0.13
Red-bellied Woodpecker	0.00	0.00	0.00	0.00	0.25	0.11	0.00
Red-eyed Vireo	0.00	0.00	0.50	1.00	1.00	0.93	0.88
Ruby-throated Hummingbird	0.00	0.00	0.00	0.10	0.00	0.14	0.00
Tufted Titmouse	0.00	0.00	0.00	0.10	0.25	0.07	0.50
White-breasted Nuthatch	0.00	0.00	0.00	0.05	0.25	0.21	0.25
Yellow-billed Cuckoo	0.00	0.00	0.33	0.05	0.00	0.11	0.00
Yellow-throated Vireo	0.00	0.00	0.00	0.05	0.50	0.11	0.00
Edge Species							
American Crow	0.00	0.00	0.00	0.05	0.50	0.00	0.00
American Goldfinch	0.45	0.13	2.67	0.05	0.25	0.00	0.00
Baltimore Oriole	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blue Grosbeak	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blue Jay	0.05	0.00	0.00	0.10	0.00	0.04	0.00
Blue-winged Warbler	0.14	0.00	1.17	0.05	0.00	0.07	0.00
Brown Thrasher	0.09	0.13	0.17	0.00	0.00	0.00	0.00
Brown-headed Cowbird	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Cedar Waxwing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chipping Sparrow	0.00	0.00	0.17	0.00	0.00	0.00	0.00
Commom Yellowthroat	0.41	0.25	0.50	0.00	0.00	0.00	0.00
Eastern Bluebird	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Field Sparrow	0.50	0.00	1.00	0.00	0.00	0.00	0.00
Golden-winged Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gray Catbird	0.00	0.00	0.17	0.00	0.00	0.00	0.00
Indigo Bunting	0.95	0.38	0.83	0.20	0.00	0.00	0.13
Mourning Dove	0.00	0.25	0.00	0.00	0.00	0.00	0.00
Northern Bobwhite	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Northern Cardinal	0.00	0.00	0.50	0.10	0.00	0.00	0.00
Orchard Oriole	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prairie Warbler	0.14	0.00	0.67	0.00	0.00	0.00	0.00

Appendix 3. Continued.

Species/Guild	Treatment: Grasslands Hobet	Grasslands Daltex	Shrub/pole Hobet	Fragmented Forest Hobet	Fragmented Forest Daltex	Intact Forest Hobet	Intact Forest Daltex
Song Sparrow	0.09	0.50	0.00	0.00	0.25	0.00	0.00
White-eyed Vireo	0.09	0.00	0.33	0.00	0.00	0.00	0.00
Yellow Warbler	0.36	0.13	0.33	0.00	0.00	0.00	0.00
Yellow-breasted Chat	0.32	0.00	0.67	0.00	0.00	0.00	0.00
Grassland Species							
Bobolink	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dickcissel	0.00	0.75	0.00	0.00	0.00	0.00	0.00
Eastern Meadowlark	0.59	0.75	0.00	0.00	0.00	0.00	0.00
Grasshopper Sparrow	2.27	2.13	0.33	0.00	0.00	0.00	0.00
Henslow's Sparrow	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horned Lark	0.41	0.13	0.00	0.00	0.00	0.00	0.00
Red-winged Blackbird	1.23	1.75	0.00	0.00	0.00	0.00	0.00
Vesper Sparrow	0.05	0.13	0.00	0.00	0.00	0.00	0.00
Willow Flycatcher	0.18	0.00	0.00	0.00	0.00	0.00	0.00
Habitat Guilds							
Grassland	4.09	5.00	0.33	0.00	0.00	0.00	0.00
Edge	2.86	1.25	6.67	0.35	0.25	0.14	0.13
Interior-edge	0.05	0.00	1.50	2.95	3.75	2.39	3.25
Forest Interior	0.09	0.50	1.00	2.80	2.00	3.93	5.00
Nesting Guilds							
Ground	3.45	4.00	2.50	1.55	1.00	1.82	2.50
Shrub	3.50	2.63	5.50	0.45	0.25	0.29	1.00
Subcanopy	0.00	0.00	1.67	3.10	2.50	2.86	3.75
Canopy	0.05	0.00	0.00	0.80	0.75	0.96	0.75
Cavity	0.00	0.00	0.00	0.75	1.50	0.93	1.00
Total	8.32	7.38	12.17	7.75	6.75	8.00	10.38
Richness	5.50	4.25	9.17	6.70	6.75	6.57	8.63

Appendix 4. Mean abundance of songbird species and guilds in grassland, shrub/pole, fragmented forest, and intact forest treatments on the Hobet, Daltex, and Cannelton mines in 2000.

	Treatment										
	Grasslands			Shrub/pole		Fragmented Forest			Intact Forest		
Species	Hobet	Daltex	Cannelton	Hobet	Cannelton	Hobet	Daltex	Cannelton	Hobet	Daltex	Cannelton
Forest Interior Species											
Acadian Flycatcher	0.00	0.00	0.00	0.06	0.00	0.90	0.50	1.00	1.40	1.12	1.50
Black-throated Green Warbler	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.50	0.10	0.24	0.20
Blue-headed Vireo	0.00	0.00	0.00	0.00	0.00	0.05	0.17	0.50	0.30	0.24	0.70
Cerulean Warbler	0.00	0.00	0.00	0.06	0.00	0.35	0.17	0.30	0.35	0.24	0.60
Eastern Wood-pewee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
Great Crested Flycatcher	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
Kentucky Warbler	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.40	0.24	0.00
Louisiana Waterthrush	0.00	0.00	0.00	0.00	0.00	0.25	0.17	0.10	0.05	0.12	0.00
Ovenbird	0.00	0.00	0.00	0.06	0.00	0.75	0.17	0.60	1.25	1.35	1.50
Pileated Woodpecker	0.00	0.00	0.10	0.00	0.00	0.05	0.17	0.10	0.10	0.06	0.00
Scarlet Tanager	0.00	0.00	0.00	0.12	0.06	0.45	0.00	0.20	0.70	0.53	0.90
Summer Tanager	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.15	0.06	0.20
Swainson's Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Wood Thrush	0.00	0.00	0.00	0.00	0.00	0.55	0.17	0.10	0.70	0.41	0.90
Worm-eating Warbler	0.00	0.00	0.00	0.00	0.00	0.25	0.17	0.10	0.15	0.12	0.30
Yellow-throated Warbler	0.00	0.00	0.00	0.00	0.00	0.20	0.33	0.00	0.10	0.00	0.20
Interior-edge Species											
American Redstart	0.00	0.00	0.00	0.12	0.00	0.20	0.33	0.30	0.85	0.65	0.80
American Robin	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.10
Black-and-white Warbler	0.00	0.00	0.00	0.06	0.00	0.25	0.33	0.30	0.35	0.29	0.40
Black-capped Chickadee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Blue-gray Gnatcatcher	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.06	0.00
Carolina Chickadee	0.06	0.00	0.00	0.12	0.44	0.35	1.00	0.20	0.25	0.18	0.50
Carolina Wren	0.00	0.00	0.00	0.06	0.00	0.25	0.17	0.10	0.10	0.06	0.00
Dark-eyed Junco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Downy Woodpecker	0.00	0.00	0.00	0.18	0.19	0.20	0.33	0.40	0.00	0.00	0.00
Eastern Phoebe	0.00	0.00	0.00	0.12	0.19	0.00	0.00	0.00	0.00	0.06	0.10
Eastern Towhee	0.17	0.00	0.00	0.53	1.00	0.00	0.00	0.00	0.05	0.00	0.00

Appendix 4. Continued.

	Treatment										
	Grasslands			Shrub/pole		Fragmented Foresr			Intact Forest		
Species	Hobet	Daltex	Cannelton	Hobet	Cannelton	Hobet	Daltex	Cannelton	Hobet	Daltex	Cannelton
Hairy Woodpecker	0.00	0.00	0.00	0.12	0.06	0.05	0.17	0.00	0.15	0.06	0.00
Hooded Warbler	0.00	0.00	0.00	0.00	0.06	0.10	0.00	0.30	0.60	0.53	0.60
Northern Flicker	0.00	0.00	0.10	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.10
Northern Parula	0.00	0.00	0.00	0.00	0.06	0.35	0.00	0.60	0.05	0.06	0.30
Red-bellied Woodpecker	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.10	0.12	0.00
Red-eyed Vireo	0.06	0.00	0.00	0.24	0.63	1.70	1.67	1.80	1.40	1.24	1.60
Ruby-throated Hummingbird	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tufted Titmouse	0.00	0.00	0.00	0.12	0.06	0.30	0.33	0.20	0.20	0.35	0.10
White-breasted Nuthatch	0.00	0.00	0.00	0.00	0.06	0.25	0.00	0.20	0.20	0.18	0.00
Yellow-billed Cuckoo	0.06	0.00	0.00	0.00	0.13	0.25	0.00	0.00	0.00	0.00	0.00
Yellow-throated Vireo	0.00	0.00	0.00	0.00	0.00	0.20	0.33	0.20	0.10	0.12	0.10
Edge Species											
American Crow	0.00	0.00	0.00	0.06	0.12	0.00	0.00	0.00	0.00	0.00	0.00
American Goldfinch	0.28	0.25	0.20	0.53	0.56	0.10	0.50	0.00	0.05	0.00	0.00
Baltimore Oriole	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00
Blue Grosbeak	0.06	0.33	0.10	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Blue Jay	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.10	0.12	0.10
Blue-winged Warbler	0.00	0.00	0.00	0.53	0.44	0.00	0.00	0.00	0.00	0.00	0.00
Brown Thrasher	0.17	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Brown-headed Cowbird	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.25	0.12	0.00
Cedar Waxwing	0.28	0.00	0.00	0.18	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Chipping Sparrow	0.00	0.00	0.00	0.24	0.31	0.00	0.00	0.00	0.00	0.00	0.00
Common Yellowthroat	0.22	0.17	0.00	0.88	0.69	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Bluebird	0.00	0.08	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Field Sparrow	1.06	0.33	0.40	1.35	1.19	0.00	0.00	0.00	0.00	0.00	0.00
Golden-winged Warbler	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Gray Catbird	0.00	0.00	0.00	0.18	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Indigo Bunting	1.00	0.83	1.10	1.47	1.94	0.15	0.50	0.10	0.00	0.18	0.00
Mourning Dove	0.11	0.08	0.00	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Northern Bobwhite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Cardinal	0.06	0.00	0.00	0.12	0.38	0.05	0.67	0.10	0.00	0.12	0.00
Orchard Oriole	0.06	0.00	0.10	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 4. Continued.

	Treatment										
	Grasslands			Shrub/pole		Fragmented Foresr			Intact Forest		
Species	Hobet	Daltex	Cannelton	Hobet	Cannelton	Hobet	Daltex	Cannelton	Hobet	Daltex	Cannelton
Prairie Warbler	0.39	0.00	0.20	1.06	1.25	0.00	0.00	0.00	0.00	0.00	0.00
Song Sparrow	0.11	0.58	0.00	0.00	0.19	0.05	0.00	0.00	0.00	0.00	0.00
White-eyed Vireo	0.17	0.00	0.00	0.41	0.50	0.00	0.17	0.00	0.00	0.00	0.00
Yellow Warbler	0.17	0.00	0.00	0.53	0.00	0.00	0.17	0.00	0.00	0.00	0.00
Yellow-breasted Chat	0.28	0.08	0.00	1.24	1.44	0.10	0.00	0.00	0.00	0.00	0.00
Grassland Species											
Bobolink	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dickcissel	0.00	0.33	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Meadowlark	0.39	0.75	0.70	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Grasshopper Sparrow	3.11	2.67	3.00	0.35	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Henslow’s Sparrow	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horned Lark	0.17	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-winged Blackbird	0.56	1.33	0.30	0.65	0.06	0.05	0.00	0.00	0.00	0.00	0.00
Willow Flycatcher	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Habitat Guilds											
Grassland	3.78	4.50	4.20	1.00	0.31	0.05	0.00	0.00	0.00	0.00	0.00
Edge	3.67	2.17	1.90	6.24	6.69	0.45	1.33	0.10	0.25	0.29	0.10
Interior-edge	0.56	0.17	0.10	1.88	3.06	3.45	3.50	3.00	3.00	2.29	3.10
Forest Interior	0.00	0.00	0.10	0.53	0.19	3.60	2.17	3.50	5.80	4.82	7.00
Nesting Guilds											
Ground	3.61	3.83	3.90	2.29	2.25	1.85	0.83	1.00	2.20	1.94	2.20
Shrub	4.06	3.17	2.10	6.24	6.31	0.55	1.33	0.30	0.60	0.71	0.60
Subcanopy	0.22	0.00	0.10	0.76	1.13	2.25	2.83	2.50	3.05	2.35	3.80
Canopy	0.00	0.00	0.00	0.18	0.13	2.15	1.67	2.50	2.80	1.94	3.50
Cavity	0.06	0.08	0.20	0.65	0.88	1.20	1.67	0.90	0.95	0.88	0.70
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	9.17	8.33	6.60	12.18	12.88	9.60	9.17	8.40	10.85	9.18	11.90
Richness	6.00	5.00	3.50	9.00	9.75	8.05	7.00	6.90	8.15	7.24	8.60

Appendix 5. Mean abundance of raptor species for each treatment (GR=grassland; SH=shrub/pole; FR=fragmented forest; IN=intact forest) on each of the 3 mines.

	Cannelton				Daltex			Hobet			
Species	GR	SH	FR	IN	GR	FR	IN	GR	SH	FR	IN
Overall Abundance	0.75	0.48	0.08	0.17	0.75	0.18	0.05	0.83	0.18	0.28	0.33
American Kestrel	0.03	0.00	0.00	0.00	0.15	0.00	0.00	0.03	0.00	0.00	0.00
Peregrine Falcon	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cooper's Hawk	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accipiter spp.[a]	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Harrier	0.10	0.02	0.00	0.00	0.10	0.00	0.00	0.05	0.00	0.00	0.00
Red-tailed Hawk	0.08	0.02	0.03	0.00	0.05	0.05	0.03	0.05	0.02	0.13	0.08
Red-shouldered Hawk	0.00	0.00	0.05	0.17	0.00	0.03	0.00	0.00	0.05	0.03	0.10
Eastern Screech Owl	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.02	0.00	0.00
Barred Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Turkey Vulture	0.50	0.43	0.00	0.00	0.45	0.03	0.00	0.70	0.10	0.13	0.13
Unknown	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00

[a]Either Sharp-shinned Hawk or Cooper's Hawk.

Appendix 6. Small mammal richness and abundance on each mine in grassland, shrub/pole, fragmented forest and intact forest treatments.

	Mine										
	Cannelton				Daltex			Hobet			
	GR[a]	SH	FR	IN	GR	FR	IN	GR	SH	FR	IN
Species Richness											
1999	-	-	-	-	2.0	1.8	2.5	1.6	-	1.8	2.2
2000	1.0	2.0	1.8	2.0	1.8	1.3	1.0	1.5	1.3	1.5	1.3
Relative Abundance											
Total											
1999	-	-	-	-	18.0	11.3	22.0	15.6	-	13.3	12.0
2000	33.0	25.1	12.1	22.7	8.9	6.2	4.1	22.3	18.2	6.0	2.9
Peromyscus species											
1999	-	-	-	-	13.1	10.0	19.4	14.1	-	11.1	8.7
2000	33.0	21.5	8.0	20.0	4.1	5.6	4.1	21.5	17.6	5.5	2.9
House mouse											
1999	-	-	-	-	4.9	0.0	0.0	0.9	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Woodland jumping mouse											
1999	-	-	-	-	0.0	0.0	0.0	0.0	-	0.9	0.0
2000	0.0	0.0	4.1	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meadow vole											
1999	-	-	-	-	0.0	0.0	0.0	0.1	-	0.0	0.0
2000	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Short-tailed shrew											
1999	-	-	-	-	0.0	1.0	1.9	0.4	-	0.9	2.1
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Eastern chipmunk											
1999	-	-	-	-	0.0	0.3	0.0	0.0	-	0.9	1.2
2000	0.0	0.0	0.0	0.4	0.0	0.3	0.0	0.1	0.0	0.0	1.3

Appendix 6. Cont.

	Mine										
	Cannelton				Daltex			Hobet			
	GR[a]	SH	FR	IN	GR	FR	IN	GR	SH	FR	IN
Eastern woodrat											
1999	-	-	-	-	0.0	0.0	0.0	0.0	-	0.0	0.0
2000	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
Southern bog lemming											
1999	-	-	-	-	0.0	0.0	0.0	0.0	-	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0
Masked shrew											
1999	-	-	-	-	0.0	0.0	0.4	0.0	-	0.1	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Virginia opossum											
1999	-	-	-	-	0.0	0.0	0.0	0.0	-	0.4	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Eastern cottontail											
1999	-	-	-	-	0.0	0.0	0.0	0.1	-	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0

[a] GR=grassland; SH=shrub/pole; FR=fragmented forest; IN=intact forest.

UPDATE to the Wood et al. 2001 TERRESTRIAL STUDIES REPORT

January 2002

Introduction

The following document summarizes data collected in 2001 and additional analyses of the data collected in 1999-2000 that was not included in the original report. Note that additional analyses for the raptor data are not included here because a master's thesis (Balcerzak 2001) has already been submitted with these data. The sections included in this update are as follows:

A. Species-Specific Logistic Regression Models

Regression models were developed for grassland and edge species as requested in the review of the original report. Reclaimed mines are providing habitat for these species, although we do not know if populations are breeding successfully. Models for grassland species indicate that dense vegetation is not suitable habitat, therefore, reclaimed grasslands will not remain suitable for these species without active management. Models were developed for additional interior-edge and forest-interior species.

B. Grasshopper Sparrow Habitat and Nesting Success

Additional data collected in 2001 confirm that reclaimed grassland habitats provide suitable breeding habitat for Grasshopper Sparrows as long as vegetation does not become too dense.

C. Small Mammal Sherman Trapping Data

Additional analyses of the 1999 and 2000 small mammal data suggest higher productivity for *Peromyscus* species within the reclaimed grassland habitats. Abundance was negatively related to bareground.

D. Small Mammal Data from Herp Arrays

Additional species were captured in pitfall traps associated with arrays (particularly shrews) resulting in greater species richness within the reclaimed habitats. For woodland jumping mice and short-tailed shrews, abundance was greater in fragmented forests, similar to findings from the sherman trap data.

E. Herpetofaunal Surveys

The two years of data showed similar trends to those reported in the original report for the 1-year data set.

F. Appendix A-1. Changes to the Wood et al. 2001 MTMVF terrestrial report

Logistic regression models were updated and none of the species tested showed negative relationships with distance to edges.

A. Species-Specific Logistic Regression Models

In the final report we included species-specific logistic regression models for several forest-interior species listed as species of concern by Partners in Flight (PIF). Here we provide habitat models for 32 additional species: 6 grassland, 13 edge species, and 13 forest species.

In response to review comments from the W. Va. Coal Association, we are adding more information on grassland and early successional species that were detected on MTMVF mines. Many of these species are known to be declining in all or part of their breeding range (Sauer et al. 2001), and MTMVF mines may provide habitat for these species in a region that is dominated by mature forest habitat. We present findings on 6 grassland species: Dickcissel, Grasshopper Sparrow, Eastern Meadowlark, Red-winged Blackbird, Horned Lark, and Willow Flycatcher, and 13 edge species: White-eyed Vireo, Yellow-breasted Chat, Prairie Warbler, Blue-winged Warbler, Common Yellowthroat, Yellow Warbler, Indigo Bunting, Northern Cardinal, American Goldfinch, Song Sparrow, Chipping Sparrow, Field Sparrow, and Eastern Towhee.

Of the grassland species, the Dickcissel was found to be declining significantly range-wide from 1966-2000 by the Breeding Bird Survey (BBS), but the species was not detected on any routes in West Virginia (Sauer et al. 2001). All of the other species, except the Willow Flycatcher, were found to be declining in West Virginia and range-wide. Willow Flycatcher populations appear to be stable both in West Virginia and range-wide. Of the edge species, the BBS found the Prairie Warbler, Common Yellowthroat, Indigo Bunting, American Goldfinch, and Eastern Towhee to be declining significantly in West Virginia and range-wide. White-eyed Vireo, Yellow Warbler, Blue-winged Warbler, and Northern Cardinal populations appear to be stable both in West Virginia and range-wide. The Yellow-breasted Chat and Chipping Sparrow appear to be declining in West Virginia, whereas populations are stable range-wide (Sauer et al. 2001). The Song Sparrow is declining range-wide, but populations appear stable in West Virginia.

Additional models for 13 forest species also are included in this report. Of the 13 species analyzed, 8 are interior-edge species and 5 are forest-interior species. The interior-edge species analyzed were: American Redstart, Carolina Chickadee, Northern Parula, Carolina Wren, Downy Woodpecker, Tufted Titmouse, Red-bellied Woodpecker, and White-breasted Nuthatch. The forest-interior species were: Black-throated Green Warbler, Ovenbird, Pileated Woodpecker, Yellow-throated Warbler, and Summer Tanager. Of these species, 6 are considered “residents” (i.e. they do not migrate for the winter): Carolina Chickadee, Carolina Wren, Downy Woodpecker, Pileated Woodpecker Red-bellied Woodpecker, Tufted Titmouse, and White-breasted Nuthatch.

Methods

We modeled habitat preferences of these additional species using stepwise logistic regression (Stokes et al. 1995). The significance level for entry and staying in the model was P=0.15. The Hosmer-Lemeshow goodness-of-fit test was used to determine the validity of the models. Models that failed the goodness-of-fit test (P<0.10) were considered invalid (Stokes et al. 1995). These are the same methods used for examining forest-interior and interior-edge species in the final report. For grassland and edge species, analyses included only points in the grassland and shrub/pole treatments. We developed models for species detected at ≥10% of these sampling points. Both treatments were included in the development of the models because some grassland birds were detected in shrub/pole habitat and some edge birds were detected in grassland habitat. Habitat variables included in models for grassland species were: aspect code, slope, distance to minor edge, distance to habitat edge, height of grass/forbs, litter depth, Robel pole index, elevation, density of trees >0-2.5 cm, >2.5-8 cm, and >8-23 cm, and all ground cover variables. These variables also were used in models for edge species, along with density of trees >23-38 cm, and density of snags. Density of larger trees were excluded from models because no trees >38 cm were found in these habitats, and no snags were found in the grassland habitat.

For the 13 additional forest species (interior-edge and forest-interior species), we used the same methods and variables as we used for the species in the final report and as described above for the grassland and edge species.

Results and Discussion

Grassland Species and Edge Species

Grassland Species

Dickcissel

We found Dickcissel presence to be positively correlated to distance from habitat edge, Robel pole index, and bareground/rock cover (Table 1). This indicates that Dickcissels prefer areas far from edge, that have a high biomass of green vegetation, with some areas of bareground. Zimmerman (1971) determined that Dickcissels prefer old fields over prairies for nesting, presumably because of the taller vegetation, greater forb cover, and higher amounts of vegetation in old fields. We found similar results, because Dickcissels were related positively to Robel pole index, which is an indicator of biomass. As stated in the Final Report, Dickcissels may be expanding their range eastward and MTMVF mines may provide habitat for them. However, it is unknown if these birds are breeding on MTMVF mines.

Grasshopper Sparrow

Grasshopper Sparrow presence was negatively correlated to density of trees >8-23 cm (Table 1). This species prefers moderately open grassland and generally avoids areas with extensive shrub cover (Vickery 1996). They also appear to prefer areas with sparse vegetation and greater bareground cover (Vickery 1996). This was the most common species we encountered on the grassland treatment, occurring at 99% of point counts. Further information on Grasshopper Sparrow populations is reported elsewhere in this report.

Eastern Meadowlark

Presence of this species was negatively correlated to both density of trees >2.5-8 cm and shrub cover (Table 2). This species uses a variety of grassland situations, including pastures, savannas, hay fields, roadsides, airports, and golf courses (Lanyon 1995). It appears to prefer areas with high grass and litter cover (Wiens and Rotenberry 1981). Our results indicate that the species prefers grassland areas that are more open with few trees or shrubs present. MTMVF mines provide habitat for this species for several years after reclamation, but as succession proceeds on the mines these areas will become unfavorable for them.

Red-winged Blackbird

Red-winged Blackbird occurrence was negatively correlated to shrub cover on our study areas (Table 2). Red-winged Blackbirds are found in a variety of habitats, such as field edges, marshes, roadsides, old fields, ditches, and pastures (DeGraaf and Rappole 1995). We commonly observed Red-winged Blackbirds in grasslands near created wetlands, stands of cattail *(Typha* spp.), and valleyfills on the mines. MTMVF mines appear to provide a considerable amount of habitat for this species, especially along the periphery of created wetlands.

Horned Lark
No habitat variables were selected by stepwise logistic regression to predict the presence of Horned Larks (Table 3). Horned Larks prefer open, barren areas with few trees and a minimum of vegetation (DeGraaf and Rappole 1995). We observed them most frequently in and along the roads on the mines. All detections of this species were at the Hobet and Daltex mines. Although presence was not related to any habitat variables, the species generally was present in areas with low tree densities (Table 3). Because Horned Larks prefer barren areas with little vegetation, MTMVF mines likely provide significant habitat for them during a short time span after reclamation, before grasses and forbs begin to develop a dense ground cover. After ground cover is established, Horned Larks will likely continue to use roads and barren areas on the mines.

Willow Flycatcher
No variables were selected by stepwise logistic regression for predicting the occurrence of Willow Flycatchers (Table 3). All of our detections of Willow Flycatchers were at the Hobet mine in blocks of autumn olive. Because none of our point counts were placed in blocks of autumn olive, we may not have been able to accurately determine the habitat factors important for predicting Willow Flycatcher presence. The edges of some autumn olive blocks were sampled during vegetation surveys, but entire blocks were never completely within a 50-m radius of the point count center. DeGraaf and Rappole (1995) report that the species occurs in a variety of habitats, including brushy fields, willow thickets, streamsides, shelterbelts, and woodland edges. However, they appear to prefer thickets or groves surrounded by grasslands, which is what we observed on the MTMVF sites. Based on our observations, it appears MTMVF mining will only provide habitat for this species if areas are planted with high densities of autumn olive. However, autumn olive is not a native plant and can become invasive and a nuisance; it is no longer recommended for planting in several counties.

Edge Species

White-eyed Vireo
We found the White-eyed Vireo to be positively related to density of trees >0-2.5 cm (Table 4), which is an expected result since this species prefers areas with low shrubby vegetation or brushy woodlands (DeGraaf and Rappole 1995). Denmon (1998) also found this species to be more abundant in areas with high shrub/sapling/pole density.

Yellow-breasted Chat
This species was found to be negatively associated to distance to habitat edge, and positively related to density of trees >0-2.5 cm and forb cover (Table 4). However, the logistic regression model failed the Hosmer-Lemeshow goodness-of-fit test. Chats prefer dense, shrubby areas with few tall trees (DeGraaf and Rappole 1995). Denmon (1998) found the species occurred more frequently in areas with a high density of stems >0-7.6 cm, which confirms our results.

Prairie Warbler
Presence of Prairie Warblers was negatively related to slope and distance from habitat edge, and positively related to litter depth, density of trees >23-38 cm, and percent green ground cover (Table 5). This species prefers areas with dense low trees, especially areas with some conifers (DeGraaf and Rappole 1995, Denmon 1998). We detected this species mostly in

shrub/pole habitat, but it also was observed at grassland points where there were scattered shrubs and blocks of autumn olive nearby. MTMVF may provide more habitat for this species in the future if tree species return to areas reclaimed to grasses. However, the bird appears to prefer areas close to edge, and we often detected it along edges of forests. Thus, large, open expanses of grassland as occurs in MTMVF may be detrimental to the species.

Blue-winged Warbler

Blue-winged Warbler presence was positively associated with the density of trees >2.5-8 cm dbh (Table 5). Denmon (1998) observed this species more frequently in areas with a high density of trees from >0-7.6 cm and a low density of trees from 7.6-15 cm dbh. Thus, it appears from these results that Blue-winged Warblers are more likely to occur in areas where tree diameter growth has not yet reached 8 cm.

Common Yellowthroat

We found Common Yellowthroats to be positively related to density of trees >0- 2.5 cm and negatively related to density of trees >23-38 cm (Table 6). This species prefers areas with a mixture of small trees, and dense, herbaceous vegetation, typically in damp or wet situations (DeGraaf and Rappole 1995, Denmon 1998), and our results confirm this prediction. We commonly found them in shrubby areas around ponds on MTMVF mines (primarily Cannelton), along forest/mine edges, and in blocks of autumn olive.

Yellow Warbler

This species was detected more frequently at lower elevations and was positively related to litter cover (Table 6). It is a common and widespread species that prefers moist habitats (streamsides, bogs, swamps) with dense understories, typically of willow (*Salix* spp.) and alder (*Alnus* spp.) (DeGraaf and Rappole 1995). Denmon (1998) found a higher abundance of Yellow Warblers in grass/shrub-dominated habitat than in wooded, shrub-dominated, or thicket/shrub early successional habitats in West Virginia. Surprisingly, we did not detect this species on the Cannelton mine. It was observed most frequently at the Hobet mine in blocks of autumn olive, and it was detected in small wooded thickets at the Daltex mine. The Cannelton mine was at higher elevations than the other 2 mines, and this likely influenced the result showing this species to be negatively associated with elevation.

Indigo Bunting

This species was widely distributed, being observed at 86% of grassland and shrub/pole points combined, and at 94% of shrub/pole points alone. Stepwise logistic regression identified two variables, density of trees >2.5-8 cm and bareground/rock cover, as predictors of Indigo Bunting presence. They were positively correlated to tree density and negatively correlated to bareground/rock cover (Table 7). Indigo Buntings are found in a variety of edge situations: along roadsides, in brushy old fields, old burns, wooded clearings, and brushy ravines (DeGraaf and Rappole 1995). They typically build their nests in a shrub or small tree.

Northern Cardinal

The Northern Cardinal was positively associated with the density of trees >2.5-8 cm (Table 7). Similar results were found by Denmon (1998), who found Northern Cardinals more frequently in areas with high shrub/sapling/pole density. She also found them in higher abundances in thickets with dense shrubs and small trees than in grass/shrub, shrub, or wooded early successional habitats. These results indicate that Northern Cardinals prefer advanced successional stages when young trees begin to dominate, but before the trees become too big and shade out lower-growing vegetation.

American Goldfinch
No variables were chosen by stepwise logistic regression for predicting presence of the American Goldfinch (Table 8). The only variable found by Denmon (1998) to be related to American Goldfinch presence was density of trees >15.c cm, which was negatively related. Goldfinches typically use a variety of edge situations, including old fields and roadsides (DeGraaf and Rappole 1995).

Song Sparrow
This species was positively related to distance from habitat edge (Table 8). Of the points where this species was detected, 75% were at the Hobet and Daltex mines in grassland habitat, with a few low scattered trees and shrubs used for perching. Conversely, at the Cannelton mine, this species was only detected in shrub/pole habitat. Denmon (1998) only found herbaceous plant height to be positively related to Song Sparrow presence.

Chipping Sparrow
Chipping Sparrows were positively related to the density of trees >8-23 cm (Table 9), but the model failed the Hosmer-Lemeshow goodness-of-fit test and may not be valid.
This species prefers open, wooded areas, forest edges, and clearings (DeGraaf and Rappole 1995), and our results confirm that they prefer areas with some large trees present.

Field Sparrow
This species was positively associated with density of trees >2.5-8 cm and negatively associated with bareground/rock (Table 9). Approximately 42% of the detections for this species were in grassland habitat, and the other 57% in shrub/pole habitat. This species uses small trees for song perches and will nest in them after leaf-out (Best 1978). They typically nest in grasses and forbs earlier in the season (Best 1978), which may be one reason they prefer areas with less bareground/rock. Denmon (1998) found them in higher abundances in grass/shrub, and shrub-dominated habitat than in thickets and wooded areas.

Eastern Towhee
Eastern Towhees were positively correlated to density of trees >8-23 cm (Table 10). Our results agree with Greenlaw (1996) who reported that this species occupies areas characterized by dense shrubs and small trees and appears to favor mid- to late- stages of succession with greatest densities in thickets and open-canopy woodland situations.

In summary, our results indicate that MTMVF mines are providing habitat for grassland and early successional songbird species in West Virginia. Many of these species would be rare or absent from this region if MTMVF mines were not present (see final report). However, it is not known if these populations are breeding successfully on MTMVF mines. If reproductive success is low, then these mines could be acting as habitat sinks for these species.

Interior-edge and Forest-interior Species

Interior-edge species

American Redstart
Presence of this species was positively related to aspect code and negatively related to density of trees >2.5- 8 cm (Table 11). This is an adaptable species that breeds in a variety of forested situations including coniferous-deciduous woods, regenerating hardwoods, aspen groves, and shrubbery around farms and streams (DeGraaf and Rappole 1995). It is unlikely the MTMVF will have much affect on this species given the wide variety of habitats in which it will nest

Carolina Chickadee

Carolina Chickadee presence was positively related to trees >8-23 cm (Table 11). It is found in a variety of habitats, including deciduous woods, thickets, and suburban parks (Ehrlich et al. 1988). It is often seen near edges, and MTMVF mining could increase habitat for this species by increasing edge habitats.

Northern Parula

Northern Parula occurrence was positively associated with water cover and canopy cover >3-6 m and negatively associated with canopy cover >6-12 m (Table 12). This species is often associated with bottomlands, so it is not surprising that we found it to be related to water cover (DeGraaf and Rappole 1995). We commonly found this species near drainages in forested fragments and intact forest, and it does not appear to avoid edges.

Carolina Wren

Presence of this species was negatively related to aspect code and to density of trees 2.5 –8 cm (Table 12). This species is found in a variety of wooded situations, including brushy bottomlands, open deciduous woods, and parks (Ehrlich et al. 1988).

Downy Woodpecker

The occurrence of Downy Woodpeckers was positively associated to aspect code (Table 13). This bird is often found near edges and inhabits deciduous and mixed-deciduous stands, riparian stands, and parks (Ehrlich et al. 1988). MTMVF mining could potentially increase habitat for this species by increasing edge habitats, but the reduction in forest cover by MTMVF mining could also have a negative impact on the species.

Tufted Titmouse

Tufted Titmouse occurrence was positively associated with green ground cover (Table 13). Like the Carolina Chickadee and Downy Woodpecker, this species inhabits a variety of wooded situations, often being seen in parks, open deciduous woods, and edges (Ehrlich et al. 1995).

Red-bellied Woodpecker

The presence of this species was negatively associated to canopy cover >24m.
(Table 14). Red-bellied Woodpeckers primarily inhabit deciduous woods, but are also found on edges, in parks, and suburban situations (Ehrlich et al. 1988). Impacts of MTMVF mining on this species would likely be minimal because of its generalist nature.

White-breasted Nuthatch

No variables were selected by stepwise logistic regression for predicting the presence of this species (Table 14). Although this species is often found on edges and in suburban and park situations, it appears to prefer forests with large, old, decaying snags (Ehrlich et al. 1988). MTMVF mining could increase edge habitat for this species, but ultimately it could have negative effects on the species if large, dead snags are not present.

Forest-interior species

Ovenbird

Ovenbird presence was positively associated with bareground/rock cover and negatively associated with canopy cover from >3-6 m. (Table 15). This species prefers extensive, open, mature forests without thickets and tangles, with “an abundance of fallen leaves, logs and rocks” (DeGraaf and Rappole 1995), and our results agree with this assessment. This species was found to be less abundant in forests fragmented by MTMVF mining, and could be detrimentally impacted if MTMVF mining continues.

Black-throated Green Warbler

The Black-throated Green Warbler was negatively related to density of trees >8-23 cm (Table 15). DeGraaf and Rappole (1995) state that this species inhabits "large stands of mature open mixed woodlands (especially northern hardwood-hemlock stands)." Our observations agree with this assessment. We most frequently encountered Black-throated Green Warblers in stands of hardwoods intermixed with eastern hemlock, along streams in mature woods.

Pileated Woodpecker

The presence of the Pileated Woodpecker was negatively associated to canopy cover >24 m (Table 16). This large woodpecker prefers deciduous woods with large trees, but it also is found on edges and in parks and suburban situations (Ehrlich et al. 1988).

Yellow-throated Warbler

Presence of this species was negatively associated with aspect code, indicating a preference for drier slopes and ridges, and negatively associated with canopy cover from >12- 18 m (Table 16.) This species is often found along streams and rivers, typically in large, tall trees of bottomland hardwood forests, however, it also is often found in stands of pine, oaks, or mixed forests (DeGraaf and Rappole 1995). Most of our detections of this species were on ridge tops dominated by oak species.

Summer Tanager

No variables were selected by stepwise logistic regression for predicting the occurrence of Summer Tanagers (Table 17). This species is typically found in dry, open woodlands of oak, pine, and hickory in the southeast, but may also be found in bottomlands in the north (DeGraaf and Rappole 1995).

In summary, for most interior-edge species, MTMVF mining may have mixed impacts on their populations. MTMVF mining would create more edge for these species, but it would also decrease the amount of mature forest, which these species also require. The least-impacted species would likely be resident species such as the woodpeckers, chickadees, and titmice that use a variety of habitats. Forest-interior species would most likely be negatively impacted if the amount of forest cover continues to be reduced without any subsequent reforestation.

B. Grasshopper Sparrow Habitat and Nesting Success

Songbird species that require grassland and other early successional habitats were observed and documented on reclaimed MTRVF mines, some at relatively high densities Wood et al. (2001). Grasshopper sparrows (*Ammodramus savannarum*), in particular, were very abundant and were successfully breeding on the sites. However, nesting success data from 1999-2000 was limited and we felt that no conclusions could be drawn from the data. The objectives of this study are to continue examining habitat and nesting requirements and nesting success of Grasshopper Sparrow populations colonizing reclaimed MTRVF mine sites in southern West Virginia.

Methods

Study areas are the same three MTRVF mine sites in southwestern West Virginia that were investigated by Wood et al. (2001). The Hobet 21 mine is located in the Mud River watershed in Boone County, the Daltex mine is located in the Spruce Fork watershed in Logan County, and the Cannelton mine is located on the border of Kanawha and Fayette counties in the Twentymile Creek watershed. Two 40 ha sample plots were established on each mine complex, (Hobet Adkins (HA1), Hobet Sugar Tree (HN2), Daltex Rock house (DR1), Daltex Spruce Fork (DN2), Cannelton Lynch Fork (CL1), and Cannelton (CV2)) for a total of six search areas. Additional nest plots were established for nests found on mine complexes but not within sample plots, (Daltex off plot (DO1) and Hobet off plot (HO1)).

Adult male and female Grasshopper Sparrows were captured on each study site with mist nets and conspecific song playback from April 2001 to July 2001. All captured individuals were banded with Fish and Wildlife Service bands. Basic physical information (sex, weight, wing cord measurements, and overall condition) was recorded, and then each individual was marked with a unique combination of two colored plastic bands for future identification. Juveniles were similarly processed and marked with a single colored band prior to fledging from the nest.

Nest searching and habitat sampling methodologies are similar to those previously presented in Wood et al. (2001). Briefly, nest searching was conducted on two 40-ha nest search plots in reclaimed grassland areas of Hobet 21 (HA1 & HN2), Daltex (DR1 & DN2), and Cannelton (CL1 & CV2) mine sites for a total of six search areas. Eight fixed vegetation-sampling sub-plots were systematically selected and surveyed on each search plot (N=48) to examine differential nest site selection preferences in this species.

To obtain a good estimate of species-specific nest survival, a minimum of 20 nests must be monitored (Martin et al. 1997). Therefore, I set a target of 25-30 nests for Grasshopper Sparrows nesting in the grassland habitat of the study sites. Field personnel trained in proper searching and monitoring techniques (Martin and Geupel 1993) searched each nesting area every 3-4 days. Nest searching began one-half hour after sunrise and concluded 8-10 hr later (approximately 0600-1600 EST). Nest searching methods followed national BBIRD (Breeding Biology Research and Monitoring Database) protocols (Martin et al. 1997). To control for search effort, nests were located by systematically searching study plots.

All Grasshopper Sparrow nests found were monitored every 3-4 days (Martin et al. 1997) to confirm activity. Because Grasshopper Sparrow nests are typically well concealed within vegetation, they were marked for relocation using a staked flag placed at a minimum distance of 15m from the nest. Care was taken when monitoring the nest to avoid disturbing the female. When possible, nest searchers observed the nest from a distance of no less than 15 m for up to 30 min to confirm that it was still active. Each nest was approached and visually checked for contents a maximum of four times: once when it is initially found, once to confirm clutch size, once to confirm brood size, and once to confirm fledging success or failure. Nests were not approached when avian predators (e.g., American Crows and/or Blue Jays) were observed nearby because these birds are known to follow humans to nests (Martin et al. 1997). Observers also continued to walk in a straight line after visually observing nest contents to avoid leaving a dead-end scent trail directly to the nest that might be followed by mammalian predators (Martin et al. 1997). The vegetation concealing the nest was moved to the side using a wooden stick to avoid putting human scent on the nest if the vegetation blocks the observer's view of the contents.

A nest was considered successful if it fledged at least one young. Fledging success was confirmed by searching the area around the nest for fledglings or for parent-fledgling interactions. However, if no fledglings were observed, the nest was considered to have fledged young if the median date between the last active nest check and the final nest check when the nest was empty and was within two days of the predicted fledging date (Martin et al. 1997). Nest survival was calculated using the Mayfield method (Mayfield 1961, Mayfield 1975). Daily nest survival estimates were calculated for the incubation and brooding periods separately because there might be differential nest survival between these two periods. The overall daily survival rate was calculated as the product of incubation and brood daily survival. Survival during the egg-laying stage will not be included in the calculation of overall nest survival because few nests were located during this stage of the nesting cycle.

After each nest fledged or failed, vegetation within an 11.3 m radius circle surrounding the nest was sampled to determine habitat characteristics important to nest survival. We measured vegetation for each nest monitored using methods modified from James and Shugart (1970) and the Breeding Bird Research Database program (BBIRD; Martin et al. 1997). These included estimates of percent ground cover in nine cover types (grass/sedge, shrub/seedling, fern, moss, bare ground, forb/herbaceous, woody debris, litter, and water). Percent ground cover was estimated using an ocular sighting tube (James and Shugart 1970). The sight-tube was a 5.0-cm pvc pipe with cross-hairs at one end. Five sight-tube readings were taken on each subplot every 2.26 m along four, 11.3-m transects that intersected at the center of the subplot. The percentage of each cover type present in the sight-tube was estimated and recorded. Grass height and organic litter layer depth was measured at 13 locations along the 4 transects: at the center and at distances of 1 m, 3 m, and 5 m along each transect. A Robel pole (Robel et al. 1970) was used to calculate an index of vegetative cover and an index of biomass (Kirsch et al. 1978). Additional nest measurements including percent slope, slope orientation, nest height (cm), width and depth of nest rim and cup (cm), nest substrate height (vegetative and reproductive), and distance to foliage edge were surveyed to examine differences among individual nests. Habitat and nest variables were tested for differences among nests and habitat plots using one-way analysis of variance (ANOVA) (α=0.05) (Zar 1999).

Results and Discussion

A total of 202 Grasshopper Sparrows were captured, banded, and processed on the MTRVF study sites during the 2001 breeding season. Mist netting effort resulted in an overall capture rate of 0.25 captures per net hour with 193 captures in 785.63 hours (Table 18). Juveniles that were banded in and around nests (N=9) were not included in the mist net capture effort calculations. An additional 45 non-target individuals were captured on the study plots with the most common species including Eastern Meadowlark, Field Sparrow, Indigo Bunting, and Savannah Sparrow. Systematic searches of study plots produced 37 active Grasshopper Sparrow nests on the three mines surveyed. Overall nest search effort was one nest per 10.06 hours of effort for all sites combined (Table 19). Nests located off of the study plots (N=4) are not included in nest search effort because they were not located by systematically searching study areas. Mean clutch size (Table 19) for the surveyed nests was 3.73 $\pm$ 0.16 and is similar to those reported in the literature (Wray et al. 1982, Ehrlich et al. 1988).

Grasshopper sparrow nest survival for 2001 breeding season (30%) is comparable to survival rates previously reported on these study sites (36.4%) (Wood et al. 2001). Nest survival for this species reported from other areas has ranged from 7-41% as summarized in Wood et al. (2001).

Comparisons of habitat variables surrounding successful (n=17) and unsuccessful (n=20) nests (Table 20) indicate no significant differences among slope, aspect, distances to nearest minor edge, ground cover variables, grass height, and litter depth. Significant differences were detected in the Robel pole index at the nest (F=6.56, P=0.01) and at 1 meter from the nest (F=6.68 P=0.01). These analyses suggest that less dense vegetation near the nest may be an important factor in nest success.

Comparisons of habitat variables measured at nests (N=37) and at the fixed habitat plots (N=48) suggest differences in several of the ground cover estimates (Table 21). Percent green (F=574.53, P<0.0001) and percent grass (F=26.25, P=<0.0001) estimates were significantly lower at the nest plots while percent bare ground (F=24.73, P<0.0001), percent litter (F=7.65, P=0.01) and percent moss (F=3.05, P<0.0001) was significantly higher at nest plots. These findings support previous studies that suggest Grasshopper Sparrows require a high degree of bare ground associated with nesting sites for foraging (Whitmore 1979, Wray et al. 1982). Significant differences were also detected in the Robel pole index for all comparisons (all <0.0001), with nests placed where vegetation density was greater than generally available on the plot. No differences were detected in grass height comparisons except at the five-meter distance from sample plot centers (F=7.78, P=0.0056). Litter depth differed significantly between the fixed habitat plots and nest plots at all measured distances.

In summary, data suggest that the large reclaimed grassland habitats available on the mountaintop removal/valley fill mine complexes surveyed in this study are sufficient to support breeding populations of Grasshopper Sparrows with nest success rates similar to populations found in other grassland habitats. Important nesting habitat characteristics included patches of dense grassland vegetation interspersed with patches of bare ground. These habitat conditions support high densities of breeding Grasshopper Sparrows, even on newly reclaimed sites. As ground cover develops, however, sites will become unsuitable for Grasshopper Sparrows unless habitats are managed to maintain the required conditions.

C. Small Mammal Sherman Trapping Data

Additional analyses were completed on small mammal data collected through Sherman trapping to assess differences in habitat quality among treatments, as abundance alone is not necessarily a reliable indicator of habitat quality for a given species. Some studies have suggested that reclaimed lands may act as a population sink for *Peromyscus* and that adjacent unmined lands may provide superior breeding and foraging habitat (DeCapita and Bookout 1975). As a measure of habitat quality, we compared the proportion of adult *Peromyscus* spp. individuals that were in breeding condition among treatments (within a year) and between years (within a treatment) (Table 22), where mice weighing 16 g or more were considered adults (Whitaker and Hamilton 1998). In 1999, a significantly greater proportion of males and females were in reproductive condition in the grasslands than in either of the forest treatments. In 2000, only females had significant differences among the 4 treatments sampled; a lower percentage of individuals were in reproductive condition in the intact forest than in the other 3 treatments. These results generally followed the abundance trends, suggesting that reclaimed areas were not acting as population sinks on our study sites, but were actually more productive breeding sites than adjacent forests. Reclaimed areas appear to be better breeding habitat for *Peromyscus* probably due to their greater biomass of grasses, forbs, and invertebrates.

Reproductive condition differed between the 2 years of the study in the two forest treatments, but not in the grasslands. A higher proportion of both males and females in fragmented forest were in reproductive condition in 2000 than in 1999. In the intact forest, differences between the years were found in males but not in females. In all cases of between year differences, the proportion of reproductive individuals was greater in 2000 than in 1999, suggesting that the 1999 summer drought may have reduced the reproductive rates of *Peromyscus*, or that the moist and mild summer weather in 2000 may have improved conditions for breeding. These differences may have been a function of the greater plant biomass in 2000 than 1999.

Peromyscus spp. abundance was compared among treatments by age and sex groups (adult male, adult female, juvenile male, and juvenile female). In 1999, adult males were more abundant in grassland than in fragmented or intact forest and adult females were more abundant in grasslands than in intact forest (Table 23). In 2000, for adult males, adult females, and juvenile females, the grassland and shrub/pole treatments were similar, but had significantly greater abundances than fragmented forest and intact forest, which were also similar to each other. These differences, which followed overall *Peromyscus* abundance trends, suggested that early-successional areas (i.e. grassland and shrub/pole treatment) provided habitat that was superior to the forested areas. We also compared juvenile abundance, as it is an indicator of reproductive success of adults in a treatment. We found no differences among treatments in 1999, but in 2000, differences were found among treatments for both males and females. Juvenile males were more abundant in grasslands than in either forest treatment and greater in shrub/pole than in the fragmented forest treatment. Juvenile females were greater in the grassland and shrub/pole treatments than in the 2 forested treatments. As with adults, results generally followed overall *Peromyscus* abundance trends.

Habitat and environmental variables were used in regression analyses to identify factors that were predictive of small mammal richness and abundance. The grassland treatment was analyzed separately from the other three treatments in the regression procedures because it had several habitat variables not recorded in the other treatments due to considerably different vegetation structure. Stepwise multiple linear regression was used for *Peromyscus* spp. abundance, total small mammal abundance, and species richness, while logistic regression was performed on presence/absence data of less commonly captured species (house mice in grasslands and short-tailed shrews, woodland jumping mice, and eastern chipmunks in the other three treatments). In both types of regression, an entry level of 0.30 and a stay level of 0.10 was used. Environmental variables incorporated into the regression models included precipitation (cm) (National Oceanic and Atmospheric Administration/National Weather Service, Charleston, W. Va.) averaged over the 3-night trapping session, low temperature (°C) (NOAA/NWS, Charleston, W. Va.), moon phase expressed as a percentage of moon’s surface illuminated (Astronomical Applications Department, US Naval Observatory), and an index of nighttime ambient light. The ambient light index was calculated as a product of the percentage of the moon’s surface illuminated and cloud cover (NOAA/NWS, Charleston, W. Va.) on a scale of 1 (clear skies) to 0.1 (overcast). Habitat variables included those described in the original project report (Wood et al. 2001).

In multiple linear regression analysis for shrub/pole, fragmented forest and intact forest treatments, daily low temperature and precipitation were negatively related, and the percentage of bareground was positively related to species richness (Table 24). Relationships were weak as no single variable contributed a partial R^2 of more than 0.10. Several variables were significant predictors of total small mammal abundance. Of these, canopy cover from 0.5-3m was negatively related and contributed the most to the model (partial R^2 of 0.21). Canopy cover from 0.5-3m also was the most important predictor of *Peromyscus* spp. abundance, with a partial R^2 of 0.31. Generally, *Peromyscus* spp. had greater abundance at sites with less low canopy cover, lower canopy height, more bare ground, and when precipitation during the trapping period was not heavy.

Average grass height was the only variable related to richness in grasslands, based on multiple linear regression analysis; it was a positive relationship with a partial R^2 of 0.24 (Table 25). Areas with taller grass may have held more species because they provided better cover and more forage for small mammals. Three variables were positively related to total abundance, with the amount of green groundcover being the strongest (partial R^2 of 0.37). Precipitation was a positive predictor and the percentage of bareground was a negative predictor, though both relationships were weak. For *Peromyscus* spp. abundance, bareground had a strong negative relationship, with a partial R^2 of 0.45. It is likely that *Peromyscus* spp. avoid areas of bareground to avoid exposure to predators. In addition, precipitation and the number of shrub stems were weakly positive predictors of *Peromyscus* spp. presence.

Presence of short-tailed shrews in shrub/pole, forest fragment, and intact forest treatments, was positively related to the percentage of bare ground in the logistic regression model (Table 26). This was contrary to expectations as shrews generally seek cover (Whitaker and Hamilton 1998). Moon illumination had a negative relationship with the presence of woodland jumping mice, while water as a groundcover and canopy cover from 0.5-3m had a positive relationship. Many small mammals species are less active when the moon is bright, presumably to avoid predation (Kaufman and Kaufman 1982). For chipmunk presence, there were 4 variables that contributed significantly to the regression model. Water as a groundcover had a negative relationship, and bareground, canopy cover above 12m, and stem density of trees from 8-38 cm DBH had positive relationships with abundance. The preference for larger, taller trees may be due to their reliance on mast as a food source. In the grassland treatment, average grass height was the only significant variable; it was a positive predictor for the presence of house mice.

D. Small Mammal Data from Herp Arrays

Small mammals were trapped in pitfall and funnel traps associated with drift-fence arrays targeting herpetofauna. Estimates of species richness and abundance of 9 species were calculated based on 13 trapping sessions conducted between March 2000 -October 2001. An Analysis of Variance (ANOVA) model was used to detect differences among treatments. The model included treatment and trapping session as its main factors and a treatment by session interaction term. If the ANOVA found that means were different, a Waller-Duncan k-ratio t-test was used to compare means among treatments.

Species richness and total small mammal abundance were significantly lower in the intact forest treatment than in the other 3 treatments. Richness estimates conflicted with those from Sherman trapping which did not differ among treatments in either 1999 or 2000 and were generally much lower than array estimates. The difference between the 2 estimates is most likely due to the fact that Sherman trapping is not effective at capturing *Sorex* spp. because shrews generally are not heavy enough to spring Sherman traps; also, as insectivores, they are less likely to be attracted to the peanut butter and oat bait. For this reason, the estimates of richness from the drift-fence arrays are likely to be a more accurate reflection of the species present in each treatment (Kirkland 1994). Differences in total small mammal abundance among treatments also was not in agreement with results from Sherman trapping, in which the 2 reclaimed treatments were similar to each other and greater than the 2 forest treatments, which were also similar to each other. The reason for the difference in total abundance trends between methods was that *Peromyscus* spp. dominated Sherman trapping results (87% of captures), driving trends in total abundance. Differences between the methods are expected, as trapping methods have been shown to affect capture rates of species (Kirkland 1994). Sherman trapping is more effective for catching mice than drift fence arrays because Sherman traps are baited. For this reason, Sherman trapping resulted in many more *Peromyscus* per 100 trap nights than drift fence arrays. The lower species richness and abundance in intact forest than fragmented forest was unexpected and is contrary to the theories of island biogeography (MacCarthur and Wilson 1967), which predict that larger patches of habitat will hold more species and more individuals than smaller patches. Studies of small mammals have found a positive relationship between richness and habitat island size (Gottfried 1977, Rosenblatt et al. 1999) and between abundance and habitat island size (Gottfried 1977). The greater richness and abundance in reclaimed areas than in intact forests was similar to the findings of Kirkland (1977) in a study comparing richness and abundance of small mammals among different aged clearcuts on the Monongahela National Forest in West Virginia. He found that there was an initial increase in the diversity and abundance of small mammals in response to clearcutting that persisted until the area succeeded back into forest. He speculated that the increased herbaceous vegetation layer created by openings improved foraging habitat for small mammals.

The only significant difference in *Peromyscus* spp. abundance among treatments was between grasslands and intact forest, with grasslands having the higher abundance. Most previous studies have also found that *Peromyscus* spp. benefit from disturbances that create early-successional habitats such as mining (Verts 1957, Mumford and Bramble 1969, DeCapita and Bookout 1975, Kirkland 1976, Hansen and Warnock 1978) and forest clearcutting (Kirkland 1977, Buckner and Shure 1985). Sherman trapping results from 2001 were slightly different, with the 2 reclaimed treatments having higher abundances than the 2 forest treatments. Again the results differ between the 2 methods because Sherman trapping is more effective at capturing *Peromyscus* spp.

Three species of microtine rodents, southern bog lemmings woodland voles, and meadow voles, were captured by drift fence arrays. Southern bog lemmings were the most common of these (86 individuals). Their abundance was higher in the two reclaimed treatments than in the forest treatments, while they were not captured at all in the intact forest. This was consistent with other accounts of the bog lemming. Kirkland (1977) described capturing bog lemmings in clearcuts but not in either deciduous or coniferous forests and Connor (1959) found them to be reliant on sedges and grasses for a food source. Woodland voles (47 individuals) were less abundant in grasslands than in intact forests. Despite their name, woodland voles can be found in a variety of habitats, including forests, orchards, and dry fields (Whitaker and Hamilton 1998). However, in a laboratory study, woodland voles chose sites with cooler, more organic soils over warmer, rocky soils (Rhodes and Richmond 1985). This may explain their lower numbers in the grassland treatment, where soils were likely to be too warm and rocky for them. Meadow voles, the least frequently captured of the microtines (22 individuals), did not differ in abundance among treatments. This may have been a function of having a small sample size and the fact that this species is a habitat generalist (Whitaker and Hamilton 1998).

Woodland jumping mice and short-tailed shrews were significantly more abundant in fragmented forest than in the other 3 treatments. We did not find any other research suggesting that these species prefer fragmented forests to intact forests. For woodland jumping mice, however, Sherman trapping data concurred with this abundance trend. Woodland jumping mice are reported to prefer dense understory (Whitaker and Wrigley 1972) and to often be found near forest streams (Whitaker and Hamilton 1998). Fragmented forest treatments always followed along streams, and may have provided more understory vegetation than intact forests due to the effect of sunlight entering the forest at edges. Short-tailed shrews are known to prefer moist, cool sites (Getz 1961) because they have a high rate of evaporative water loss through their skin. Spring and summer 2000 were wetter and cooler than average, so even open grasslands were relatively wet and cool; therefore, it is unclear as to why this species was more abundant in the fragmented forest treatment.

Three shrew species of the genus *Sorex* were captured in all 4 treatments: masked shrews, smoky shrews, and pygmy shrews. Masked shrews, the most common of the 3, were more abundant in the shrub/pole treatment than in either forest treatment and were more abundant in the grassland treatment than the intact forest treatment. This species is a habitat generalist that exists in just about any habitat so long as it is moist (Moore 1949). Smoky shrew abundance did not differ among treatments. Reported to select for damp woods (Caldwell and Bryan 1982), smoky shrews were not expected to occur in grasslands. The rainfall during spring - summer 2000 may have allowed smoky shrews to exist in grasslands that would otherwise be too hot and dry. Pygmy shrew abundance was greater in the fragmented forest than in the shrub/pole treatment. The smallest of the shrews, this species is usually found in upland woods (Whitaker and Hamilton 1998), but a small sample size (16 individuals) made trends in abundance difficult to detect.

E. Herpetofaunal Surveys

Drift fence arrays established and sampled in 2000 were sampled again in 2001 using methods described in Wood et al. (2001). Arrays were opened for approximately eight days each month from March through October. In 2001, an additional intact sampling array was added near the Daltex mine in Pigeonroost Hollow; it was sampled September and October.

In 2001, we also initiated a pilot project to assess aquatic herpetofaunal diversity and abundance in intact forest streams not impacted by mining and in fragmented forest streams located below valley fills.

Methods

Stream Searches – Sampling Techniques

To quantify aquatic and semi-aquatic herpetofaunal diversity and abundance, three fragmented forest streams and three intact forest streams were sampled once per month in May, June, and August -October of 2001. In addition, another forest fragment stream was added and sampled in September and October 2001. Streams were selected based on proximity to the drift fence arrays. Fragmented forest streams were located below valley fills.

A different 35-m segment was sampled in each stream each month. By moving down and sampling new, adjacent stream segments, the intention was to sample as much of the entire length of each stream as possible. Searching more than 35 m per visit is not practical, as some segments require several hours of search time due to their complex substrate. Each segment sampled was classified by stream order (ephemeral, first order, or second order) and by predominant structures (Table 28).

Sampling methods were similar to those of Crump and Scott (1994). All rocks and coarse woody debris located within the width of the stream are lifted and checked under for herpetofauna. In addition, all rocks and coarse woody debris found up to 1-m from the edge of the stream were also sampled. A count was kept of all rocks and coarse woody debris checked under during the sample (Table 28). Time in person minutes was recorded, as were species, length of salamanders from snout to anterior portion of vent (cm) (done by placing salamander in a Ziploc bag); and length (cm), width (cm), and type of substrate (e.g., rock) under which the animal was found (Table 28).   In addition, soil temperature in the stream (°C) was measured using a REOTEMP Heavy Duty Soil Thermometer (Ben Meadows Company) and air temperature (°C) was determined using a –30 to 50 °C / 1° Pocket Thermometer (Ben Meadows Company). Individuals were toe-clipped for identification of recaptures. Cover objects that would cloud the water with bottom substrate upon lifting are not included in the sample, as any salamanders would escape capture before their presence could be detected.

Data Analyses

Only data from drift fence arrays were subjected to statistical analyses. To account for differences in the lengths of trapping periods and trap effort (an unequal trapping effort resulted from theft of traps, weather conditions rendering traps nonfunctional, etc.), the sum of the number of animals captured in all pitfall and funnel traps at each array during a trapping period was divided by the number of operable traps per trapping session multiplied by the number of nights per trapping session. This value multiplied by 100 equaled mean captures per treatment in 100 array-nights (Corn 1994).

ANOVA was used to compare mean captures among treatments. Dependent variables were mean abundance of: 1) all herpetofauna, 2) major groups (e.g., salamanders, toads and frogs, etc.), 3) all amphibians, 4) all reptiles, and 5) individual species with high enough captures (≥ 30). Independent variables were treatment, year, sampling period, the interaction between treatment and year, and the interaction between treatment and sampling period (Wood et al. 2001).

Results and Discussion

Over the 2 years of sampling (2000 and 2001), 1750 individual herptiles were captured or observed using drift fence arrays, stream searches, and incidental sightings. Of a possible 58 species expected to occur in the study area, we encountered 41 (Table 29), an increase of 6 species from 2000. The 41 species included 12 salamander species, 10 toad / frog species, 3 lizard species, 13 snake species, and 3 turtle species.

A total of 625 individuals and 32 species were captured using drift fence arrays over the 2 years (Table 30) including 10 salamander species, 9 toad and frog species, 3 lizard species, 9 snake species, and 1 turtle species. Fifteen of these species are classified as terrestrial, 10 are semi-aquatic, and 7 are aquatic.

Overall mean abundance of herpetofauna did not differ among the four treatments (F=1.56, df=3, P=0.2015; Table 31) with no interactions between treatment and year (F=0.25, df=3, P=0.8641) or between treatment and sampling period (F=0.82, df=36, P=0.7471). Mean richness, however, was significantly greater in fragmented forest and shrub/pole treatments than in grasslands (F=4.04, df=3, P=0.0086; Table 31). With richness, there were no interactions between treatment and year (F=0.11, df=3, P=0.9533) or between treatment and sampling period (F=0.99, df=36, P=0.4955).

In a study in Pennsylvania, Yahner et al. (2001) inventoried herpetofauna in forest, riparian, and grassland habitats using 8 different survey methods, including drift fence arrays. Forest habitat produced the highest number of individuals, whereas grasslands yielded no captures. Pais et al. (1988) conducted a study in eastern Kentucky, where the herpetofaunal community is similar to that on our sites. Using techniques similar to ours (drift fences in conjunction with pitfalls and funnel traps), they found no difference in total captures of herpetofauna among clearcuts, mature forest, and wildlife clearings, although herpetofaunal richness was lower in mature forest than in clearcuts and wildlife clearings. Although clearcuts can resemble reclaimed mine sites in vegetation structure, the magnitude of soil disturbance is greater on reclaimed sites.

Abundance was not different among the four treatments when species were categorized into terrestrial (F=0.73, df=3, P=0.5354), aquatic (F=2.02, df=3, P=0.1142), and semiaquatic herpetofauna (F=0.41, df=3, P=0.7426; Table 31). Amphibian abundance also did not differ among the four treatments (F=0.82, df=3, P=0.4874), whereas reptiles were significantly more abundant in shrub/pole habitat than in intact forests, forest fragments, and grasslands (F=6.09, df=3, P=0.0006). Adams et al. (1996) found a higher abundance and species richness of reptiles in disturbed habitat (clearcuts) than in unharvested stands.

Salamander abundance was similar between the 2 forested treatments but was higher than in grassland and shrub/pole treatments (F=5.97, df=3, P=0.0007; Table 31). This taxonomic group comprised 22% to 38% of captures in forested treatments and approximately 7% in grassland and shrub/pole treatments (Table 32). Number of species also was higher in forested treatments. The red-spotted newt was the most abundant salamander and was the only salamander species found at every sampling point (Table 30). Both the red-spotted newt and the spotted salamander were found in every treatment. The only other salamander species found in reclaimed habitat was the four-toed salamander, which was captured in grassland and shrub/pole treatments. Both the spotted salamander and the four-toed salamander require moist forests, so the individuals found at a grassland point may have been migrating to a nearby wet area or forested habitat. The shrub/pole point at which a spotted salamander was captured is particularly wet compared to all other treatment points; pitfalls are often rendered nonfunctional due to the ground water pushing them up and out of the ground.

Forests tend to have cooler, moister, and more homogeneous climatic conditions than grasslands and should therefore better meet the habitat requirements of salamanders. Increased insolation and reduction in soil moisture retention associated with grassland habitat may limit the ability of a salamander to forage. Native vegetation removal alters rainfall interception rates and evapotranspiration, thereby additionally affecting soil moisture levels (Kapos 1989). In a review of 18 studies of amphibian responses to clearcutting, deMaynadier and Hunter (1995) found that amphibian abundance was 3.5 times higher in unharvested stands than in recent clearcuts. Other studies not covered in this review have found decreased abundance (Buhlmann et al. 1988, Sattler and Reichenbach 1998, Harpole and Haas 1999) or that responses are species-specific (Cole et al. 1997, Grialou 2000). Ross et al. (2000) found salamander richness and abundance to decrease as a function of increasing removal of live tree basal area. Ash (1997) observed an initial decrease in salamander abundance following clearcutting, but found that within 4-6 years, it returned to preharvesting levels and then proliferated. Because mining results in greater soil disturbance, however, salamander populations may take longer to recover on reclaimed sites than reported by Ash. Generally for salamanders, high site fidelity, small home ranges, physiological limitations, low fecundity, and the inability to traverse large distances quickly make them especially susceptible to effects of forest alterations (Pough et al. 1987, Petranka et al. 1993, Petranka et al. 1994, Blaustein et al. 1994, Droege et al. 1997, Gibbs 1998b, Ross et al. 2000).

Toads and frogs showed no difference in abundance among the treatments (F=1.79, df=3, P=0.1515; Table 31). This taxonomic group was consistently present in the highest numbers in each treatment, comprising from 44% to 73% of all individual herptiles captured within treatments (Table 32). The green frog was the only anuran species captured at every sampling point (Table 30). Both eastern American toads and pickerel frogs were captured in every treatment (Table 29). The green frog and the pickerel frog were the most abundant species in this study (Table 30), totaling 45% of all captures. Toads and frogs are more tolerant of temperature extremes than salamanders (Stebbins and Cohen 1995), and thus can occur in non-forested habitats. Ross et al. (2000) found toad and frog richness to have a positive relationship with increases in tree basal area.

Snakes varied from 12% to 28% of captures in each treatment and five species were found in all four treatments, the black rat snake eastern gartersnake, eastern milk snake, northern black racer, and northern copperhead (Table 30). Snakes were more abundant in shrub / pole treatments (F=7.18, df=3, P=0.0002; Table 31). Ross et al. (2000) found snake abundance and species richness to be inversely related to tree basal area. The Florida king snake (*Lampropeltis getula floridana*) benefited from conversion of its native habitat (cypress ponds, savannah pine lands, and prairies) to sugarcane fields; this conversion increased prey density and provided additional shelter for the snakes with the creation of limestone dredge material along the banks of the irrigation canals (Pough et al. 2001). Perhaps the creation of riprap channels and rock chimneys in reclaimed habitat has served the snake population on mountaintop mines in a similar way. Forested habitat is preferred or required by four snake species captured in this study; one prefers grasslands, and four can be found in a variety of habitats (Behler and King 1995, Green and Pauley 1987, Conant and Collins 1998). The four ubiquitous species comprised the majority of snake captures (82%).

Lizards were not captured in high enough abundances to conduct statistical analyses; they made up only 2% to 3% of total herpetofauna captured in each treatment (Table 32). Three of the five lizard species expected to occur in our study area were captured in drift fence arrays (Table 29); they included three northern-fence lizards, eight common five-lined skinks, and two little brown skinks. While only three fence lizards were captured, this species was commonly sighted in all treatments except intact forest). Because this species is not typically found in moist forests, it may not have been abundant on the study sites prior to mining. The little brown skink is classified as an S3 species by the West Virginia Natural Heritage Program (2000) meaning that there are only 21 to 100 documented occurrences in the state and that it may be under threat of extirpation. It prefers dry, open woodlands and uses leaf litter and decaying wood for concealment and foraging (Green and Pauley 1987, Conant and Collins 1998). Captures occurred in pitfalls, one in grassland habitat and the other in intact forest (Table 29). Leaf litter is present in negligible amounts and CWD is absent from our grassland sampling points (Table 33), so grassland habitats generally would not be suitable for little brown skinks.

Turtles were also not captured in high enough abundance to conduct statistical analyses. Only one species of turtle, the eastern box turtle, was captured in the arrays (Table 29). Eastern box turtles are seldom captured in pitfall traps and may have a natural wariness of pitfalls (Pais et al. 1988). Furthermore, they are too large to fit through the entrance of funnel traps used in this study. As this species was commonly sighted as an incidental and was found in every treatment, it probably has fairly high population numbers on the study sites.

Six species had ≥ 30 individuals captured, so abundance was compared among treatments (Table 31). The northern black racer had highest abundance in the shrub/pole treatment and did not occur in the forest fragment and intact forest treatments (F=15.3, df=3, P=<0.0001). The eastern American toad was significantly more abundant in the shrub/pole than in the forest fragment treatment (F=2.68, df=3, P=0.0507). Abundance of the red-spotted newt (F=1.89, df=3, P=0.1345), northern green frog (F=1.94, df=3, P=0.1265), pickerel frog (F=1.78, df=3, P=0.1539), and eastern gartersnake (F=0.73, df=3, P=0.5354) did not differ among the four treatments. Other studies have found the red-spotted newt to be sensitive to forest fragmentation (Gibbs 1998a) and forest edge (Gibbs 1998b). However, deMaynadier and Hunter (1998) looked at even-aged silvicultural treatments (clearcuts and conifer plantations) and did not find a difference in newt abundance between these treatments and the bordering mature forest. Ross et al. (2000) observed a positive association of eastern garter snakes with forest stands containing negligible amounts of residual tree basal area.

Several species captured or detected during the 2 years of the study are listed as S2 or S3 status by the West Virginia Natural Heritage Program (2000). A species with S2 status is described as "very rare and imperiled," with as few as 6-20 documented cases in West Virginia. The northern leopard frog is listed as an S2 species. Drift fence arrays captured two individuals in forest fragments and two in shrub/pole habitat (Table 30). In addition, a few individuals were heard singing in a forest fragment (Table 29). S3 species documented in our study included the northern red salamander, little brown skink (discussed earlier), eastern wormsnake, timber rattlesnake, eastern hog-nosed snake, and northern rough greensnake. One of the seven timber rattlesnakes sighted was in an intact site, the other six were in or on the border of shrub/pole habitat; all were incidental sightings. One northern rough greensnake was found in shrub/pole habitat and the other in an intact forest, both as incidental sightings. Two eastern hog-nosed snakes were captured in shrub/pole habitat in funnel traps of the drift fence array. Another was captured in grassland habitat, also in a funnel trap, and there was one incidental sighting in grassland habitat. Three northern red salamanders were found at 2 intact forest sites, while a fourth was found in a forest fragment; this species was captured in both drift fence arrays and stream surveys.

Data from the 2001 stream surveys were not analyzed statistically because the sample sites were not paired by stream order and structure. Therefore, these data are preliminary and will be used to more effectively design the surveys for 2002. Generally, a range of habitat conditions was sampled in the segments (Table 28).

A total of 678 stream herpetofauna of 15 species were captured in stream surveys. Total captures were higher in intact forest streams (IFS) (n = 389) than in fragmented forest streams (FFS) (n = 289; Tables 34 and 36), although 2 extra stream segments were sampled in FFS. More species (n = 13) were captured in the FFS (n = 13) than in the IFS (n = 10). Salamanders comprised 97% of total captures, so toads, frogs, and snakes were excluded from abundance calculations per stream segment. Second order FFS had the highest (68.5 ± 7.5) and lowest (1.8 ± 0.97) means of stream salamanders per stream segment (Table 35). Means of herpetofauna and habitat characteristics per segment of stream sampled are summarized and presented in Tables 35 and 36.

In summary, 6 additional species of herpetofauna were captured in 2001. Three of these (the northern rough greensnake, northern leopard frog, and northern red salamander) are listed as special status by the West Virginia Natural Heritage Program (2000) which brings the total to seven for the 2 years of the study. Species richness based only on the year 2000 array data did not differ among treatments; based on data from both years, richness was higher in fragmented forest and shrub/pole treatments than in grasslands. The only salamander species captured outside of a forested treatment in 2000 was a spotted salamander; it was found in a grassland. This year, another spotted salamander was found in shrub/pole habitat and a four-toed salamander was found in a grassland. Salamander abundance was similar between the fragmented and intact forest treatment but was greater than the reclaimed grassland and shrub/pole treatments.

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Table 1. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Dickcissels and Grasshopper Sparrows at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Dickcissel						Grasshopper Sparrow					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	1.3	0.2			0.7	0.2	1.0	0.1		
Slope (%)	13.1	1.5	21.8	6.6			8.5	2.1	16.5	1.9		
Distance to Minor Edge (m)	101.4	11.3	28.5	5.0			68.1	10.4	105.4	14.2		
Distance to Habitat Edge (m)	188.2	25.6	585.1	149.0	6.571	0.010+	87.0	14.5	290.1	40.3		
Grass/Forb Height (dm)	6.9	0.3	5.9	1.1			6.0	0.6	7.2	0.3		
Litter Depth (cm)	2.0	0.1	1.9	0.4			1.5	0.2	2.2	0.2		
Robel Pole Index	3.5	0.2	3.8	0.5	4.043	0.044+	4.2	0.3	3.2	0.2		
Elevation (m)	386.1	6.5	441.6	19.5			381.6	14.6	396.1	6.7		
<u>Tree Density (no./ha)</u>:												
>0-2.5 cm	4050.7	885.6	175.8	137.5			8173.2	2143.6	1599.1	441.9		
>2.5-8 cm	509.5	149.5	46.9	25.7			1135.4	398.2	156.3	33.8		
>8-23 cm	60.7	13.2	0.1	0.1			143.2	29.9	14.2	5.3	19.810	<0.001-
<u>Ground Cover (%)</u>:												
Water	0.1	0.1	0.3	0.3			0.1	0.1	0.2	0.1		
Litter	7.8	1.3	2.8	1.2			7.5	2.4	7.1	1.3		
Bareground/rock	4.4	0.7	13.8	4.1	9.611	0.002+	2.6	1.2	6.6	1.0		
Woody Debris	0.2	0.1	0.0	0.0			0.3	0.2	0.1	0.0		
Moss	1.3	0.4	1.9	1.4			2.4	1.2	0.9	0.3		
Green	84.5	2.0	80.6	3.5			82.3	4.6	84.9	1.8		
Grass	45.6	2.9	34.8	6.1			43.6	6.1	44.9	2.9		
Forb	22.7	1.9	24.8	5.9			19.6	3.0	24.4	2.3		
Shrub	17.6	2.2	20.9	8.0			22.8	3.4	15.7	2.6		
Hosmer-Lemeshow Goodness-of-Fit Test					3.368	0.909					0.796	0.851

Table 2. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Eastern Meadowlarks and Red-winged Blackbirds at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' indicate a negative relationship between presence and the habitat variables. Only significant results are reported.

	Eastern Meadowlark						Red-winged Blackbird					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	1.1	0.1			0.8	0.1	1.1	0.1		
Slope (%)	13.0	1.8	16.4	2.6			10.9	1.8	19.0	2.4		
Distance to Minor Edge (m)	88.4	11.2	105.6	23.0			98.0	14.3	87.2	15.1		
Distance to Habitat Edge (m)	161.4	30.0	373.2	61.9			176.8	28.6	308.3	61.1		
Grass/Forb Height (dm)	6.5	0.3	7.6	0.4			6.4	0.4	7.4	0.3		
Litter Depth (cm)	1.9	0.2	2.2	0.2			1.6	0.1	2.6	0.2		
Robel Pole Index	3.8	0.2	2.9	0.3			3.8	0.2	3.0	0.2		
Elevation (m)	392.3	8.4	390.4	9.4			403.8	8.1	373.0	9.9		
Tree Density (no./ha):												
>0-2.5cm	5021.8	1119.1	614.6	172.9			3883.6	1097.7	3279.2	1163.2		
>2.5-8cm	615.6	191.8	121.1	44.0	7.480	0.006-	465.4	105.3	455.2	308.0		
>8-23cm	75.6	16.5	7.6	5.3			72.7	18.3	25.7	9.7		
Ground Cover(%):												
Water	0.1	0.1	0.3	0.2			0.1	0.1	0.2	0.1		
Litter	6.6	1.3	8.7	2.3			6.1	1.5	9.0	1.8		
Bareground/rock	4.5	1.0	7.3	1.6			4.4	1.0	6.9	1.5		
Woody Debris	0.2	0.1	0.1	0.1			0.2	0.1	0.2	0.1		
Moss	1.7	0.6	0.7	0.4			1.3	0.6	1.5	0.6		
Green	84.6	2.3	82.9	3.2			86.7	2.2	80.0	3.2		
Grass	42.4	3.4	49.0	4.4			40.7	3.6	50.4	3.8		
Forb	22.2	2.1	24.4	3.7			23.0	2.3	22.7	3.1		
Shrub	21.7	2.6	9.5	3.2	4.813	0.028-	23.6	2.9	9.0	2.4	9.937	0.002-
Hosmer-Lemeshow Goodness-of-Fit Test					10.231	0.249					4.779	0.573

Table 3. Means, standard errors (SE) for the presence/absence of Horned Larks and Willow Flycatchers at point counts in grassland and shrub/pole habitats in southwestern West Virginia. No variables were chosen by stepwise logistic regression as predictors for either of these species.

	Horned Lark				Willow Flycatcher			
	Absent		Present		Absent		Present	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Aspect Code	0.9	0.1	1.0	0.2	0.9	0.1	1.2	0.2
Slope (%)	11.8	1.5	22.0	4.0	14.1	1.7	13.9	2.0
Distance to Minor Edge (m)	90.2	11.3	106.5	26.2	88.1	10.4	142.4	45.1
Distance to Habitat Edge (m)	167.9	24.4	433.3	90.1	219.7	32.5	305.3	76.1
Grass/Forb Height (dm)	6.6	0.3	7.6	0.4	6.7	0.3	8.1	0.3
Litter Depth (cm)	1.8	0.1	2.8	0.3	1.9	0.1	2.4	0.3
Robel Pole Index	3.8	0.2	2.6	0.2	3.6	0.2	2.6	0.3
Elevation (m)	392.9	7.8	387.8	10.3	393.1	7.0	379.5	13.4
Tree Density (no./ha):								
>0-2.5cm	4373.4	1007.6	1088.2	435.0	3903.1	893.1	1449.2	242.1
>2.5-8cm	562.5	170.9	104.8	33.5	494.1	150.0	179.7	63.5
>8-23cm	69.8	14.9	0.0	0.0	60.7	13.2	0.0	0.0
Ground Cover (%):								
Water	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0
Litter	6.1	1.3	11.3	2.4	7.1	1.2	8.3	3.6
Bareground/rock	4.5	0.9	8.3	1.7	5.4	0.9	5.2	2.8
Woody Debris	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.2
Moss	1.3	0.5	1.7	0.8	1.4	0.5	1.1	0.9
Green	85.7	2.2	78.6	3.2	84.0	2.0	85.3	6.4
Grass	43.6	3.3	47.5	4.4	43.2	3.0	55.2	3.6
Forb	22.8	2.1	23.3	3.6	23.1	2.0	21.3	4.5
Shrub	20.8	2.5	7.8	3.2	19.0	2.3	8.9	3.0

Table 4. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of White-eyed Vireos and Yellow-breasted Chats at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	White-eyed Vireo						Yellow-breasted Chat					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	0.8	0.2			1.0	0.1	0.9	0.1		
Slope (%)	14.4	1.7	12.9	3.1			17.7	2.3	10.1	1.7		
Distance to Minor Edge (m)	99.3	12.8	75.7	15.5			104.8	17.0	81.9	11.6		
Distance to Habitat Edge (m)	270.4	37.4	86.0	12.2			338.4	50.1	103.6	13.1	4.663	0.031-
Grass/Forb Height (dm)	6.8	0.3	6.8	0.6			7.2	0.3	6.4	0.4		
Litter Depth (cm)	2.0	0.1	2.1	0.3			2.2	0.2	1.8	0.2		
Robel Pole Index	3.3	0.2	4.2	0.4			3.1	0.2	4.0	0.3		
Elevation (m)	396.2	7.1	376.6	14.5			403.0	8.5	378.9	9.6		
Tree Density (no./ha):												
>0-2.5cm	2060.9	646.4	8850.7	2373.0	8.739	0.003+	566.4	171.9	6979.7	1488.7	11.423	0.001+
>2.5-8cm	434.3	171.5	550.3	136.6			152.3	40.9	795.6	268.4		
>8-23cm	45.2	14.1	84.7	21.6			29.6	15.5	81.3	17.8		
>23-38 cm	1.6	0.9	5.2	2.6			1.1	1.1	3.9	1.5		
Snags	5.4	2.7	7.3	2.9			0.9	0.9	11.5	4.4		
Ground Cover (%):												
Water	0.1	0.1	0.3	0.2			0.2	0.1	0.1	0.1		
Litter	7.1	1.4	7.8	2.1			6.6	1.7	8.0	1.6		
Bareground/rock	6.3	1.0	2.5	0.7			7.4	1.3	3.2	0.9		
Woody Debris	0.1	0.1	0.2	0.1			0.1	0.1	0.2	0.1		
Moss	1.3	0.5	1.7	0.7			1.6	0.7	1.2	0.4		
Green	83.1	2.3	87.4	2.3			84.1	2.5	84.1	2.8		
Grass	46.4	3.1	38.3	5.4			47.5	3.8	41.2	3.8		
Forb	21.6	2.1	27.2	3.5			19.5	2.4	26.6	2.6	4.526	0.033+
Shrub	16.6	2.5	22.1	4.2			17.1	3.3	18.8	2.6		
Hosmer-Lemeshow Goodness-of-Fit Test					5.037	0.656					50.074	<0.001

Table 5. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Prairie Warblers and Blue-winged Warblers at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Prairie Warbler						Blue-winged Warbler					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.1	0.1	0.8	0.1			1.0	0.1	0.8	0.2		
Slope (%)	15.9	2.3	12.0	1.8	4.872	0.027-	14.7	1.7	12.0	2.9		
Distance to Minor Edge (m)	98.4	16.1	88.8	13.3			94.8	12.0	90.5	22.1		
Distance to Habitat Edge (m)	351.7	48.8	88.4	11.2	6.040	0.014-	267.0	37.5	97.4	16.5		
Grass/Forb Height (dm)	6.6	0.4	7.0	0.4			6.9	0.3	6.7	0.6		
Litter Depth (cm)	1.9	0.2	2.1	0.2	8.658	0.003+	2.0	0.1	2.0	0.3		
Robel Pole Index	3.2	0.2	3.9	0.3			3.4	0.2	3.9	0.4		
Elevation (m)	405.2	8.2	376.4	9.6			399.0	6.8	366.8	15.3		
Tree Density (no./ha):												
>0-2.5cm	2542.2	959.5	4843.8	1299.9			2583.2	756.8	7138.9	2245.4		
>2.5-8cm	351.6	232.1	580.2	126.8			180.1	32.8	1383.7	520.3	8.766	0.003+
>8-23cm	38.8	19.5	71.3	13.3			44.2	14.0	87.9	21.8		
>23-38 cm	1.7	1.2	3.2	1.4	8.520	0.004+	1.4	0.8	5.9	2.8		
Snags	4.6	3.0	7.3	3.2			5.9	2.7	5.6	2.5		
Ground Cover (%):												
Water	0.2	0.1	0.1	0.1			0.1	0.1	0.2	0.2		
Litter	8.3	1.8	6.1	1.5			7.0	1.4	8.2	2.2		
Bareground/rock	8.2	1.4	2.3	0.6			6.1	1.0	3.0	0.8		
Woody Debris	0.1	0.1	0.2	0.1			0.1	0.1	0.2	0.1		
Moss	1.8	0.8	0.9	0.3			1.3	0.5	1.7	0.7		
Green	79.0	3.0	89.6	1.9	6.378	0.012+	84.9	2.0	81.6	4.4		
Grass	41.2	3.3	48.0	4.3			45.4	3.2	41.6	4.9		
Forb	22.1	2.5	23.7	2.7			22.5	2.1	24.2	3.9		
Shrub	17.3	3.0	18.6	3.1			17.1	2.5	20.8	4.1		
Hosmer-Lemeshow Goodness-of-Fit Test					8.395	0.396					7.755	0.170

Table 6. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Common Yellowthroats and Yellow Warblers at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Common Yellowthroat						Yellow Warbler					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	1.0	0.1			0.9	0.1	1.1	0.2		
Slope (%)	14.0	2.2	14.1	2.0			12.8	1.8	18.1	2.5		
Distance to Minor Edge (m)	107.0	16.3	79.5	12.6			91.9	11.9	100.0	22.5		
Distance to Habitat Edge (m)	270.1	40.3	183.4	44.8			224.2	35.0	241.7	61.3		
Grass/Forb Height (dm)	6.7	0.4	7.0	0.4			6.5	0.3	7.9	0.4		
Litter Depth (cm)	1.9	0.2	2.1	0.2			1.8	0.1	2.6	0.3		
Robel Pole Index	3.1	0.2	3.9	0.2			3.7	0.2	2.9	0.3		
Elevation (m)	409.1	7.9	373.0	9.6			404.0	7.4	353.0	8.8	8.119	0.004-
Tree Density (no./ha):												
>0-2.5cm	1303.9	525.6	6182.4	1475.6	13.797	<0.001+	3413.7	949.3	4416.7	1502.7		
>2.5-8cm	186.7	48.2	758.4	269.3			365.5	86.0	776.0	507.7		
>8-23cm	48.9	20.2	60.3	12.5			55.3	14.3	51.4	21.6		
>23-38 cm	3.4	1.7	1.4	0.6	4.157	0.041-	3.2	1.2	0.0	0.0		
Snags	4.1	3.0	7.7	3.1			5.4	2.5	7.2	4.5		
Ground Cover (%):												
Water	0.2	0.1	0.1	0.1			0.1	0.1	0.2	0.2		
Litter	8.0	1.9	6.5	1.3			6.0	1.2	11.3	2.7	3.953	0.047+
Bareground/rock	6.8	1.3	3.8	1.0			5.8	1.0	4.0	1.3		
Woody Debris	0.2	0.1	0.2	0.1			0.1	0.1	0.3	0.1		
Moss	1.2	0.7	1.5	0.5			1.3	0.5	1.6	0.7		
Green	83.6	2.6	84.6	2.8			85.7	1.9	79.0	4.8		
Grass	45.1	3.8	43.8	3.9			41.6	3.2	54.0	4.7		
Forb	21.0	2.7	24.9	2.5			25.2	2.2	15.4	2.6		
Shrub	17.6	3.0	18.3	3.1			19.4	2.4	13.1	4.8		
Hosmer-Lemeshow Goodness-of-Fit Test					3.636	0.726					3.605	0.891

Table 7. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Indigo Buntings and Northern Cardinals at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Indigo Bunting						Northern Cardinal					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.2	0.2	0.9	0.1			1.0	0.1	0.8	0.3		
Slope (%)	20.4	4.0	12.9	1.6			15.0	1.6	8.9	3.3		
Distance to Minor Edge (m)	107.8	35.1	91.2	10.7			97.2	11.8	75.4	20.6		
Distance to Habitat Edge (m)	364.8	81.8	199.0	31.4			255.7	34.6	75.9	13.0		
Grass/Forb Height (dm)	6.8	0.8	6.8	0.3			7.1	0.3	5.6	0.9		
Litter Depth (cm)	2.0	0.3	2.0	0.1			2.1	0.1	1.7	0.3		
Robel Pole Index	3.6	0.4	3.5	0.2			3.3	0.2	4.7	0.5		
Elevation (m)	397.7	15.0	390.4	7.2			393.4	6.4	382.3	23.6		
Tree Density (no./ha):												
>0-2.5cm	1291.7	1181.8	4083.2	920.6			2932.7	699.0	7523.4	3418.8		
>2.5-8cm	119.8	77.6	524.5	158.2	4.372	0.037+	377.9	144.9	914.1	350.3	5.134	0.0235+
>8-23cm	17.7	13.1	61.2	13.9			50.4	13.8	76.0	18.6		
>23-38 cm	0.0	0.0	2.9	1.1			2.4	1.1	2.6	1.2		
Snags	1.3	1.3	6.8	2.6			6.2	2.5	4.2	2.9		
Ground Cover (%):												
Water	0.2	0.2	0.1	0.1			0.2	0.1	0.0	0.0		
Litter	6.0	2.2	7.5	1.3			7.5	1.3	6.0	2.3		
Bareground/rock	11.0	3.2	4.3	0.7	5.055	0.025-	5.6	0.9	4.4	2.5		
Woody Debris	0.0	0.0	0.2	0.1			0.2	0.1	0.2	0.2		
Moss	1.5	1.0	1.4	0.5			1.6	0.5	0.2	0.2		
Green	81.3	3.5	84.6	2.1			84.0	2.0	84.8	4.9		
Grass	42.8	5.4	44.8	3.1			46.0	2.7	36.3	9.0		
Forb	19.9	4.3	23.4	2.0			22.3	2.0	26.1	4.7		
Shrub	18.5	6.1	17.8	2.3			16.7	2.3	24.7	5.9		
Hosmer-Lemeshow Goodness-of-Fit Test					9.006	0.252					5.801	0.326

Table 8. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of American Goldfinches and Song Sparrows at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '+' indicates a positive relationship between presence and the habitat variables. Only significant results are reported.

	American Goldfinch						Song Sparrow					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	0.9	0.1			0.9	0.1	1.3	0.2		
Slope (%)	14.0	2.1	14.1	2.1			13.4	1.6	17.6	4.7		
Distance to Minor Edge (m)	102.4	13.6	79.5	16.3			98.4	11.7	66.1	20.3		
Distance to Habitat Edge (m)	238.2	40.1	211.5	45.4			177.8	21.8	510.9	134.7	7.953	0.0048+
Grass/Forb Height (dm)	6.7	0.3	7.1	0.5			6.9	0.3	6.6	0.8		
Litter Depth (cm)	1.9	0.2	2.2	0.2			2.0	0.2	2.0	0.2		
Robel Pole Index	3.5	0.2	3.5	0.3			3.4	0.2	4.0	0.6		
Elevation (m)	395.5	7.8	385.2	11.3			386.6	7.0	420.3	14.7		
Tree Density (no./ha):												
>0-2.5cm	4289.7	1167.6	2586.2	902.2			3730.1	872.2	3156.3	2179.2		
>2.5-8cm	519.5	206.1	365.3	112.1			495.7	156.5	255.7	87.4		
>8-23cm	60.3	17.4	44.6	14.1			57.2	13.5	37.5	24.2		
>23-38 cm	2.5	1.1	2.4	1.7			2.7	1.1	1.1	1.1		
Snags	5.6	2.7	6.3	3.8			5.6	2.3	7.3	6.2		
Ground Cover (%):												
Water	0.2	0.1	0.0	0.0			0.2	0.1	0.0	0.0		
Litter	7.0	1.5	7.7	1.9			7.2	1.3	7.6	2.3		
Bareground/rock	5.5	1.1	5.2	1.4			5.1	0.9	7.0	2.8		
Woody Debris	0.2	0.1	0.2	0.1			0.2	0.1	0.0	0.0		
Moss	1.7	0.6	0.9	0.4			1.2	0.4	2.6	1.3		
Green	83.4	2.4	85.2	3.1			84.3	2.1	82.9	3.9		
Grass	41.4	3.3	49.5	4.6			44.9	3.0	41.6	5.5		
Forb	24.8	2.4	19.7	2.7			22.4	2.0	25.7	5.1		
Shrub	19.0	2.6	16.1	3.6			18.3	2.3	15.5	5.7		
Hosmer-Lemeshow Goodness-of-Fit Test					--	--					12.390	0.135

Table 9. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Chipping and Field Sparrows at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Chipping Sparrow						Field Sparrow					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	0.9	0.3			1.0	0.1	0.9	0.1		
Slope (%)	14.7	1.6	9.2	3.6			17.5	2.8	11.6	1.6		
Distance to Minor Edge (m)	100.3	11.6	44.6	9.7			85.8	12.6	99.5	15.6		
Distance to Habitat Edge (m)	245.8	33.5	92.8	21.0			313.2	56.8	164.3	28.3		
Grass/Forb Height (dm)	6.8	0.3	7.2	0.8			6.6	0.4	7.0	0.3		
Litter Depth (cm)	2.0	0.1	1.8	0.2			1.9	0.2	2.1	0.2		
Robel Pole Index	3.4	0.2	4.1	0.3			3.2	0.2	3.7	0.2		
Elevation (m)	392.2	7.0	387.6	15.3			406.3	9.0	380.7	8.8		
Tree Density (no./ha):												
>0-2.5cm	2918.2	765.9	9163.2	3346.8			2414.1	1127.1	4525.7	1111.3		
>2.5-8cm	413.6	148.9	822.9	241.1			410.2	289.9	497.9	107.8	5.736	0.0166+
>8-23cm	48.5	13.4	99.3	11.8	7.952	0.0048+	46.5	23.9	60.0	11.8		
>23-38 cm	1.8	0.9	6.9	3.2			3.5	1.9	1.7	0.8		
Snags	3.5	1.9	24.3	11.1			7.0	4.3	5.0	2.1		
Ground Cover (%):												
Water	0.2	0.1	0.0	0.0			0.2	0.1	0.1	0.1		
Litter	7.5	1.3	5.7	2.2			7.4	2.0	7.2	1.4		
Bareground/rock	5.4	0.9	5.1	3.2			8.5	1.6	3.1	0.7	3.960	0.0466-
Woody Debris	0.1	0.1	0.3	0.2			0.2	0.1	0.1	0.1		
Moss	1.4	0.5	1.3	0.8			1.3	0.8	1.4	0.4		
Green	83.6	2.1	87.7	4.0			80.2	3.4	86.8	2.1		
Grass	44.3	2.8	46.1	10.8			43.0	4.1	45.5	3.6		
Forb	22.7	1.9	24.6	5.9			20.6	2.7	24.5	2.4		
Shrub	18.0	2.3	17.1	4.7			18.6	3.5	17.4	2.7		
Hosmer-Lemeshow Goodness-of-Fit Test					7.101	0.069					4.323	0.742

Table 10. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Eastern Towhees at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables.

	Eastern Towhee					
	Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.1	0.1	0.7	0.2		
Slope (%)	16.4	1.9	9.5	2.2		
Distance to Minor Edge (m)	104.3	14.8	73.1	10.3		
Distance to Habitat Edge (m)	298.7	41.4	85.0	13.5		
Grass/Forb Height (dm)	7.3	0.3	5.9	0.6		
Litter Depth (cm)	2.1	0.2	1.8	0.3		
Robel Pole Index	3.1	0.2	4.3	0.4		
Elevation (m)	393.5	7.2	388.2	13.3		
Tree Density (no./ha):						
>0-2.5cm	1984.1	597.8	6912.3	1945.1		
>2.5-8cm	393.4	190.6	595.0	142.1		
>8-23cm	25.6	11.6	110.8	24.1	19.783	<0.001+
>23-38 cm	0.6	0.4	6.0	2.5		
Snags	5.3	2.8	7.0	3.4		
Ground Cover (%):						
Water	0.2	0.1	0.0	0.0		
Litter	6.6	1.3	8.5	2.3		
Bareground/rock	6.6	1.1	2.9	1.2		
Woody Debris	0.2	0.1	0.1	0.1		
Moss	1.1	0.4	1.9	1.0		
Green	83.4	2.2	85.6	3.6		
Grass	47.1	3.0	39.3	5.5		
Forb	22.8	2.3	23.0	2.9		
Shrub	15.2	2.4	23.3	4.0		
Hosmer-Lemeshow Goodness-of-Fit Test					1.072	0.784

Table 11. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of American Redstarts and Carolina Chickadees in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	American Redstart						Carolina Chickadee					
	Absent (n=45)		Present (n=40)				Absent (n=49)		Present (n=36)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.8	0.1	1.3	0.1	12.391	<0.001+	1.0	0.1	1.1	0.1		
Slope (%)	33.8	2.1	33.8	2.2			34.1	2.1	33.3	2.2		
Elevation	359.0	10.3	376.4	11.6			378.5	10.3	350.6	11.2		
Distance to minor edge (m)	48.1	9.3	59.9	10.6			54.1	8.5	53.1	11.8		
Distance to habitat edge (m)	630.9	122.6	1262.7	181.4			1052.9	148.9	724.0	160.6		
Canopy height (m)	22.4	0.7	22.5	0.8			22.9	0.6	21.9	0.8		
Ground Cover (%):												
Water	0.8	0.3	0.8	0.2			0.7	0.2	0.8	0.3		
Bareground/rock	8.8	0.8	6.2	0.7			7.7	0.7	7.4	0.8		
Leaf litter	53.2	1.6	48.2	2.1			49.8	1.5	52.3	2.3		
Woody debris	4.9	0.4	4.3	0.5			4.9	0.4	4.3	0.4		
Moss	2.1	0.3	1.9	0.4			2.2	0.3	1.8	0.4		
Green	30.0	1.5	38.4	2.2			34.6	1.6	33.1	2.5		
Tree Density (no./ha):												
≤2.5 cm	6628.5	732.7	4501.6	429.7			6150.5	696.5	4915.8	466.5		
>2.5-8 cm	841.7	53.4	583.6	70.5	6.919	0.008-	688.8	57.6	763.0	73.9		
>8-23 cm	305.3	23.2	283.4	22.9			263.0	18.8	338.5	27.5	5.635	0.018+
>23-38 cm	90.7	4.9	89.7	5.1			92.1	5.1	87.7	4.6		
>38-53 cm	32.8	3.0	28.6	2.6			31.0	2.6	30.6	3.1		
>53-68 cm	9.3	1.5	8.3	1.3			9.8	1.4	7.5	1.4		
>68 cm	3.6	0.7	3.4	0.8			3.2	0.6	4.0	1.0		
Snags (>8 cm)	46.1	5.3	45.1	6.2			45.2	5.2	46.3	6.3		

Table 11 cont.

<u>Canopy Cover (%)</u>:												
>0.5-3 m	53.2	2.1	47.9	2.7			50.3	2.2	51.3	2.7		
>3-6 m	63.2	2.3	55.9	2.4			58.1	2.1	61.9	2.8		
>6-12 m	63.9	1.8	65.0	1.6			62.2	1.6	67.5	1.9		
>12-18 m	56.8	2.3	64.1	2.3			60.3	2.5	60.1	2.2		
>18 m	44.3	3.1	50.3	3.2			49.5	2.9	43.8	3.4		
>24 m	17.8	2.4	16.7	2.2			15.8	1.9	19.2	2.8		
Structural Diversity Index	59.8	1.4	60.0	1.4			59.3	1.3	60.8	1.5		
Hosmer-Lemeshow Goodness-of-fit Test					9.127	0.332					7.076	0.529

Table 12. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Northern Parulas and Carolina Wrens in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Northern Parula						Carolina Wren					
	Absent (n=62)		Present (n=23)				Absent (n=57)		Present (n=28)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.1	0.1	1.0	0.1			1.0	0.1	1.2	0.1		
Slope (%)	33.6	1.8	34.3	2.8			33.1	2.0	35.0	2.4		
Elevation	373.8	8.7	347.5	15.8			378.7	10.0	340.2	9.2	5.966	0.015-
Distance to minor edge (m)	55.9	9.2	47.6	7.6			58.2	10.1	44.4	4.8		
Distance to habitat edge (m)	1017.3	131.8	631.7	192.0			990.1	138.3	747.8	178.0		
Canopy height (m)	22.3	0.6	22.9	0.8			22.3	0.6	22.8	0.9		
Ground Cover (%):												
Water	0.6	0.2	1.3	0.3	6.815	0.009+	0.5	0.1	1.3	0.4		
Bareground/rock	7.4	0.7	7.9	0.8			7.5	0.7	7.6	0.9		
Leaf litter	50.5	1.6	51.7	2.1			53.4	1.5	45.6	2.4	5.889	0.015-
Woody debris	4.6	0.3	4.7	0.7			4.6	0.4	4.6	0.5		
Moss	1.9	0.3	2.3	0.3			2.0	0.3	2.0	0.4		
Green	34.8	1.7	31.7	2.1			31.8	1.6	38.3	2.5		
Tree Density (no./ha):												
≤2.5 cm	5594.8	554.7	5716.0	747.5			6008.2	547.9	4852.7	783.0		
>2.5-8 cm	677.4	51.4	835.6	93.1			766.4	54.5	626.1	81.0		
>8-23 cm	297.8	18.5	287.5	34.6			278.8	17.5	327.9	34.0		
>23-38 cm	91.1	4.0	87.8	7.3			90.1	4.3	90.4	6.3		
>38-53 cm	31.9	2.4	28.0	3.5			30.3	2.4	31.9	3.6		
>53-68 cm	9.7	1.2	6.5	1.7			8.3	1.1	9.8	2.0		
>68 cm	3.5	0.7	3.5	1.0			3.5	0.7	3.6	0.9		
Snags (>8 cm)	47.7	5.1	40.1	5.5			42.3	4.2	52.3	8.5		

Table 12 cont.

Canopy Cover (%):												
>0.5-3 m	49.0	2.0	55.4	3.3			51.9	2.0	48.2	3.2		
>3-6 m	56.9	1.9	67.4	2.9	8.859	0.003+	59.8	2.1	59.6	2.7		
>6-12 m	64.8	1.3	63.4	2.9	4.491	0.034-	63.7	1.5	65.9	2.1		
>12-18 m	61.5	2.0	56.8	3.2			59.7	1.9	61.4	3.3		
>18 m	48.0	2.6	44.6	4.3			51.0	2.5	39.1	4.0		
>24 m	17.3	1.9	17.1	3.2			18.9	2.0	13.9	2.7		
Structural Diversity Index	59.5	1.1	61.0	2.0			61.0	1.2	57.6	1.6		
Hosmer-Lemeshow Goodness-of-fit Test					9.761	0.282					5.656	0.686

Table 13. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Downy Woodpeckers and Tufted Titmice in forested habitats in southwestern West Virginia. The '+' indicates a positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Downy Woodpecker						Tufted Titmouse					
	Absent (n=60)		Present (n=25)				Absent (n=60)		Present (n=25)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	1.5	0.2	4.907	0.027+	1.0	0.1	1.1	0.1		
Slope (%)	33.8	1.6	33.3	5.3			33.5	1.9	34.3	2.5		
Elevation	371.3	8.6	337.7	12.4			366.5	9.7	367.7	12.1		
Distance to minor edge (m)	56.6	7.9	33.8	5.7			58.2	9.6	42.7	5.1		
Distance to habitat edge (m)	1008.6	120.4	302.8	200.1			830.9	124.1	1116.1	227.1		
Canopy height (m)	22.5	0.5	22.4	1.6			21.9	0.6	23.9	0.9		
Ground Cover (%):												
Water	0.8	0.2	0.7	0.4			0.8	0.2	0.6	0.3		
Bareground/rock	7.6	0.5	7.5	1.9			7.8	0.6	7.0	1.0		
Leaf litter	50.1	1.4	56.0	3.8			53.4	1.3	44.6	2.8		
Woody debris	4.7	0.3	4.3	0.9			4.5	0.4	5.1	0.5		
Moss	2.1	0.3	1.5	0.5			2.2	0.3	1.6	0.3		
Green	34.6	1.5	29.9	3.0			31.0	1.4	41.0	2.9	8.392	0.004+
Tree Density (no./ha):												
≤2.5 cm	5777.9	510.7	4616.5	477.9			5764.6	547.7	5298.8	796.7		
>2.5-8 cm	700.6	50.1	852.3	96.8			729.2	49.8	698.8	100.2		
>8-23 cm	286.7	16.4	351.1	61.0			300.5	21.0	281.8	23.5		
>23-38 cm	89.6	3.9	94.3	7.3			87.6	4.3	96.5	6.0		
>38-53 cm	30.2	2.2	35.2	5.1			30.8	2.5	30.8	3.0		
>53-68 cm	8.4	1.1	11.9	3.0			8.1	1.2	10.5	1.8		
>68 cm	3.4	0.6	4.5	1.7			3.0	0.6	4.8	1.2		
Snags (>8 cm)	45.8	4.5	44.9	6.2			45.3	5.0	46.5	6.7		

Table 13 cont.

Canopy Cover (%):												
>0.5-3 m	51.5	1.9	45.5	4.1			52.0	1.9	47.7	3.6		
>3-6 m	59.2	1.9	63.4	3.5			59.9	1.8	59.3	3.7		
>6-12 m	64.1	1.3	66.9	3.7			64.3	1.6	64.7	1.8		
>12-18 m	60.3	1.8	60.1	5.7			59.9	2.0	61.0	3.3		
>18 m	47.0	2.5	47.7	3.6			48.4	2.8	43.9	3.3		
>24 m	17.1	1.8	18.0	3.2			18.1	2.0	15.1	2.6		
Structural Diversity Index	59.8	1.1	60.3	1.9			60.5	1.2	58.3	1.5		
Hosmer-Lemeshow Goodness-of-fit Test					4.854	0.773					3.748	0.879

Table 14. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Downy Woodpeckers and White-breasted Nuthatches in forested habitats in southwestern West Virginia. The '-' indicateseither a negative relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Red-bellied Woodpecker						White-breasted Nuthatch					
	Absent (n=74)		Present (n=11)				Absent (n=65)		Present (n=20)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	1.0	0.2			1.0	0.1	1.0	0.1		
Slope (%)	32.9	1.6	39.6	5.3			32.8	1.7	36.9	3.4		
Elevation	371.1	8.3	336.0	18.3			370.6	9.6	354.1	9.7		
Distance to minor edge (m)	49.1	6.1	84.3	35.1			51.9	8.1	59.4	13.9		
Distance to habitat edge (m)	950.3	120.6	663.0	253.9			985.7	131.1	681.9	191.0		
Canopy height (m)	22.7	0.5	21.2	1.3			22.7	0.6	21.6	1.0		
Ground Cover (%):												
Water	0.8	0.2	0.7	0.5			0.8	0.2	0.6	0.3		
Bareground/rock	7.5	0.6	7.8	1.3			7.6	0.6	7.4	1.2		
Leaf litter	51.6	1.3	45.6	5.3			51.3	1.6	49.3	2.4		
Woody debris	4.7	0.3	4.0	0.8			4.6	0.4	4.7	0.5		
Moss	2.1	0.3	1.4	0.5			2.2	0.3	1.5	0.4		
Green	33.0	1.4	40.2	4.8			33.3	1.6	36.1	3.0		
Tree Density (no./ha):												
≤2.5 cm	5648.2	459.1	5488.6	1672.4			5193.8	365.5	7037.5	1485.8		
>2.5-8 cm	735.6	48.4	616.5	135.2			739.4	52.8	657.8	90.4		
>8-23 cm	285.4	15.6	359.7	69.9			297.9	19.4	285.6	29.6		
>23-38 cm	89.4	3.4	96.0	15.0			89.6	3.9	92.2	8.2		
>38-53 cm	31.2	2.1	28.4	5.7			29.2	2.3	35.9	4.1		
>53-68 cm	8.4	1.0	11.4	3.5			8.3	1.1	10.6	2.5		
>68 cm	3.8	0.6	1.7	0.9			3.2	0.6	4.7	1.2		
Snags (>8 cm)	43.4	4.1	60.3	13.6			44.9	4.4	48.2	9.4		

Table 14 cont.

<u>Canopy Cover (%)</u>:										
>0.5-3 m	50.3	1.9	53.2	4.1			50.8	2.0	50.3	3.5
>3-6 m	59.8	1.8	59.5	4.2			60.4	1.9	57.5	3.5
>6-12 m	64.0	1.3	67.3	3.6			65.3	1.4	61.8	2.7
>12-18 m	59.6	1.8	64.2	4.4			61.8	1.9	55.1	3.2
>18 m	47.7	2.3	42.8	8.2			47.7	2.4	45.2	5.4
>24 m	18.6	1.7	8.4	3.6	5.596	0.018-	17.8	1.9	15.4	3.2
Structural Diversity Index	60.0	1.0	59.1	3.4			60.8	1.1	57.0	2.1
Hosmer-Lemeshow Goodness-of-fit Test					4.235	0.835				

Table 15. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Ovenbirds and Black-throated Green Warblers in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Ovenbird						Black-throated Green Warbler					
	Absent (n=14)		Present (n=71)				Absent (n=70)		Present (n=15)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.2	1.0	0.1			1.0	0.1	1.3	0.1		
Slope (%)	29.0	2.9	34.7	1.7			33.0	1.6	37.4	4.7		
Elevation	360.8	16.8	368.2	8.7			358.9	7.7	406.8	23.5		
Distance to minor edge (m)	34.6	6.7	57.4	8.2			57.9	8.3	33.8	6.5		
Distance to habitat edge (m)	549.3	230.6	999.7	123.6			907.1	120.9	958.3	280.1		
Canopy height (m)	22.0	1.4	22.6	0.5			22.8	0.5	21.0	1.1		
Ground Cover (%):												
Water	0.4	0.3	0.8	0.2			0.9	0.2	0.3	0.3		
Bareground/rock	4.5	0.8	8.2	0.6	6.352	0.012+	8.1	0.6	5.3	0.8		
Leaf litter	58.8	1.8	49.2	1.5			50.2	1.5	53.7	2.1		
Woody debris	5.6	0.5	4.4	0.3			4.7	0.3	4.2	0.8		
Moss	2.6	0.6	1.9	0.3			2.0	0.3	2.2	0.6		
Green	28.1	2.1	35.1	1.6			33.9	1.6	34.1	2.6		
Tree Density (no./ha):												
≤2.5 cm	5783.5	1069.4	5596.8	499.1			5671.9	524.7	5420.8	743.4		
>2.5-8 cm	988.8	101.1	667.3	48.6			718.3	48.8	729.2	125.7		
>8-23 cm	348.2	58.0	284.5	15.8			319.0	18.2	182.9	19.1	11.820	0.001-
>23-38 cm	90.6	7.0	90.1	4.0			92.8	4.0	78.3	6.8		
>38-53 cm	26.8	5.6	31.6	2.1			29.3	2.1	37.9	5.1		
>53-68 cm	10.7	3.4	8.5	1.0			8.7	1.2	9.6	1.2		
>68 cm	3.1	1.6	3.6	0.6			3.5	0.6	3.8	1.0		
Snags (>8 cm)	48.6	12.9	45.1	4.1			50.4	4.6	24.2	4.1		

Table 15 cont.

Canopy Cover (%):												
>0.5-3 m	56.7	3.6	49.5	1.9			50.2	1.9	53.1	4.0		
>3-6 m	69.6	3.7	57.8	1.8	7.400	0.006-	60.2	1.9	57.7	3.4		
>6-12 m	70.2	3.4	63.3	1.3			65.4	1.3	59.8	3.0		
>12-18 m	55.2	4.6	61.2	1.8			59.4	1.8	64.1	4.5		
>18 m	39.6	5.9	48.6	2.4			45.3	2.5	55.7	4.7		
>24 m	18.2	3.8	17.1	1.8			17.4	1.9	16.8	3.1		
Structural Diversity Index	61.9	3.1	59.5	1.0			59.6	1.1	61.4	2.0		
Hosmer-Lemeshow Goodness-of-fit Test					13.590	0.093					6.680	0.572

Table 16. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Pileated Woodpeckers and Yellow-throated Warblers in forested habitats in southwestern West Virginia. The '-' indicates a negative relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Pileated Woodpecker						Yellow-throated Warblers					
	Absent (n=75)		Present (n=10)				Absent (n=74)		Present (n=11)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	1.3	0.2			1.1	0.1	0.5	0.2	4.630	0.031-
Slope (%)	32.9	1.6	40.1	3.8			32.3	1.6	43.6	3.5		
Elevation	368.8	8.3	350.8	20.2			367.1	8.0	364.9	27.9		
Distance to minor edge (m)	55.0	7.8	43.2	7.9			56.6	7.9	33.9	6.9		
Distance to habitat edge (m)	975.1	119.3	433.1	235.4			947.3	118.5	684.9	307.0		
Canopy height (m)	22.6	0.5	21.6	1.3			22.5	0.5	22.4	1.4		
Ground Cover (%):												
Water	0.7	0.2	1.0	0.6			0.9	0.2	0.0	0.0		
Bareground/rock	7.7	0.5	6.5	2.2			7.4	0.5	8.9	1.8		
Leaf litter	51.0	1.4	49.5	3.2			51.1	1.4	49.1	3.7		
Woody debris	4.8	0.3	3.3	0.8			4.6	0.3	5.1	0.9		
Moss	2.1	0.2	1.9	0.9			1.9	0.3	2.8	0.7		
Green	33.5	1.5	37.5	4.8			34.0	1.5	33.9	3.8		
Tree Density (no./ha):												
≤2.5 cm	5909.2	497.3	3515.6	510.7			5196.4	451.1	8528.4	1480.3		
>2.5-8 cm	736.3	47.3	600.0	156.4			709.5	50.4	792.6	96.9		
>8-23 cm	291.1	17.4	324.4	48.7			288.7	14.4	337.5	82.5		
>23-38 cm	88.5	3.8	103.1	7.9			89.9	3.8	92.0	9.4		
>38-53 cm	32.0	2.2	21.9	3.3			31.4	2.2	26.7	5.3		
>53-68 cm	9.1	1.1	6.9	2.2			8.0	1.0	14.2	2.9		
>68 cm	3.4	0.6	4.4	1.6			3.5	0.6	3.4	1.3		
Snags (>8 cm)	46.3	4.5	41.3	6.5			44.0	4.2	56.3	12.4		

Table 16 cont.

<u>Canopy Cover (%)</u>:												
>0.5-3 m	49.4	1.8	60.9	3.8			49.9	1.9	56.1	3.9		
>3-6 m	59.0	1.8	65.6	3.6			59.9	1.8	58.4	5.1		
>6-12 m	64.2	1.4	66.0	2.6			65.3	1.2	58.8	4.8		
>12-18 m	60.5	1.8	58.6	4.3			62.8	1.7	43.2	3.5	9.061	0.003-
>18 m	48.2	2.4	39.0	6.2			49.0	2.3	34.2	6.3		
>24 m	18.7	1.7	6.4	2.5	5.499	0.019-	17.3	1.8	17.2	4.0		
Structural Diversity Index	60.0	1.1	59.3	1.5			60.8	1.0	53.6	2.6		
Hosmer-Lemeshow Goodness-of-fit Test					6.326	0.611					4.361	0.823

Table 17. Means and standard errors (SE) of habitat variables in relation to presence/absence of Summer Tanagers in forested habitats in southwestern West Virginia. No variables were chosen by stepwise logistic regression for predicting Summer Tanager presence.

	Summer Tanager			
	Absent (n=70)		Present (n=15)	
Variable	Mean	SE	Mean	SE
Aspect Code	1.1	0.1	1.0	0.2
Slope (%)	33.5	1.8	35.2	2.4
Elevation	363.6	8.3	383.5	20.9
Distance to minor edge (m)	52.6	7.4	58.4	20.1
Distance to habitat edge (m)	906.5	122.0	961.4	266 .1
Canopy height (m)	22.6	0.6	21.6	1.0
Ground Cover (%):				
Water	0.9	0.2	0.2	0.2
Bareground/rock	7.8	0.6	6.3	1.1
Leaf litter	50.4	1.5	52.6	3.1
Woody debris	4.5	0.3	5.1	0.6
Moss	1.9	0.2	2.5	0.8
Green	34.1	1.5	33.3	3.6
Tree Density (no./ha):				
≤2.5 cm	5240.2	428.8	7435.4	1541.8
>2.5-8 cm	722.8	49.4	708.3	119.8
>8-23 cm	287.1	16.5	332.1	51.2
>23-38 cm	90.9	4.1	87.1	6.7
>38-53 cm	30.6	2.0	31.7	6.4
>53-68 cm	8.4	1.1	10.8	2.7
>68 cm	3.3	0.6	4.6	1.6
Snags (>8 cm)	43.8	4.0	54.2	12.8
Canopy Cover (%):				
>0.5-3 m	50.3	1.9	52.4	3.6
>3-6 m	60.0	1.8	58.3	4.5
>6-12 m	64.8	1.4	62.9	2.9
>12-18 m	60.6	1.9	58.4	4.1
>18 m	47.3	2.5	46.2	5.2
>24 m	16.6	1.7	20.3	4.2
Structural Diversity Index	59.9	1.0	59.7	2.7

Table 18. Mist net effort and the distribution of Grasshopper Sparrows captured and banded on study sites.

Site	Males	Females	Juveniles	Total Captures	Net Hours	Captures/Net Hour
CL1	21	7	2	29	124.00	0.23
CV2	11	7	3	21	72.25	0.29
DN2	29	7	2	22	85.00	0.26
DR1	27	3	14	56	217.63	0.26
HA1	30	3	6	40	210.25	0.19
HN2	22	6	2	25	76.50	0.33
Overall	140	33	29	193	785.63	0.25

Table 19. Systematic nest search effort and mean and SE of clutch size for Grasshopper Sparrow nests in the 2001 breeding season by site.

Site	Search effort (hrs)	No. Nests Found	Nests/hr	Clutch size	
				Mean	SE
CL1	72.57	4	0.06	3.25	0.75
CV2	44.33	3	0.07	4.00	0.00
DN2	48.91	10	0.20	3.80	0.33
DO1	0.33	2	6.06	3.50	0.50
DR1	26.00	5	0.19	3.40	0.60
HA1	108.50	7	0.65	3.88	0.23
HN2	69.24	4	0.06	3.67	0.67
HO1	2.00	2	0.50	4.50	0.50
Overall	372.14	37	0.10	3.73	0.16

Table 20. Mean and standard error (SE) of nest variables and habitat variables surrounding successful (n=17) and unsuccessful (n=20) nests of Grasshopper Sparrows on MTRVF areas in 2001. One-way analysis of variance (ANOVA) was used to compare habitat variables between successful and unsuccessful nests (α=0.05).

	Successful		Unsuccessful		ANOVA	
Variable	Mean	SE	Mean	SE	*F*	*P*
Slope Aspect (degrees)	161.70	22.20	167.70	21.40	0.04	0.41
Slope (%)	12.30	2.90	8.30	3.00	0.90	0.35
Overhead Cover (%)	73.70	6.40	75.00	4.80	0.03	0.87
Side Cover (%)						
North	82.40	4.20	82.50	4.80	0.00	0.98
South	91.20	4.30	93.80	3.10	0.25	0.62
East	80.90	5.50	77.50	4.80	0.22	0.64
West	92.60	4.70	87.70	5.80	0.43	0.52
Distance to Minor Edge (m)	24.60	7.60	34.10	8.80	1.45	0.23
Ground Cover (%)						
Green	73.20	3.70	79.10	3.80	1.22	0.28
Grass	40.40	2.90	38.50	3.60	0.16	0.69
Forb	27.90	2.80	28.90	2.50	0.06	0.80
Shrub	0	0	0.01	0.01	0.85	0.36
Litter	8.30	1.20	8.30	0.90	0.00	0.97
Wood	0	0	0	0	-	-
Bare ground	20.90	3.80	18.40	3.04	0.27	0.61
Moss	2.20	0.70	2.90	1.01	0.41	0.53
Water	0	0	0	0	-	-
Robel Pole Index (dm)						
Nest	3.13	0.24	4.01	0.03	6.56	0.01
1m	3.17	0.29	4.28	0.31	6.69	0.01
3m	3.65	0.34	4.12	0.31	1.12	0.29
5m	3.71	0.30	3.88	0.32	0.14	0.71
Grass Height (dm)						
1m	2.91	0.19	3.26	0.19	2.01	0.16
3m	3.22	0.24	7.69	4.60	0.83	0.37
5m	3.27	0.23	3.24	0.23	0.002	0.96
10m	3.50	0.20	3.90	0.24	1.33	0.25
Litter depth (cm)						
1m	0.21	0.04	0.20	0.03	0.03	0.86
3m	0.30	0.05	0.25	0.04	0.66	0.42
5m	0.23	0.04	0.27	0.04	0.46	0.50
10m	0.24	0.04	0.30	0.04	1.03	0.31
Nest substrate height (veg)	3.75	0.22	4.27	0.28	0.44	0.51
Nest substrate height (repro)	7.65	0.47	7.00	0.41	1.06	0.31
Nest Clump Area (cm^2)	1,216.53	142.70	1,387.98	146.71	0.69	0.41
Distance to foliage edge (cm)	19.20	3.50	20.10	2.20	0.05	0.83
Nest depth (cm)	5.80	0.31	5.90	0.22	0.15	0.70
Nest width (cm)	6.60	0.15	6.50	0.12	0.19	0.66
Nest rim width (cm)	1.97	0.10	1.98	0.07	0.01	0.94
Nest rim height (cm)	1.80	0.27	1.50	0.23	1.05	0.31

Table 21. Mean and standard error (SE) for habitat variables measured at nests (N=37) and fixed habitat plots (N=48) sampling points. One-way analysis of variance (ANOVA) was used to compare habitat variables between successful and unsuccessful nests (α=0.05).

	Nests		Habitat Plots		ANOVA	
Variable	Mean	SE	Mean	SE	*F*	*P*
Slope Aspect	164.90	15.20	207.15	17.50	3.09	0.08
Slope (%)	10.10	2.10	10.90	2.10	0.07	0.79
Distance to Minor Edge (m)	29.73	5.89	40.67	6.98	0.63	0.43
Ground Cover (%)						
Green	76.40	0.70	87.44	2.60	574.53	<0.0001
Grass	39.40	2.30	57.55	2.60	26.25	<0.0001
Forb	28.50	1.90	27.40	2.20	0.15	0.70
Shrub	0.01	0.01	0.05	0.05	0.56	0.46
Litter	8.31	0.70	5.70	0.64	7.56	0.01
Wood	0	0	0	0	-	-
Bare ground	19.60	2.40	7.14	1.20	24.73	<0.0001
Moss	2.60	0.60	1.34	0.41	3.05	0.08
Water	0	0	0	0	-	-
Robel Pole Index (dm)						
nest	3.60	0.19	1.50	0.07	24.16	<0.0001
1m	3.77	0.22	2.16	0.08	56.14	<0.0001
3m	3.91	0.23	2.05	0.09	67.41	<0.0001
5m	3.80	0.22	2.11	0.10	56.93	<0.0001
Grass Height (dm)						
1m	3.11	0.13	5.91	2.28	1.73	0.28
3m	5.63	2.48	3.62	0.11	0.85	0.36
5m	3.25	0.16	3.80	0.11	7.79	0.01
10m	3.70	0.16	4.03	0.13	2.63	0.11
Litter depth (cm)						
1m	0.21	0.02	0.13	0.01	7.53	0.01
3m	0.27	0.03	0.17	0.03	4.68	0.03
5m	0.26	0.03	0.15	0.03	6.80	0.01
10m	0.27	0.03	0.15	0.02	15.96	<0.001

Table 22. Percentage of adult *Peromyscus* spp. individuals in reproductive condition among grassland, shrub/pole, fragmented forest, and intact forest treatments in 1999 and 2000 in southwestern West Virginia.

	Treatment										
	Grassland		Shrub/Pole		Fragmented Forest		Intact Forest		ANOVA Results		
Comparison	%	N[a]	%	N	%	N	%	N	*F*	df	*P*
<u>Among Treatments</u>											
1999											
Males	65.5A[b]	14	-[c]	- -	39.9B	15	25.4B	16	7.18	2	0.0026
Females	41.9A	15	-	- -	13.4B	16	4B	16	9.11	2	0.0002
Total	48.3A	16	-	- -	25B	16	12C	16	11.33	2	0.0002
2000											
Males	79.8A	19	85.3A	11	83.3A	16	82.5A	19	0.45	3	0.7179
Females	55.8A	19	68.3A	12	54.5A	19	22.6B	16	4.57	3	0.0068
Total	66.2A	20	74.7A	12	63.2A	19	52.5A	16	1.05	3	0.3802

<u>Between Years</u>

ANOVA Results	Grassland *F*	df	*P*	Shrub/Pole *F*	df	*P*	Fragmented Forest *F*	df	*P*	Intact Forest *F*	df	*P*	ANOVA Results *F*	df	*P*
Males	0.88	1	0.3586	-[c]	-	-	19.19	1	0.0002	33.73	1	<0.0001	-	-	-
Females	1.51	1	0.2302	-	-	-	14.5	1	0.0008	0.39	1	0.5360	-	-	-
Total	3.32	1	0.0795	-	-	-	17.33	1	0.0003	15.42	1	0.0007	-	-	-

[a] N= number of trapping sessions multiplied by the number of transects in a given treatment.
[b] Means followed by different letters within a row are significantly different from one another (Waller-Duncan k-ratio t-test, $P \leq 0.05$).
[c] The shrub/pole treatment was not sampled in 1999.

Table 23. Relative abundance (mammals/100 trap nights), and standard error (SE) of *Peromyscus* spp. age and sex groups in grassland, shrub/pole, fragmented forest, and intact forest treatments in southwestern West Virginia for 1999 and 2000.

	Treatment												ANOVA Results	
	Grassland			Shrub/Pole			Fragmented Forest			Intact Forest				
	Mean	SE	N[a]	Mean	SE	N	Mean	SE	N	Mean	SE	N	*F*	*P*
1999														
Adult Males	4.0A[b]	2.8	16	-[c]	-	-	1.8B	1.4	16	1.4B	1.6	16	8.20	0.0012
Adult Females	2.1A	1.4	16	-	-	-	1.9AB	1.2	16	1.0B	1.2	16	3.51	0.0404
Juvenile Males	4.5A	3.3	16	-	-	-	3.9A	1.5	16	5.3A	4.0	16	1.03	0.3656
Juvenile Females	2.2A	2.0	16	-	-	-	3.1A	2.1	16	3.6A	2.7	16	2.11	0.1356
2000														
Adult Males	6.2A	4.9	20	5.9A	3.8	12	2.3B	1.9	20	1.1B	1.8	20	13.13	<0.0001
Adult Females	5.7A	4.0	20	6.2A	4.2	12	1.8B	1.4	20	1.9B	2.1	20	14.54	<0.0001
Juvenile Males	4.6A	4.0	20	3.9AB	2.1	12	1.3C	1.2	20	2.5BC	3.0	20	5.99	0.0013
Juvenile Females	3.8A	3.7	20	2.9A	2.5	12	0.7B	1.1	20	1.2B	3.0	20	7.50	0.0003

[a] N=number of trapping sessions multiplied by the number of transects in a given treatment.
[b] Means followed by different letters within a row are significantly different from one another (Waller-Duncan k-ratio t-test, $P \leq 0.05$).
[c] The shrub/pole treatment was not sampled in 1999.

Table 24. Results of multiple linear regression of mammal species richness, total abundance, and *Peromyscus* spp. abundance on habitat and environmental variables for shrub/pole, fragmented forest, and intact forest treatments. Significant variables in the model are listed below the dependent variable.

Variable	Parameter Estimate	*F*	*P*	Partial R^2	Model R^2
Richness					
Low Temp.	-0.0912	8.61	0.0044	0.0995	0.0995
Precip.	-0.2039	9.43	0.0030	0.0982	0.1977
Bare ground (%)	1.0570	4.60	0.0351	0.0458	0.2435
Total Abundance					
Canopy Cover >0.5-3 m	-16.4071	21.03	<0.0001	0.2123	0.2123
Canopy Height	-0.5107	8.82	0.0040	0.0809	0.2932
Precipitation	-2.0173	9.88	0.0024	0.0813	0.3745
Bare ground (%)	16.6469	11.43	0.0011	0.0827	0.4572
Low Temp.	-0.6224	9.16	0.0034	0.0598	0.5170
Peromyscus spp. abundance					
Canopy Cover >0.5-3 m	-17.0509	34.86	<0.0001	0.3088	0.3088
Canopy Height	-0.4884	12.35	0.0007	0.0955	0.4044
Bare ground (%)	12.2341	7.32	0.0084	0.0523	0.4567
Precip.	-1.3118	8.11	0.0057	0.0530	0.5098

Table 25. Results of multiple linear regression of mammal species richness, total abundance, and *Peromyscus* spp. abundance on habitat and environmental variables for grassland treatment. Significant variables in the model are shown below the dependent variable.

Variable	Parameter Estimate	*F*	*P*	Partial R^2	Model R^2
Richness					
Average grass height	0.2297	10.60	0.0026	0.2376	0.2376
Total Abundance					
Green groundcover	99.9693	5.19	0.0295	0.3699	0.3699
Precipitation	2.1868	5.79	0.0221	0.0673	0.4372
Bareground	-44.4321	4.08	0.0518	0.0637	0.5009
Peromyscus spp. abundance					
Bare ground (%)	-73.4487	15.88	0.0004	0.4454	0.4454
Precipitation	2.1953	7.11	0.0119	0.0942	0.5396
Shrub	3.0591	5.77	0.0223	0.0703	0.6099

Table 26. Results of logistic regression of short-tailed shrew, woodland jumping mouse, and chipmunk abundance on habitat and environmental variables within the shrub/pole, fragmented forest, and intact forest treatments.

Variable	Parameter Estimate	χ^2	*P*
<u>Short-tailed shrew</u>			
Bareground	4.36	4.2922	0.0383
Model		1.2314	0.8729
<u>Woodland jumping mouse</u>			
Moon illumination	-2.81	5.2752	0.0216
Water	7.84	4.0787	0.0434
Canopy Cover >0.5-3 m	8.33	3.625	0.0569
Model		8.5362	0.3829
<u>Eastern Chipmunk</u>			
Water	-22.14	9.0245	0.0027
Bareground	8.92	5.8598	0.0155
Canopy cover >12 m	6.25	5.6034	0.0179
Tree density >8-38 cm	0.01	8.378	0.0038
Model		32.8363	<0.0001

Table 27. Average mammalian species richness (# species/array), relative abundance (mammals/100 trap nights), and standard errors (SE) in grassland,shrub/pole, fragmented forest, and intact forest treatments in southwestern West Virginia in 2000 and 2001.

	Treatment												ANOVA Results	
	Grassland			Shrub/Pole			Fragmented Forest			Intact Forest				
	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	*F*	*P*
Species Richness	39	2.85 A[a]	0.25	39	2.74 A	0.21	39	2.82 A	0.28	41	1.88 B	0.24	5.58	0.0014
Relative Abundance														
Total	39	10.37 A	1.19	39	9.39 A	1.11	39	9.48 A	1.64	41	4.82 B	0.85	5.70	0.0012
Peromyscus spp.	39	4.52 A	0.73	39	3.61 AB	0.74	39	3.20 AB	0.73	41	1.77 B	0.48	3.31	0.0229
Woodland jumping mouse	39	0.03 B	0.03	39	0.05 B	0.04	39	0.53 A	0.14	41	0.08 B	0.08	7.53	0.0001
Southern bog lemming	39	1.45 A	0.34	39	0.98 A	0.25	39	0.20 B	0.09	41	0.00 B	0.00	9.51	<0.0001
Woodland vole	39	0.09 B	0.05	39	0.36 AB	0.12	39	0.44 AB	0.13	41	0.57 A	0.20	2.34	0.0778
Meadow vole	39	0.21 A	0.08	39	0.17 A	0.09	39	0.30 A	0.11	41	0.05 A	0.04	1.72	0.1674
Microtus spp. [b]	39	0.58 A	0.17	39	0.62 A	0.17	39	1.18 A	0.32	41	0.85 A	0.30	1.45	0.2317
Short-tailed shrew	39	0.45 B	0.20	39	0.51 B	0.15	39	2.66 A	0.81	41	0.52 B	0.16	10.58	<0.0001
Masked shrew	39	2.20 AB	0.44	39	2.94 A	0.71	39	1.14 BC	0.37	41	0.97 C	0.24	4.74	0.0038
Smoky shrew	39	0.27 A	0.10	39	0.12 A	0.06	39	0.14 A	0.07	41	0.23 A	0.10	0.79	0.5008
Pygmy shrew	39	0.06 AB	0.04	39	0.03 B	0.03	39	0.26 A	0.09	41	0.17 AB	0.07	2.51	0.0630
Sorex spp.[c]	39	3.28 A	0.56	39	3.62 A	0.76	39	1.69 B	0.41	41	1.55 B	0.32	4.73	0.0039

[a] Means followed by different letters within a row are significantly different (Waller-Duncan k-ratio t-test, P<0.05).
[b] Combines woodland voles, meadow voles, and unidentified *Microtus* spp.
[c] Combines masked shrews, smoky shrews, pygmy shrews, and unidentified *Sorex* spp.

Table 28. Habitat characteristics at forest fragment streams (n=4) and intact forest streams (n=3) by stream order[a].

Site No.	Segment	Substrate Type	Channel Type	No. of Coarse Woody Debris Sampled	No. of Rocks Sampled
Forest Fragment Streams – Second Order					
5	1	SR, RG	RI	NR[b]	NR
	2	SR, RG	RI	7	480
	3	SR, RG	RI	12	137
	4	SR, RG, BA	RI	6	1554
	5	SR, RG, BA	RI	19	821
44	1	SR, RG, WD	PO, RU	NR	NR
	2	SR, RG, WD	RU	74	71
	3	SR, RG, WD	RU	N4	NR
	4	SR, RG, BA, WD	RI, PO, RU	95	75
	5	SR, RG, BA, WD	RI, PO, RU	104	127
131	1	SR, RG, LR	RA	NR	NR
	2	SR, RG, LR	RA	5	457
	3	SR, RG, LR, BL	RA, PO	0	343
	4	SR, RG, BA, LR	RI	6	1266
	5	SR, RG, BA	RI, PO	25	1935
173	1	SR, RG, BA, WD	RI, PO	19	3012
	2	SR, RG, BA	RI	0	1495
Intact Forest Streams – Ephemeral					
112	1	SR, LR	RI, PO, CA	NR	NR
	2	SR, LR	DR	37	527
	5	SR, LR, BA	DR	28	1144
Intact Forest Streams – First Order					
112	3	SR, R/G	RI, PO	9	342
	4	SR, R/G, BA	RI, PO	3	2928
165	1	SR, LR	RI, PO	NR	NR
	2	SR, WD	PO	46	140
	3	SR, WD	DR	NR	NR
	4	SR, BA, WD	DR, PO	NR	NR
	5	SR, BA, WD, LR	DR, PO	111	698
Intact Forest Streams – Second Order					
21	1	SR	RI	NR	NR
	2	SR	RI	38	579
	3	SR, RG, WD	RI	NR	NR
	4	SR, WD	RI, PO	61	1473
	5	SR, WD	RI, PO	3	1219

[a] Habitat characteristics based on protocol used by USGS Patuxent Wildlife Research Center (Jung et al. 1999).

BA = bank (river edge, soil, lacks rocks)
BL = boulder (> 1.5 m in diameter)
LR = large rocks (0.5-1.5 m in diameter)
SR = small rocks (0.1-0.5 m in diameter)
RG = rubble / gravel (< 0.1 m in diameter)
WD = woody debris

RU = run (smooth current)
RA = rapid (fast current broken by obstructions)
PO = pool (standing water)
CA = cascade (water flowing over slanting rocks)
RI = riffle (ripples and waves)
DR = dry (no visible moisture or water)

[b] NR = Not recorded

Table 29. Species expected (Exp) to occur in grassland, shrub/pole, fragmented forest, and intact forest treatments in our study area in southwestern West Virginia based on Green and Pauley (1987) and personal communication with T. Pauley, compared to those actually observed (Obs) in drift fence surveys (a), stream searches (s), and from incidental sightings (i), March – October 2000 and 2001.

Species	Grassland		Shrub/ pole		Fragmented Forest		Intact Forest	
	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
<u>Terrestrial species</u>								
Salamanders								
Cumberland Plateau Salamander (*Plethodon kentucki*)					x		x	a,s,i
Southern Ravine Salamander (*Plethodon richmondi*)					x		x	
Eastern Red-backed Salamander (*Plethodon cinereus*)		i			x	i	x	a,s,i
Northern Slimy Salamander (*Plethodon glutinosus*)					x	a	x	a
Wehrle's Salamander (*Plethodon wehrlei*)					x		x	
Lizards								
Broad-headed Skink (*Eumeces laticeps*)					x		x	
Common Five-lined Skink (*Eumeces fasciatus*)	x		x	a	x	a	x	a
Little Brown Skink (*Scincella lateralis*)		a			x		x	a
Coal Skink (*Eumeces anthracinus*)	x		x		x		x	
Northern Fence-lizard (*Sceloporus undulatus hyacinthinus*)	x	a,i		a,i		i		
Snakes								
Eastern Black Kingsnake (*Lampropeltis getulus niger*)	x		x		x		x	
Black Rat Snake (*Elaphe o. obsoleta*)	x	a,i	x	a,i	x	a	x	i
Eastern Smooth Earthsnake (*Virginia v. valeriae*)	x		x		x		x	
Eastern Gartersnake (*Thamnophis s. sirtalis*)	x	a	x	a	x	a,i	x	a,i
Eastern Hog-nosed Snake (*Heterodon platirhinos*)	x	a,i		a				
Eastern Milksnake (*Lampropeltis t. triangulum*)	x	a	x	a	x	a	x	a,i
Smooth Greensnake (*Opheodrys vernalis*)	x			i				i
Eastern Wormsnake (*Carphophis a. amoenus*)	x		x		x		x	a
Northern Black Racer (*Coluber c. constrictor*)	x	a,i	x	a		i		i
Northern Brownsnake (*Storeria d. dekayi*)	x		x		x		x	
Northern Copperhead (*Agkistrodon contortrix mokasen*)		a		a	x	a	x	a,i
Northern Red-bellied Snake (*Storeria o. occipitomaculata*)	x		x		x	a	x	a,i
Northern Ring-necked Snake (*Diadophis punctatus edwardsii*)					x	s	x	i
Northern Rough Greensnake (*Opheodrys a. aestivus*)	x		x	i	x		x	i
Timber Rattlesnake (*Crotalus horridus*)[a]				i	x		x	i
Turtles								
Eastern Box Turtle (*Terrapene c. carolina*)	x	i	x	i	x	a,i	x	a,i
<u>Semiaquatic species</u>								
Salamanders								
Jefferson Salamander (*Ambystoma jeffersonianum*)					x		x	
Marbled Salamander (*Ambystoma opacum*)					x		x	
Spotted Salamander (*Ambystoma maculatum*)		a,i		a	x	a	x	a
Green Salamander (*Aneides aeneus*)					x		x	
Four-toed Salamander (*Hemidactylium scutatum*)		a			x	a	x	
Red-spotted Newt (*Notophthalmus v. viridescens*)		a,i		a,i	x	a,s,i	x	a,s,i
Toads and Frogs								
Eastern American Toad (*Bufo a. americanus*)	x	a,i	x	a,i		a,i		a,i
Fowler's Toad (*B. fowleri*)[b]		a	x			s,i		

Table 29. Continued.

Species	Grassland Exp	Grassland Obs	Shrub/pole Exp	Shrub/pole Obs	Fragmented Forest Exp	Fragmented Forest Obs	Intact Forest Exp	Intact Forest Obs
Toads and Frogs (cont'd)								
Eastern Spadefoot (*Scaphiopus holbrookii*)					x		x	
Cope's Gray Treefrog (*Hyla chrysoscelis*)				a,i	x	i	x	i
Northern Spring Peeper (*Pseudacris c. crucifer*)		i		a,i	x	i	x	i
Mountain Chorus Frog (*Pseudacris brachyphona*)				i	x		x	i
Wood Frog (*Rana sylvatica*)					x	a	x	a,i
Northern Leopard Frog (*Rana pipiens*)	x		x	a	x	a,i	x	
Pickerel frog (*Rana palustris*)	x	a	x	a,i	x	a,s,i	x	a,s,i
Aquatic species								
Salamanders								
Seal Salamander (*Desmognathus monticola*)					x	a,s,i	x	a,s,i
Northern Dusky Salamander (*D.fuscus*)					x	a,s,i	x	s,i
Eastern Hellbender (*Cryptobranchus a. alleganiensis*)					x		x	
Midland Mud Salamander (*Pseudotriton montanus diastictus*)					x		x	
Common Mudpuppy (*Necturus m. maculosus*)	x		x		x		x	
Northern Red Salamander (*Pseudotriton r. ruber*)	x		x		x	s	x	a,s
Southern Two-lined Salamander (*Eurycea cirrigera*)					x	a,s,i	x	s,i
Long-tailed Salamander (*Eurycea l. longicauda*)	x		x		x	s,i	x	
Northern Spring Salamander (*Gyrinophilus p. porphyriticus*)					x	s	x	s,i
Toads and Frogs								
American Bullfrog (*Rana catesbeiana*)	x	a,i	x	a,i	x	a,s	x	s
Northern Green Frog (*Rana clamitans melanota*)	x	a,i	x	a,i	x	a,s,i	x	a,i
Snakes								
Common Watersnake (*Nerodia s. sipedon*)	x	a	x	a	x	s,i	x	
Queen Snake (*Regina septemvittata*)					x		x	
Turtles								
Eastern Snapping Turtle (*Chelydra s. serpentina*)	x	i	x	i	x	i	x	
Eastern Spiny Softshell Turtle (*Apalone s. spinifera*)[c]	x		x		x		x	
Midland Painted Turtle (*Chrysemys picta marginata*)	x		x		x		x	
Stinkpot (*Sternotherus odoratus*)	x		x		x		x	

[a] One incidental sighting of a timber rattlesnake was also found on the edge between shrub/pole and fragmented forest habitats.

[b] One incidental sighting of a Fowler's toad was also found on the edge between shrub/pole and fragmented forest habitats.

[c] One incidental sighting of an eastern spiny softshell turtle was also found on the edge between grassland and fragmented forest habitats.

Table 30. Number of individuals of herpetofauna species captured in drift fence arrays and percent of points at which a species was captured in grassland (n = 3), shrub/pole (n = 3), fragmented forest (n = 3), and intact forest treatments (n = 4)[a] on reclaimed MTMVF areas in southwestern West Virginia, March - October, 2000 and 2001.

	Grassland		Shrub/pole		Fragmented Forest		Intact Forest	
Species	No. indivs	% of points	No. indivs	% of points	No. indivs	% of points	No. indivs	% of points
Salamanders								
Seal Salamander					1	33	1	25
Cumberland Plateau Salamander							12	75
Four-toed Salamander	1	33			1	33		
Southern Two-lined Salamander					2	33		
Northern Dusky Salamander					1	33		
Northern Red Salamander							2	50
Eastern Red-backed Salamander							5	25
Red-spotted Newt	9	100	13	100	26	100	22	100
Northern Slimy Salamander					5	33	2	25
Spotted Salamander	1	33	1	33	1	33	1	25
Toads and frogs								
American Bullfrog	2	33	4	100	2	66		
Eastern American Toad	9	66	35	100	3	66	20	75
Fowler's Toad	2	33						
Cope's Gray Treefrog			2	33				
Northern Green Frog	52	100	46	100	44	100	6	75
Northern Leopard Frog			2	33	2	33		
Northern Spring Peeper			1	33				
Pickerel Frog	43	100	25	66	48	100	19	50
Unidentified Frog	5	66	2	33			1	25
Unidentified Toad					1	33		
Wood Frog					2	66	5	75
Lizards								
Common Five-lined Skink			2	66	4	33	2	50
Little Brown Skink	1	33					1	25
Northern Fence-Lizard	2	66	2	33				
Snakes								
Black Ratsnake	5	66	6	100	1	33		
Eastern Gartersnake	6	66	6	66	10	100	8	25
Eastern Hog-nosed Snake	1	33	2	33				
Eastern Milksnake	4	33	3	66	4	66	1	25
Eastern Wormsnake							2	25
Northern Black Racer	9	100	27	100				
Northern Copperhead	1	33	8	100	4	66	5	25
Northern Red-bellied Snake					1	33	1	25
Common Watersnake	1	33	1	33				
Turtles								
Eastern Box Turtle					2	66	1	25

[a] A 4th drift fence array was installed in one of the intact forest points and opened for trapping in September and October, 2001.

Table 31. Herpetofaunal species richness and relative abundance from drift fence arrays in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in southwestern West Virginia, March - October 2000 and 2001 (adjusted for trap effort per 100 array nights).

	Grassland		Shrub/pole		Fragmented Forest		Intact Forest	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Species richness	1.89	0.28 B[a]	2.70	0.26 A	2.88	0.32 A	2.24	0.25 AB
Abundance								
Total	4.46	1.20 A	5.41	0.96 A	5.29	0.83 A	3.41	0.43 A
Amphibians	3.38	1.19 A	3.62	0.95 A	4.42	0.77 A	2.80	0.43 A
Reptiles	0.99	0.23 B	1.77	0.29 A	0.85	0.19 B	0.58	0.16 B
Terrestrial Species	0.19	0.10 A	0.17	0.09 A	0.36	0.12 A	0.22	0.09 A
Aquatic Species	1.51	0.74 A	1.41	0.37 A	1.59	0.51 A	0.25	0.09 A
Semi-aquatic Species	1.91	0.86 A	2.24	0.74 A	2.64	0.43 A	1.87	0.36 A
Salamanders	0.33	0.12 B	0.44	0.13 B	1.20	0.25 A	1.50	0.34 A
Toads and frogs	3.05	1.17 A	3.18	0.93 A	3.20	0.67 A	1.31	0.28 A
Snakes	0.90	0.22 B	1.64	0.27 A	0.67	0.14 B	0.46	0.15 B
Red-spotted Newt	0.26	0.10 A	0.41	0.13 A	0.83	0.20 A	0.69	0.27 A
Eastern American Toad	0.26	0.12 AB	0.98	0.49 A	0.10	0.06 B	0.52	0.13 AB
Northern Green Frog	1.40	0.74 A	1.25	0.35 A	1.40	0.47 A	0.15	0.06 A
Pickerel Frog	1.22	0.67 A	0.67	0.27 A	1.52	0.30 A	0.48	0.20 A
Eastern Gartersnake	0.19	0.10 A	0.17	0.09 A	0.36	0.12 A	0.22	0.09 A
Northern Black Racer	0.32	0.11 B	0.84	0.17 A	0.00	0.00 C	0.00	0.00 C

[a] Within a row, means with the same letter are not different at $\alpha = 0.05$ (Waller Duncan K-ratio t Test).

Table 32. Number of individuals and species of herpetofaunal groups captured in drift fence arrays in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in southwestern West Virginia, March-October, 2000 and 2001.

	Grassland				Shrub/pole				Fragmented Forest				Intact Forest			
	Individuals		Species		Individuals		Species		Individuals		Species		Individuals		Species	
Taxonomic Group	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Salamanders	11	7.1	3	17.6	14	7.4	2	11.1	37	22.4	7	35.0	45	38.4	7	36.8
Toads and frogs	113	73.4	5	29.4	118	62.4	7	38.9	102	61.8	6	30.0	51	43.6	4	21.1
Lizards	3	2.0	2	11.8	4	2.1	2	11.1	4	2.4	1	5.0	3	2.6	2	10.5
Snakes	27	17.5	7	41.2	53	28.1	7	38.9	20	12.1	5	25.0	17	14.5	5	26.3
Turtles	0	0.0	0	0.0	0	0.0	0	0	2	1.2	1	5.0	1	0.9	1	5.3

Table 33. Mean and standard error (SE) for habitat variables measured at grassland (n=3), shrub/pole (n=3), fragmented forest (n=3), and intact forest (n=3) sampling points [a].

	Treatment							
	Grassland		Shrub/Pole		Fragmented Forest		Intact Forest	
Variables	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Slope (%)	20.67	8.97	4.42	4.42	28.42	7.53	22.58	9.38
Aspect Code	1.62	0.06	0.60	0.57	0.73	0.14	0.68	0.13
Grass/Forb Height (dm)	6.80	1.69	4.09	1.91	-- [b]	--	--	--
Litter Depth (cm)	2.60	1.04	1.06	0.33	--	--	--	--
Elevation (m)	413.67	37.95	412.00	39.53	335.00	20.95	444.67	66.23
Distance to Minor Edge (m)	94.00	48.19	61.00	8.79	54.92	19.44	118.75	91.04
Distance to Habitat Edge (m)	408.73	324.42	68.8	15.66	175.87	77.46	1744.97	562.73
Distance to Forest/Mine Edge (m)	535.12	267.58	271.11	187.46	175.87	77.46	1744.97	562.73
Robel Pole Index	3.07	0.71	4.98	0.40	--	--	--	--
Canopy Height (m)	--	--	3.40	0.75	22.9	1.59	22.4	1.85
Ground Cover (%)								
Water	0.00	0.00	0.33	0.22	0.42	0.30	0.08	0.08
Bareground	1.33	0.79	0.5	0.14	0.83	0.08	1.83	0.71
Litter	2.42	1.53	1.67	1.67	11.50	0.63	10.58	1.23
Woody Debris	0.00	0.00	0.00	0.00	0.75	0.14	0.58	0.17
Moss	0.00	0.00	0.75	0.63	0.17	0.08	1.17	0.58
Green	16.25	1.26	15.08	2.93	6.33	0.30	5.75	0.90
Forb Cover	5.75	2.75	6.17	0.60	--	--	--	--
Grass Cover	6.75	2.38	4.42	2.19	--	--	--	--
Shrub Cover	3.75	3.63	4.50	1.13	--	--	--	--
Stem Densities (no./ha)								
<2.5 cm	42.00	41.50	5156.25	2044.75	2854.17	1464.90	6843.75	1043.18
>2.5-6 cm	0.00	0.00	406.25	62.5	562.50	118.31	343.75	160.36
>8-23 cm	0.00	0.00	85.42	33.53	225.00	71.90	275.00	74.56
>23-38 cm	0.00	0.00	0.00	0.00	68.75	25.26	81.25	19.09
>38-53 cm	0.00	0.00	0.00	0.00	33.33	11.60	10.42	2.08
>53-68 cm	0.00	0.00	0.00	0.00	2.08	2.08	2.08	2.08
>68 cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canopy Cover (%)								
>0.5-3 m	--	--	5.58	1.34	9.92	2.05	10.75	2.22
>3-6 m	--	--	4.00	2.08	13.00	1.44	10.42	1.52
>6-12 m	--	--	1.58	1.46	12.67	2.35	13.33	0.36
>12-18 m	--	--	0.00	0.00	10.17	0.79	14.67	1.45
>18-24 m	--	--	0.00	0.00	6.33	3.17	10.17	2.34
>24 m	--	--	0.00	0.00	3.83	2.00	2.75	2.38
Structural Diversity Index	--	--	11.17	4.69	55.92	2.42	62.08	5.60

[a] This table does not include habitat variables for the most recently added intact sampling point (herp data collection started September 2001 for this point).
[b] Variables were not measured in this treatment.

Table 34. Number of individuals and species of herpetofauna groups captured in stream surveys in fragmented forest streams and intact forest streams on reclaimed MTMVF areas in southwestern West Virginia, May-October, 2001.

	Fragmented Forest Streams				Intact Forest Streams			
	Individuals		Species		Individuals		Species	
Taxonomic Group	n	%	n	%	n	%	n	%
Salamanders	270	93.4	7	53.8	386	99.2	8	80.0
Toads and frogs	16	5.5	4	30.8	3	0.8	2	20.0
Lizards	0	0.0	0	0.0	0	0.0	0	0.0
Snakes	3	1.1	2	15.4	0	0.0	0	0.0
Turtles	0	0.0	0	0.0	0	0.0	0	0.0

Table 35. Mean and standard error (SE) of stream salamanders per segment of fragmented forest streams and intact forest streams on reclaimed MTMVF areas in southwestern West Virginia, May–October 2001.

Treatments							
Fragmented Forest Streams				Intact Forest Streams			
Site No.	No. Segments Sampled	Mean	SE	Site No.	No. Segments Sampled	Mean	SE
Second Order				Ephemeral			
5	5	5.4	0.93	112	3	21.0	6.11
44	5	1.8	0.97				
131	5	19.4	7.53	First Order			
173	2	68.5	7.50	112	2	45.0	25.00
				165	5	30.6	9.08
				Second Order			
				21	5	16.0	2.74

Table 36. Number of individuals and species of herpetofaunal groups captured in stream surveys in second order fragmented forest streams (n=4 streams, 17 35-m stream segments sampled), ephemeral intact forest streams (n=1 stream, 3 35-m stream segments sampled), first order intact forest streams (n=2, 7 35-m stream segments sampled), and second order intact forest treatments (n=1, 5 35-m stream segments sampled) on reclaimed MTMVF areas in southwestern West Virginia, May-October, 2001.

	Treatment			
	Fragmented Forest	Intact Forest		
Species	Second Order	Ephemeral	First Order	Second Order
Salamanders				
Cumberland Plateau Salamander		1		
Eastern Red-backed Salamander		8		
Seal Salamander	15	34	58	16
Northern Dusky Salamander	118		113	36
Desmognathus spp. (Seal or N. Dusky)	15	8	25	5
Southern Two-lined Salamander	72	8	18	10
Long-tailed Salamander	2			
Northern Spring Salamander	2	1	3	
Red-Spotted Newt	8		5	
Northern Red Salamander	1	1		
Unidentified Salamander	37	2	21	13
Total	270	63	243	80
Toads and Frogs				
Eastern American Toad	1			
American Bullfrog	1			1
Northern Green Frog	5			
Pickerel Frog	3			1
Rana spp.	3			
Unidentified Frog	3		1	
Total	16	0	1	2
Snakes				
Northern Ring-necked Snake	1			
Common Watersnake	2			
Total	3	0	0	0
Grand Total	289	63	244	82

UPDATE to the Wood et al. 2001 TERRESTRIAL STUDIES REPORT

18 February 2002

Introduction

The following document summarizes data collected in 2001 and additional analyses of the data collected in 1999-2000 that were not included in the original report. Note that additional analyses for the raptor data are not included here because a master's thesis (Balcerzak 2001) has already been submitted with these data. The sections included in this update are as follows:

A. Species-Specific Logistic Regression Models

Regression models were developed for grassland and edge species as requested in the review of the original report. Reclaimed mines are providing habitat for these species, although we do not know if populations are breeding successfully. Regression models for grassland species generally indicate that dense vegetation is not suitable habitat, therefore, reclaimed grasslands will not remain suitable for these species without active management. Models were developed for additional interior-edge and forest-interior species. For all analyses, we used stepwise logistic regression.

B. Grasshopper Sparrow Habitat and Nesting Success

Additional data collected in 2001 confirm that reclaimed grassland habitats provide suitable breeding habitat for Grasshopper Sparrows as long as vegetation does not become too dense.

C. Small Mammal Sherman Trapping Data

Additional analyses of the 1999 and 2000 small mammal data suggest higher productivity for *Peromyscus* species within the reclaimed grassland habitats. Abundance was negatively related to bareground.

D. Small Mammal Data from Herp Arrays

Additional species were captured in pitfall traps associated with arrays (particularly shrews) resulting in greater species richness within the reclaimed habitats. For woodland jumping mice and short-tailed shrews, abundance was greater in fragmented forests, similar to findings from the sherman trap data.

E. Herpetofaunal Surveys

The two years of data had trends similar to those reported in the original report for the 1-year data set. Overall species richness and abundance based on the array data for 2000 and 2001 did not differ among treatments. Although salamander abundance did not differ statistically among the treatments, it was generally higher within the 2 forested treatments.

F. Appendix A-1. Changes to the Wood et al. 2001 MTMVF terrestrial report

Logistic regression models were updated and none of the species tested showed negative relationships with distance to edges. In logistic regression analyses, we used stepwise selection rather than the forward selection used in the original report. See methods of section A in this report for a description of why we switched analyses to stepwise selection.

A. Species-Specific Logistic Regression Models

In the final report we included species-specific logistic regression models for several forest-interior species listed as species of concern by Partners in Flight (PIF). Here we provide habitat models for 32 additional species: 6 grassland, 13 edge species, and 13 forest species.

In response to review comments from the W. Va. Coal Association, we are adding more information on grassland and early successional species that were detected on MTMVF mines. Many of these species are declining in all or part of their breeding range (Sauer et al. 2001), and MTMVF mines may provide habitat for these species in a region that is dominated by mature forest habitat. Generally, the breeding range for grassland and early successional species is extensive throughout the United States. Historically, little of the breeding range for grassland species occurred in West Virginia; consequently, these species generally were uncommon. We present findings on 6 grassland species: Dickcissel, Grasshopper Sparrow, Eastern Meadowlark, Red-winged Blackbird, Horned Lark, and Willow Flycatcher, and 13 edge species: White-eyed Vireo, Yellow-breasted Chat, Prairie Warbler, Blue-winged Warbler, Common Yellowthroat, Yellow Warbler, Indigo Bunting, Northern Cardinal, American Goldfinch, Song Sparrow, Chipping Sparrow, Field Sparrow, and Eastern Towhee.

Of the grassland species, the Dickcissel was found to be declining significantly range-wide from 1966-2000 by the Breeding Bird Survey (BBS), but the species was not detected on any routes in West Virginia (Sauer et al. 2001). All of the other species, except the Willow Flycatcher, were found to be declining in West Virginia and range-wide. Willow Flycatcher populations appear to be stable both in West Virginia and range-wide. Of the edge species, the BBS found the Prairie Warbler, Common Yellowthroat, Indigo Bunting, American Goldfinch, and Eastern Towhee to be declining significantly in West Virginia and range-wide. White-eyed Vireo, Yellow Warbler, Blue-winged Warbler, and Northern Cardinal populations appear to be stable both in West Virginia and range-wide. The Yellow-breasted Chat and Chipping Sparrow appear to be declining in West Virginia, whereas populations are stable range-wide (Sauer et al. 2001). The Song Sparrow is declining range-wide, but populations appear stable in West Virginia.

Additional models for 13 forest species also are included in this report. Of the 13 species analyzed, 8 are interior-edge species and 5 are forest-interior species. The interior-edge species analyzed were: American Redstart, Carolina Chickadee, Northern Parula, Carolina Wren, Downy Woodpecker, Tufted Titmouse, Red-bellied Woodpecker, and White-breasted Nuthatch. The forest-interior species were: Black-throated Green Warbler, Ovenbird, Pileated Woodpecker, Yellow-throated Warbler, and Summer Tanager. Of these species, 6 are considered “residents” (i.e. they do not migrate for the winter): Carolina Chickadee, Carolina Wren, Downy Woodpecker, Pileated Woodpecker Red-bellied Woodpecker, Tufted Titmouse, and White-breasted Nuthatch.

Methods

We modeled habitat preferences of these additional species using stepwise logistic regression (Stokes et al. 1995). We chose to use stepwise logistic regression over forward logistic regression for two reasons. First, forward selection is a simplified version of stepwise regression; it does not test whether a variable once entered into the model should be dropped as other variables are added (Neter et al. 1996). Thus, the final model in forward regression may include variables that would have been dropped as new ones were added in stepwise regression. We found with our data that forward regression typically chose more variables for inclusion in the model than stepwise regression. Because stepwise both adds and deletes variables as it proceeds, we believe it produces the "best" regression model. Second, stepwise regression is the most widely used procedure (Neter et al. 1996) and is typically the method used by other ornithologists and wildlife biologists. The significance level for entry and staying in the model was P=0.10. The Hosmer-Lemeshow goodness-of-fit test was used to determine the validity of the models. Models that failed the goodness-of-fit test (P<0.10) were considered invalid (Stokes et al. 1995).

For grassland and edge species, analyses included only points in the grassland and shrub/pole treatments. We developed models for species detected at ≥10% of these sampling points. Both treatments were included in the development of the models because some grassland birds were detected in shrub/pole habitat and some edge birds were detected in grassland habitat. Habitat variables included in models for grassland species were: aspect code, slope, distance to minor edge, distance to habitat edge, height of grass/forbs, litter depth, Robel pole index, elevation, density of trees >0-2.5 cm, >2.5-8 cm, and >8-23 cm, and all ground cover variables. These variables also were used in models for edge species, along with density of trees >23-38 cm, and density of snags. Density of larger trees were excluded from models because no trees >38 cm were found in these habitats, and no snags were found in the grassland habitat.

For the 13 additional forest species (interior-edge and forest-interior species), we used the same methods and variables as we used for the species in the final report and as described above for the grassland and edge species.

Results and Discussion

Grassland Species and Edge Species

Grassland Species

Dickcissel
We found Dickcissel presence to be positively correlated to distance from habitat edge, Robel pole index, and bareground/rock cover (Table 1). This indicates that Dickcissels prefer areas far from edge, that have a high biomass of green vegetation, with some areas of bareground. Zimmerman (1971) determined that Dickcissels prefer old fields over prairies for nesting, presumably because of the taller vegetation, greater forb cover, and higher amounts of vegetation in old fields. We found similar results, because Dickcissels were related positively to Robel pole index, which is an indicator of biomass. As stated in the Final Report, Dickcissels may be expanding their range eastward and MTMVF mines may provide habitat for them. However, it is unknown if these birds are breeding on MTMVF mines.

Grasshopper Sparrow
Grasshopper Sparrow presence was negatively correlated to density of trees >8-23 cm (Table 1). This species prefers moderately open grassland and generally avoids areas with extensive shrub cover (Vickery 1996). They also appear to prefer areas with sparse vegetation and greater bareground cover (Vickery 1996). This was the most common species we encountered on the grassland treatment, occurring at 99% of point counts. Further information on Grasshopper Sparrow populations is reported elsewhere in this report.

Eastern Meadowlark
Presence of this species was negatively correlated to both density of trees >2.5-8 cm and shrub cover (Table 2). This species uses a variety of grassland situations, including pastures,

savannas, hay fields, roadsides, airports, and golf courses (Lanyon 1995). It appears to prefer areas with high grass and litter cover (Wiens and Rotenberry 1981). Our results indicate that the species prefers grassland areas that are more open with few trees or shrubs present. MTMVF mines provide habitat for this species for several years after reclamation, but as succession proceeds on the mines these areas will become unfavorable for them.

Red-winged Blackbird

Red-winged Blackbird occurrence was negatively correlated to shrub cover on our study areas (Table 2). Red-winged Blackbirds are found in a variety of habitats, such as field edges, marshes, roadsides, old fields, ditches, and pastures (DeGraaf and Rappole 1995). We commonly observed Red-winged Blackbirds in grasslands near created wetlands, stands of cattail *(Typha* spp.), and valleyfills on the mines. MTMVF mines appear to provide a considerable amount of habitat for this species, especially along the periphery of created wetlands.

Horned Lark

No habitat variables were selected by stepwise logistic regression to predict the presence of Horned Larks (Table 3). Horned Larks prefer open, barren areas with few trees and a minimum of vegetation (DeGraaf and Rappole 1995). We observed them most frequently in and along the roads on the mines. All detections of this species were at the Hobet and Daltex mines. Although presence was not related to any habitat variables, the species generally was present in areas with low tree densities (Table 3). Because Horned Larks prefer barren areas with little vegetation, MTMVF mines likely provide significant habitat for them during a short time span after reclamation, before grasses and forbs begin to develop a dense ground cover. After ground cover is established, Horned Larks will likely continue to use roads and barren areas on the mines.

Willow Flycatcher

No variables were selected by stepwise logistic regression for predicting the occurrence of Willow Flycatchers (Table 3). All of our detections of Willow Flycatchers were at the Hobet mine in blocks of autumn olive. Because none of our point counts were placed in blocks of autumn olive, we may not have been able to accurately determine the habitat factors important for predicting Willow Flycatcher presence. The edges of some autumn olive blocks were sampled during vegetation surveys, but entire blocks were never completely within a 50-m radius of the point count center. DeGraaf and Rappole (1995) report that the species occurs in a variety of habitats, including brushy fields, willow thickets, streamsides, shelterbelts, and woodland edges. However, they appear to prefer thickets or groves surrounded by grasslands, which is what we observed on the MTMVF sites. Based on our observations, it appears MTMVF mining will only provide habitat for this species if areas are planted with high densities of autumn olive. However, autumn olive is not a native plant and can become invasive and a nuisance; it is no longer recommended for planting in several counties.

Edge Species

White-eyed Vireo

We found the White-eyed Vireo to be positively related to density of trees >0-2.5 cm (Table 4), which is an expected result since this species prefers areas with low shrubby vegetation or brushy woodlands (DeGraaf and Rappole 1995). Denmon (1998) also found this species to be more abundant in areas with high shrub/sapling/pole density.

Yellow-breasted Chat

This species was found to be negatively associated to distance to habitat edge, and positively related to density of trees >0-2.5 cm and forb cover (Table 4). However, the logistic regression model failed the Hosmer-Lemeshow goodness-of-fit test. Chats prefer dense, shrubby areas with few tall trees (DeGraaf and Rappole 1995). Denmon (1998) found the species occurred more frequently in areas with a high density of stems >0-7.6 cm, which confirms our results.

Prairie Warbler

Presence of Prairie Warblers was negatively related to slope and distance from habitat edge, and positively related to litter depth, density of trees >23-38 cm, and percent green ground cover (Table 5). This species prefers areas with dense low trees, especially areas with some conifers (DeGraaf and Rappole 1995, Denmon 1998). We detected this species mostly in shrub/pole habitat, but it also was observed at grassland points where there were scattered shrubs and blocks of autumn olive nearby. MTMVF may provide more habitat for this species in the future if tree species return to areas reclaimed to grasses. However, the bird appears to prefer areas close to edge, and we often detected it along edges of forests. Thus, large, open expanses of grassland as occurs in MTMVF may be detrimental to the species.

Blue-winged Warbler

Blue-winged Warbler presence was positively associated with the density of trees >2.5-8 cm dbh (Table 5). Denmon (1998) observed this species more frequently in areas with a high density of trees from >0-7.6 cm and a low density of trees from 7.6-15 cm dbh. Thus, it appears from these results that Blue-winged Warblers are more likely to occur in areas where tree diameter growth has not yet reached 8 cm.

Common Yellowthroat

We found Common Yellowthroats to be positively related to density of trees >0- 2.5 cm and negatively related to density of trees >23-38 cm (Table 6). This species prefers areas with a mixture of small trees, and dense, herbaceous vegetation, typically in damp or wet situations (DeGraaf and Rappole 1995, Denmon 1998), and our results confirm this prediction. We commonly found them in shrubby areas around ponds on MTMVF mines (primarily Cannelton), along forest/mine edges, and in blocks of autumn olive.

Yellow Warbler

This species was detected more frequently at lower elevations and was positively related to litter cover (Table 6). It is a common and widespread species that prefers moist habitats (streamsides, bogs, swamps) with dense understories, typically of willow (*Salix* spp.) and alder (*Alnus* spp.) (DeGraaf and Rappole 1995). Denmon (1998) found a higher abundance of Yellow Warblers in grass/shrub-dominated habitat than in wooded, shrub-dominated, or thicket/shrub early successional habitats in West Virginia. Surprisingly, we did not detect this species on the Cannelton mine. It was observed most frequently at the Hobet mine in blocks of autumn olive, and it was detected in small wooded thickets at the Daltex mine. The Cannelton mine was at higher elevations than the other 2 mines, and this likely influenced the result showing this species to be negatively associated with elevation.

Indigo Bunting

This species was widely distributed, being observed at 86% of grassland and shrub/pole points combined, and at 94% of shrub/pole points alone. Stepwise logistic regression identified two variables, density of trees >2.5-8 cm and bareground/rock cover, as predictors of Indigo Bunting presence. They were positively correlated to tree density and negatively correlated to bareground/rock cover (Table 7). Indigo Buntings are found in a variety of edge situations:

along roadsides, in brushy old fields, old burns, wooded clearings, and brushy ravines (DeGraaf and Rappole 1995). They typically build their nests in a shrub or small tree.

Northern Cardinal

The Northern Cardinal was positively associated with the density of trees >2.5-8 cm (Table 7). Similar results were found by Denmon (1998), who found Northern Cardinals more frequently in areas with high shrub/sapling/pole density. She also found them in higher abundances in thickets with dense shrubs and small trees than in grass/shrub, shrub, or wooded early successional habitats. These results indicate that Northern Cardinals prefer advanced successional stages when young trees begin to dominate, but before the trees become too big and shade out lower-growing vegetation.

American Goldfinch

No variables were chosen by stepwise logistic regression for predicting presence of the American Goldfinch (Table 8). The only variable found by Denmon (1998) to be related to American Goldfinch presence was density of trees >15.c cm, which was negatively related. Goldfinches typically use a variety of edge situations, including old fields and roadsides (DeGraaf and Rappole 1995).

Song Sparrow

This species was positively related to distance from habitat edge (Table 8). Of the points where this species was detected, 75% were at the Hobet and Daltex mines in grassland habitat, with a few low scattered trees and shrubs used for perching. Conversely, at the Cannelton mine, this species was only detected in shrub/pole habitat. Denmon (1998) only found herbaceous plant height to be positively related to Song Sparrow presence.

Chipping Sparrow

Chipping Sparrows were positively related to the density of trees >8-23 cm (Table 9), but the model failed the Hosmer-Lemeshow goodness-of-fit test and may not be valid.
This species prefers open, wooded areas, forest edges, and clearings (DeGraaf and Rappole 1995), and our results confirm that they prefer areas with some large trees present.

Field Sparrow

This species was positively associated with density of trees >2.5-8 cm and negatively associated with bareground/rock (Table 9). Approximately 42% of the detections for this species were in grassland habitat, and the other 57% in shrub/pole habitat. This species uses small trees for song perches and will nest in them after leaf-out (Best 1978). They typically nest in grasses and forbs earlier in the season (Best 1978), which may be one reason they prefer areas with less bareground/rock. Denmon (1998) found them in higher abundances in grass/shrub, and shrub-dominated habitat than in thickets and wooded areas.

Eastern Towhee

Eastern Towhees were positively correlated to density of trees >8-23 cm (Table 10). Our results agree with Greenlaw (1996) who reported that this species occupies areas characterized by dense shrubs and small trees and appears to favor mid- to late- stages of succession with greatest densities in thickets and open-canopy woodland situations.

In summary, our results indicate that MTMVF mines are providing habitat for grassland and early successional songbird species in West Virginia in a region historically dominated by mature forest habitats. Many of these species would be rare or absent from this region if MTMVF mines were not present (see final report). However, it is not known if these populations are breeding successfully on MTMVF mines. If reproductive success is low, then these mines could be acting as habitat sinks for these species.

Interior-edge and Forest-interior Species

<u>*Interior-edge species*</u>

<u>American Redstart</u>
Presence of this species was positively related to aspect code and negatively related to density of trees >2.5- 8 cm (Table 11). This is an adaptable species that breeds in a variety of forested situations including coniferous-deciduous woods, regenerating hardwoods, aspen groves, and shrubbery around farms and streams (DeGraaf and Rappole 1995). It is unlikely the MTMVF will have much affect on this species given the wide variety of habitats in which it will nest

<u>Carolina Chickadee</u>
Carolina Chickadee presence was positively related to trees >8-23 cm (Table 11). It is found in a variety of habitats, including deciduous woods, thickets, and suburban parks (Ehrlich et al. 1988). It is often seen near edges, and MTMVF mining could increase habitat for this species by increasing edge habitats.

<u>Northern Parula</u>
Northern Parula occurrence was positively associated with water cover and canopy cover >3-6 m and negatively associated with canopy cover >6-12 m (Table 12). This species is often associated with bottomlands, so it is not surprising that we found it to be related to water cover (DeGraaf and Rappole 1995). We commonly found this species near drainages in forested fragments and intact forest, and it does not appear to avoid edges.

<u>Carolina Wren</u>
Presence of this species was negatively related to aspect code and to density of trees 2.5 –8 cm (Table 12). This species is found in a variety of wooded situations, including brushy bottomlands, open deciduous woods, and parks (Ehrlich et al. 1988).

<u>Downy Woodpecker</u>
The occurrence of Downy Woodpeckers was positively associated to aspect code (Table 13). This bird is often found near edges and inhabits deciduous and mixed-deciduous stands, riparian stands, and parks (Ehrlich et al. 1988). MTMVF mining could potentially increase habitat for this species by increasing edge habitats, but the reduction in forest cover by MTMVF mining could also have a negative impact on the species.

<u>Tufted Titmouse</u>
Tufted Titmouse occurrence was positively associated with green ground cover (Table 13). Like the Carolina Chickadee and Downy Woodpecker, this species inhabits a variety of wooded situations, often being seen in parks, open deciduous woods, and edges (Ehrlich et al. 1995).

<u>Red-bellied Woodpecker</u>
The presence of this species was negatively associated to canopy cover >24m. (Table 14). Red-bellied Woodpeckers primarily inhabit deciduous woods, but are also found on edges, in parks, and suburban situations (Ehrlich et al. 1988). Impacts of MTMVF mining on this species would likely be minimal because of its generalist nature.

White-breasted Nuthatch
No variables were selected by stepwise logistic regression for predicting the presence of this species (Table 14). Although this species is often found on edges and in suburban and park situations, it appears to prefer forests with large, old, decaying snags (Ehrlich et al. 1988). MTMVF mining could increase edge habitat for this species, but ultimately it could have negative effects on the species if large, dead snags are not present.

Forest-interior species

Ovenbird
Ovenbird presence was positively associated with bareground/rock cover and negatively associated with canopy cover from >3-6 m. (Table 15). This species prefers extensive, open, mature forests without thickets and tangles, with "an abundance of fallen leaves, logs and rocks" (DeGraaf and Rappole 1995), and our results agree with this assessment. This species was found to be less abundant in forests fragmented by MTMVF mining, and could be detrimentally impacted if MTMVF mining continues.

Black-throated Green Warbler
The Black-throated Green Warbler was negatively related to density of trees >8-23 cm (Table 15). DeGraaf and Rappole (1995) state that this species inhabits "large stands of mature open mixed woodlands (especially northern hardwood-hemlock stands)." Our observations agree with this assessment. We most frequently encountered Black-throated Green Warblers in stands of hardwoods intermixed with eastern hemlock, along streams in mature woods.

Pileated Woodpecker
The presence of the Pileated Woodpecker was negatively associated to canopy cover >24 m (Table 16). This large woodpecker prefers deciduous woods with large trees, but it also is found on edges and in parks and suburban situations (Ehrlich et al. 1988).

Yellow-throated Warbler
Presence of this species was negatively associated with aspect code, indicating a preference for drier slopes and ridges, and negatively associated with canopy cover from >12- 18 m (Table 16.) This species is often found along streams and rivers, typically in large, tall trees of bottomland hardwood forests, however, it also is often found in stands of pine, oaks, or mixed forests (DeGraaf and Rappole 1995). Most of our detections of this species were on ridge tops dominated by oak species.

Summer Tanager
No variables were selected by stepwise logistic regression for predicting the occurrence of Summer Tanagers (Table 17). This species is typically found in dry, open woodlands of oak, pine, and hickory in the southeast, but may also be found in bottomlands in the north (DeGraaf and Rappole 1995).

In summary, for most interior-edge species, MTMVF mining may have mixed impacts on their populations. MTMVF mining would create more edge for these species, but it would also decrease the amount of mature forest, which these species also require. The least-impacted species would likely be resident species such as the woodpeckers, chickadees, and titmice that use a variety of habitats. Forest-interior species would most likely be negatively impacted if the amount of forest cover continues to be reduced without any subsequent reforestation.

B. Grasshopper Sparrow Habitat and Nesting Success

Songbird species that require grassland and other early successional habitats were observed and documented on reclaimed MTRVF mines, some at relatively high densities Wood et al. (2001). Grasshopper sparrows (*Ammodramus savannarum*), in particular, were very abundant and were successfully breeding on the sites. However, nesting success data from 1999-2000 was limited and we felt that no conclusions could be drawn from the data. The objectives of this study are to continue examining habitat and nesting requirements and nesting success of Grasshopper Sparrow populations colonizing reclaimed MTRVF mine sites in southern West Virginia.

Methods

Study areas are the same three MTRVF mine sites in southwestern West Virginia that were investigated by Wood et al. (2001). The Hobet 21 mine is located in the Mud River watershed in Boone County, the Daltex mine is located in the Spruce Fork watershed in Logan County, and the Cannelton mine is located on the border of Kanawha and Fayette counties in the Twentymile Creek watershed. Two 40 ha sample plots were established on each mine complex, (Hobet Adkins (HA1), Hobet Sugar Tree (HN2), Daltex Rock house (DR1), Daltex Spruce Fork (DN2), Cannelton Lynch Fork (CL1), and Cannelton (CV2)) for a total of six search areas. Additional nest plots were established for nests found on mine complexes but not within sample plots, (Daltex off plot (DO1) and Hobet off plot (HO1)).

Adult male and female Grasshopper Sparrows were captured on each study site with mist nets and conspecific song playback from April 2001 to July 2001. All captured individuals were banded with Fish and Wildlife Service bands. Basic physical information (sex, weight, wing cord measurements, and overall condition) was recorded, and then each individual was marked with a unique combination of two colored plastic bands for future identification. Juveniles were similarly processed and marked with a single colored band prior to fledging from the nest.

Nest searching and habitat sampling methodologies are similar to those previously presented in Wood et al. (2001). Briefly, nest searching was conducted on two 40-ha nest search plots in reclaimed grassland areas of Hobet 21 (HA1 & HN2), Daltex (DR1 & DN2), and Cannelton (CL1 & CV2) mine sites for a total of six search areas. Eight fixed vegetation-sampling sub-plots were systematically selected and surveyed on each search plot (N=48) to examine differential nest site selection preferences in this species.

To obtain a good estimate of species-specific nest survival, a minimum of 20 nests must be monitored (Martin et al. 1997). Therefore, I set a target of 25-30 nests for Grasshopper Sparrows nesting in the grassland habitat of the study sites. Field personnel trained in proper searching and monitoring techniques (Martin and Geupel 1993) searched each nesting area every 3-4 days. Nest searching began one-half hour after sunrise and concluded 8-10 hr later (approximately 0600-1600 EST). Nest searching methods followed national BBIRD (Breeding Biology Research and Monitoring Database) protocols (Martin et al. 1997). To control for search effort, nests were located by systematically searching study plots.

All Grasshopper Sparrow nests found were monitored every 3-4 days (Martin et al. 1997) to confirm activity. Because Grasshopper Sparrow nests are typically well concealed within vegetation, they were marked for relocation using a staked flag placed at a minimum distance of 15m from the nest. Care was taken when monitoring the nest to avoid disturbing the female.

When possible, nest searchers observed the nest from a distance of no less than 15 m for up to 30 min to confirm that it was still active. Each nest was approached and visually checked for contents a maximum of four times: once when it is initially found, once to confirm clutch size, once to confirm brood size, and once to confirm fledging success or failure. Nests were not approached when avian predators (e.g., American Crows and/or Blue Jays) were observed nearby because these birds are known to follow humans to nests (Martin et al. 1997). Observers also continued to walk in a straight line after visually observing nest contents to avoid leaving a dead-end scent trail directly to the nest that might be followed by mammalian predators (Martin et al. 1997). The vegetation concealing the nest was moved to the side using a wooden stick to avoid putting human scent on the nest if the vegetation blocks the observer's view of the contents.

A nest was considered successful if it fledged at least one young. Fledging success was confirmed by searching the area around the nest for fledglings or for parent-fledgling interactions. However, if no fledglings were observed, the nest was considered to have fledged young if the median date between the last active nest check and the final nest check when the nest was empty and was within two days of the predicted fledging date (Martin et al. 1997). Nest survival was calculated using the Mayfield method (Mayfield 1961, Mayfield 1975). Daily nest survival estimates were calculated for the incubation and brooding periods separately because there might be differential nest survival between these two periods. The overall daily survival rate was calculated as the product of incubation and brood daily survival. Survival during the egg-laying stage will not be included in the calculation of overall nest survival because few nests were located during this stage of the nesting cycle.

After each nest fledged or failed, vegetation within an 11.3 m radius circle surrounding the nest was sampled to determine habitat characteristics important to nest survival. We measured vegetation for each nest monitored using methods modified from James and Shugart (1970) and the Breeding Bird Research Database program (BBIRD; Martin et al. 1997). These included estimates of percent ground cover in nine cover types (grass/sedge, shrub/seedling, fern, moss, bare ground, forb/herbaceous, woody debris, litter, and water). Percent ground cover was estimated using an ocular sighting tube (James and Shugart 1970). The sight-tube was a 5.0-cm pvc pipe with cross-hairs at one end. Five sight-tube readings were taken on each subplot every 2.26 m along four, 11.3-m transects that intersected at the center of the subplot. The percentage of each cover type present in the sight-tube was estimated and recorded. Grass height and organic litter layer depth were measured at 13 locations along the 4 transects: at the center and at distances of 1 m, 3 m, and 5 m along each transect. A Robel pole (Robel et al. 1970) was used to calculate an index of vegetative cover and an index of biomass (Kirsch et al. 1978). Additional nest measurements including percent slope, slope orientation, nest height (cm), width and depth of nest rim and cup (cm), nest substrate height (vegetative and reproductive), and distance to foliage edge were surveyed to examine differences among individual nests. Habitat and nest variables were tested for differences among nests and habitat plots using one-way analysis of variance (ANOVA) (α=0.05) (Zar 1999).

Results and Discussion

A total of 202 Grasshopper Sparrows were captured, banded, and processed on the MTRVF study sites during the 2001 breeding season. Mist netting effort resulted in an overall capture rate of 0.25 captures per net hour with 193 captures in 785.63 hours (Table 18). Juveniles that were banded in and around nests (N=9) were not included in the mist net capture effort calculations. An additional 45 non-target individuals were captured on the study plots with the most common species including Eastern Meadowlark, Field Sparrow, Indigo Bunting, and Savannah Sparrow.

Systematic searches of study plots produced 37 active Grasshopper Sparrow nests on the three mines surveyed. Overall nest search effort was one nest per 10.06 hours of effort for all sites combined (Table 19). Nests found opportunistically off of the study plots (N=4) are not included in search effort calculations because they were not located by systematically searching study areas. Mean clutch size (Table 19) for the surveyed nests was 3.73 ± 0.16 and is similar to those reported in the literature (Wray et al. 1982, Ehrlich et al. 1988). Grasshopper sparrow nest survival for 2001 breeding season (30%) is comparable to survival rates previously reported on these study sites (36.4%) (Wood et al. 2001). Nest survival for this species reported from other areas has ranged from 7-41% as summarized in Wood et al. (2001).

Comparisons of habitat variables surrounding successful (n=17) and unsuccessful (n=20) nests (Table 20) indicate no significant differences among slope, aspect, distances to nearest minor edge, ground cover variables, grass height, and litter depth. Significant differences were detected in the Robel pole index at the nest (F=6.56, P=0.01) and at 1 meter from the nest (F=6.68 P=0.01). These analyses suggest that less dense vegetation near the nest may be an important factor in nest success.

Comparisons of habitat variables measured at nests (N=37) and at the fixed habitat plots (N=48) suggest differences in several of the ground cover estimates (Table 21). Percent green (F=574.53, P<0.0001) and percent grass (F=26.25, P=<0.0001) estimates were significantly lower at the nest plots while percent bare ground (F=24.73, P<0.0001), percent litter (F=7.65, P=0.01) and percent moss (F=3.05, P<0.0001) was significantly higher at nest plots. These findings support previous studies that suggest Grasshopper Sparrows require a high degree of bare ground associated with nesting sites for foraging (Whitmore 1979, Wray et al. 1982). Significant differences were also detected in the Robel pole index for all comparisons (all <0.0001), with nests placed where vegetation density was greater than generally available on the plot. No differences were detected in grass height comparisons except at the five-meter distance from sample plot centers (F=7.78, P=0.0056). Litter depth differed significantly between the fixed habitat plots and nest plots at all measured distances.

In summary, data suggest that the large reclaimed grassland habitats available on the mountaintop removal/valley fill mine complexes surveyed in this study are sufficient to support breeding populations of Grasshopper Sparrows with nest success rates similar to populations found in other grassland habitats. Important nesting habitat characteristics included patches of dense grassland vegetation interspersed with patches of bare ground. These habitat conditions support high densities of breeding Grasshopper Sparrows, even on newly reclaimed sites. As ground cover develops, however, sites will become unsuitable for Grasshopper Sparrows unless habitats are managed to maintain the required conditions.

C. Small Mammal Sherman Trapping Data

Additional analyses were completed on small mammal data collected through Sherman trapping to assess differences in habitat quality among treatments, as abundance alone is not necessarily a reliable indicator of habitat quality for a given species. Some studies have suggested that reclaimed lands may act as a population sink for *Peromyscus* and that adjacent unmined lands may provide superior breeding and foraging habitat (DeCapita and Bookout 1975). As a measure of habitat quality, we compared the proportion of adult *Peromyscus* spp.

individuals that were in breeding condition among treatments (within a year) and between years (within a treatment) (Table 22), where mice weighing 16 g or more were considered adults (Whitaker and Hamilton 1998). In 1999, a significantly greater proportion of males and females were in reproductive condition in the grasslands than in either of the forest treatments. In 2000, only females had significant differences among the 4 treatments sampled; a lower percentage of individuals were in reproductive condition in the intact forest than in the other 3 treatments. These results generally followed the abundance trends, suggesting that reclaimed areas were not acting as population sinks on our study sites, but were actually more productive breeding sites than adjacent forests. Reclaimed areas appear to be better breeding habitat for *Peromyscus* probably due to their greater biomass of grasses, forbs, and invertebrates. Reproductive condition differed between the 2 years of the study in the two forest treatments, but not in the grasslands. A higher proportion of both males and females in fragmented forest were in reproductive condition in 2000 than in 1999. In the intact forest, differences between the years were found in males but not in females. In all cases of between year differences, the proportion of reproductive individuals was greater in 2000 than in 1999, suggesting that the 1999 summer drought may have reduced the reproductive rates of *Peromyscus*, or that the moist and mild summer weather in 2000 may have improved conditions for breeding. These differences may have been a function of the greater plant biomass in 2000 than 1999.

Peromyscus spp. abundance was compared among treatments by age and sex groups (adult male, adult female, juvenile male, and juvenile female). In 1999, adult males were more abundant in grassland than in fragmented or intact forest and adult females were more abundant in grasslands than in intact forest (Table 23). In 2000, for adult males, adult females, and juvenile females, the grassland and shrub/pole treatments were similar, but had significantly greater abundances than fragmented forest and intact forest, which were also similar to each other. These differences, which followed overall *Peromyscus* abundance trends, suggested that early-successional areas (i.e. grassland and shrub/pole treatment) provided habitat that was superior to the forested areas. We also compared juvenile abundance, as it is an indicator of reproductive success of adults in a treatment. We found no differences among treatments in 1999, but in 2000, differences were found among treatments for both males and females. Juvenile males were more abundant in grasslands than in either forest treatment and greater in shrub/pole than in the fragmented forest treatment. Juvenile females were greater in the grassland and shrub/pole treatments than in the 2 forested treatments. As with adults, results generally followed overall *Peromyscus* abundance trends.

Habitat and environmental variables were used in regression analyses to identify factors that were predictive of small mammal richness and abundance. The grassland treatment was analyzed separately from the other three treatments in the regression procedures because it had several habitat variables not recorded in the other treatments due to considerably different vegetation structure. Stepwise multiple linear regression was used for *Peromyscus* spp. abundance, total small mammal abundance, and species richness, while logistic regression was performed on presence/absence data of less commonly captured species (house mice in grasslands and short-tailed shrews, woodland jumping mice, and eastern chipmunks in the other three treatments). In both types of regression, an entry level of 0.30 and a stay level of 0.10 was used. Environmental variables incorporated into the regression models included precipitation (cm) (National Oceanic and Atmospheric Administration/National Weather Service, Charleston, W. Va.) averaged over the 3-night trapping session, low temperature (°C) (NOAA/NWS, Charleston, W. Va.), moon phase expressed as a percentage of moon's surface illuminated (Astronomical Applications Department, US Naval Observatory), and an index of nighttime ambient light. The ambient light index was calculated as a product of the percentage of the moon's surface illuminated and cloud cover (NOAA/NWS, Charleston, W. Va.) on a scale of 1 (clear skies) to 0.1 (overcast). Habitat variables included those described in the original project report (Wood et al. 2001).

In multiple linear regression analysis for shrub/pole, fragmented forest and intact forest treatments, daily low temperature and precipitation were negatively related to species richness, and the percentage of bareground was positively related (Table 24). Relationships were weak as no single variable contributed a partial R^2 of more than 0.10. Several variables were significant predictors of total small mammal abundance. Of these, canopy cover from 0.5-3m was negatively related and contributed the most to the model (partial R^2 of 0.21). Canopy cover from 0.5-3m also was the most important predictor of *Peromyscus* spp. abundance, with a partial R^2 of 0.31. Generally, *Peromyscus* spp. had greater abundance at sites with less low canopy cover, lower canopy height, more bare ground, and when precipitation during the trapping period was not heavy.

Average grass height was the only variable related to richness in grasslands, based on multiple linear regression analysis; it was a positive relationship with a partial R^2 of 0.24 (Table 25). Areas with taller grass may have held more species because they provided better cover and more forage for small mammals. Three variables were positively related to total abundance, with the amount of green groundcover being the strongest (partial R^2=0.37). Precipitation was a positive predictor and the percentage of bareground was a negative predictor, though both relationships were weak. For *Peromyscus* spp. abundance, bareground had a strong negative relationship, with a partial R^2 of 0.45. It is likely that *Peromyscus* spp. avoid areas of bareground to avoid exposure to predators. In addition, precipitation and the number of shrub stems were weak positive predictors of *Peromyscus* spp. presence.

Presence of short-tailed shrews in shrub/pole, forest fragment, and intact forest treatments, was positively related to the percentage of bare ground in the logistic regression model (Table 26). This was contrary to expectations as shrews generally seek cover (Whitaker and Hamilton 1998). Moon illumination had a negative relationship with the presence of woodland jumping mice, while water as a groundcover and canopy cover from 0.5-3m had a positive relationship. Many small mammals species are less active when the moon is bright, presumably to avoid predation (Kaufman and Kaufman 1982). For chipmunk presence, 4 variables contributed significantly to the regression model. Water as a groundcover had a negative relationship, and bareground, canopy cover above 12m, and stem density of trees from 8-38 cm DBH had positive relationships with abundance. The preference for larger, taller trees may be due to their reliance on mast as a food source. In the grassland treatment, average grass height was the only significant variable; it was a positive predictor for the presence of house mice.

D. Small Mammal Data from Herp Arrays

Small mammals were trapped in pitfall and funnel traps associated with drift-fence arrays targeting herpetofauna. Estimates of species richness and abundance of 9 species were calculated based on 13 trapping sessions conducted between March 2000 -October 2001. Analysis of variance (ANOVA) was used to detect differences among treatments. The model included treatment and trapping session as the main factors and a treatment by session interaction term. If the ANOVA found that means were different, a Waller-Duncan k-ratio t-test was used to compare means among treatments.

Species richness of small mammals was significantly lower in the intact forest treatment than in the other 3 treatments (Table 27). Richness estimates were different from those of Sherman trapping which found that richness did not differ among treatments in either 1999 or 2000 and were generally much lower than array estimates. The difference between the 2 estimates is most likely due to the fact that Sherman trapping is not effective at capturing *Sorex* spp. because shrews generally are not heavy enough to spring Sherman traps and, as insectivores, they are less likely to be attracted to the peanut butter and oat bait. For this reason, the estimates of richness from the drift-fence arrays are likely to be a more accurate reflection of the species present in each treatment (Kirkland 1994).

Similarly, total abundance of small mammals captured in herp arrays (Table 27) was significantly lower in the intact forest treatment than in the other 3 treatments. Sherman trapping data found that the 2 reclaimed treatments were similar in abundance to each other and greater than the 2 forest treatments, which also were similar to each other. The difference in total abundance trends between the 2 methods likely was that *Peromyscus* spp. dominated Sherman trapping results (87% of captures), driving trends in total abundance. Sherman trapping is more effective for catching mice than drift fence arrays because Sherman traps are baited. For this reason, Sherman trapping resulted in many more *Peromyscus* per 100 trap nights than drift fence arrays.

The greater richness and abundance in reclaimed areas than in intact forests was similar to the findings of Kirkland (1977) in a study comparing richness and abundance of small mammals among different aged clearcuts on the Monongahela National Forest in West Virginia. He found that there was an initial increase in the diversity and abundance of small mammals in response to clearcutting that persisted until the area succeeded back into forest. He speculated that the increased herbaceous vegetation layer created by openings improved foraging habitat for small mammals.

The only significant difference in *Peromyscus* spp. abundance among treatments was between grasslands and intact forest, with grasslands having the higher abundance (Table 27). Most previous studies have also found that *Peromyscus* spp. benefit from disturbances that create early-successional habitats such as mining (Verts 1957, Mumford and Bramble 1969, DeCapita and Bookout 1975, Kirkland 1976, Hansen and Warnock 1978) and forest clearcutting (Kirkland 1977, Buckner and Shure 1985). Sherman trapping results from 2001 were slightly different, with the 2 reclaimed treatments having higher abundances than the 2 forest treatments. Again the results differ between the 2 methods because Sherman trapping is more effective at capturing *Peromyscus* spp.

Three species of microtine rodents, southern bog lemmings, woodland voles, and meadow voles, were captured by drift fence arrays (Table 27). Southern bog lemmings were the most common of these (86 individuals). Their abundance was higher in the two reclaimed treatments than in the forest treatments, while they were not captured at all in the intact forest. This was consistent with other accounts of the bog lemming. Kirkland (1977) described capturing bog lemmings in clearcuts but not in either deciduous or coniferous forests and Connor (1959) found them to be reliant on sedges and grasses for a food source. Woodland voles (47 individuals) were less abundant in grasslands than in intact forests. Despite their name, woodland voles can be found in a variety of habitats, including forests, orchards, and dry fields (Whitaker and Hamilton 1998). However, in a laboratory study, woodland voles chose sites with cooler, more organic soils over warmer, rocky soils (Rhodes and Richmond 1985). This may explain their lower numbers in the grassland treatment, where soils were likely too warm and rocky for them. Meadow voles, the least frequently captured of the microtines (22 individuals), did not differ in abundance among treatments. This may have been a function of having a small sample size and the fact that this species is a habitat generalist (Whitaker and Hamilton 1998).

Woodland jumping mice and short-tailed shrews were significantly more abundant in fragmented forest than in the other 3 treatments (Table 27). We did not find any other research suggesting that these species prefer fragmented forests to intact forests. For woodland jumping mice, however, Sherman trapping data concurred with this abundance trend. Woodland jumping mice are reported to prefer dense understory (Whitaker and Wrigley 1972) and are often found near forest streams (Whitaker and Hamilton 1998). Similarly, short-tailed shrews are known to prefer moist, cool sites (Getz 1961) because they have a high rate of evaporative water loss through their skin. Fragmented forest transects tended to follow slightly larger streams than did intact forest transects; consequently presence of water may have been driving greater abundance of these species (as described in section C above).

Three shrew species of the genus *Sorex* were captured in all 4 treatments: masked shrews, smoky shrews, and pygmy shrews (Table 27). Masked shrews, the most common of the 3, were more abundant in the shrub/pole treatment than in either forest treatment and were more abundant in the grassland treatment than the intact forest treatment. This species is a habitat generalist that exists in just about any habitat so long as it is moist (Moore 1949). Smoky shrew abundance did not differ among treatments. This species typically is found in damp woods (Caldwell and Bryan 1982) and was not expected to occur in grasslands. The high rainfall during spring - summer 2000 may have allowed smoky shrews to exist in grasslands that would otherwise have been too hot and dry. Pygmy shrew abundance was greater in the fragmented forest than in the shrub/pole treatment. The smallest of the shrews, this species usually is found in upland woods (Whitaker and Hamilton 1998). Small sample size (16 individuals) limits interpretation of trends in abundance for this species.

E. Herpetofaunal Surveys

Drift fence arrays established and sampled in 2000 were sampled again in 2001 using methods described in Wood et al. (2001). Arrays were opened for approximately eight days each month from March through October (excluding April). In 2001, an additional intact sampling array was added near the Daltex mine in Pigeonroost Hollow; it was sampled September and October.

In 2001, we also initiated a pilot project to assess aquatic herpetofaunal diversity and abundance in intact forest streams not impacted by mining and in fragmented forest streams located below valley fills.

Methods

Stream Searches – Sampling Techniques

To quantify aquatic and semi-aquatic herpetofaunal diversity and abundance, three fragmented forest streams and three intact forest streams were sampled once per month in May, June, and August -October of 2001. In addition, another forest fragment stream was added and sampled in September and October 2001. Streams were selected based on proximity to the drift fence arrays. Fragmented forest streams were located below valley fills.

A different 35-m segment was sampled in each stream each month. By moving down and sampling new, adjacent stream segments, the intention was to sample as much of the entire length of each stream as possible. Searching more than 35 m per visit is not practical, as some segments require several hours of search time due to their complex substrate. Each segment sampled was classified by stream order (intermittent, first order, second order, or third order) and by predominant structures (Table 28). Stream order was determined from topographic maps using the following definitions from the Federal Interagency Stream Restoration Working Group (1998; pages 25-26). "The uppermost channels in a drainage network (i.e., headwater channels with no upstream tributaries) are designated as first-order streams down to their first confluence. A second-order stream is formed below the confluence of two first-order channels. Third-order streams are created when two second-order channels join, and so on." Fragmented forest streams located below valley fills were assigned the stream order that they would have had before mining occurred.

Herpetofaunal sampling methods in streams were similar to those of Crump and Scott (1994). All rocks and coarse woody debris located within the width of the stream were lifted and checked under for herpetofauna. In addition, all rocks and coarse woody debris found up to 1-m from the edge of the stream were also sampled. A count was kept of all rocks and coarse woody debris checked under during the sample (Table 28). Time in person minutes was recorded, as were species, length of salamanders from snout to anterior portion of vent (cm) (done by placing salamander in a Ziploc bag); and length (cm), width (cm), and type of substrate (e.g., rock) under which the animal was found (Table 28). In addition, soil temperature in the stream (°C) was measured using a REOTEMP Heavy Duty Soil Thermometer (Ben Meadows Company) and air temperature (°C) was determined using a –30 to 50 °C / 1° Pocket Thermometer (Ben Meadows Company). Individuals were toe-clipped for identification of recaptures. Cover objects that would cloud the water with bottom substrate upon lifting are not included in the sample, as any salamanders would escape capture before their presence could be detected.

Data Analyses

Only data from drift fence arrays were subjected to statistical analyses. To account for differences in the lengths of trapping periods and in trap effort (an unequal trapping effort resulted from theft of traps, weather conditions rendering traps nonfunctional, etc.), the sum of the number of animals captured in all pitfall and funnel traps at each array during a trapping period was divided by the number of operable traps over the trapping session. This value multiplied by 100 equaled mean captures per treatment in 100 array-nights (Corn 1994).

ANOVA was used to compare mean captures among treatments. Dependent variables were mean abundance of: 1) all herpetofauna, 2) major groups (e.g., salamanders, toads and frogs, etc.), 3) all amphibians, 4) all reptiles, and 5) individual species with high enough captures (≥ 30). Main effect independent variables were treatment, year, sampling period, and mine. All anova tests excluded data from the new intact forest point because it was sampled for only 2 months in 2001; all other summary tables include this information.

Results and Discussion

Over the 2 years of sampling (2000 and 2001), 1750 individuals were captured or observed using drift fence arrays, stream searches, and incidental sightings. Of a possible 58 species expected to occur in the study area, we encountered 41 (Table 29), an increase of 6 species from 2000. The 41 species included 12 salamander species, 10 toad and frog species, 3 lizard species, 13 snake species, and 3 turtle species.

A total of 625 individuals and 32 species were captured using drift fence arrays over the 2 years (Table 30) including 10 salamander species, 9 toad and frog species, 3 lizard species, 9 snake species, and 1 turtle species. Fifteen of these species are classified as terrestrial, 10 are semi-aquatic, and 7 are aquatic.

Overall mean abundance of herpetofauna did not differ among the four treatments (F=1.62, df=3, P=0.28; Table 31). Mean richness also was not different among treatments (F=0.86, df=3, P=0.51; Table 31). In a study in Pennsylvania, Yahner et al. (2001) inventoried herpetofauna in forest, riparian, and grassland habitats using 8 different survey methods, including drift fence arrays. Forest habitat produced the highest number of individuals, whereas grasslands yielded no captures. Pais et al. (1988) conducted a study in eastern Kentucky, where the herpetofaunal community is similar to that on our sites. Using techniques similar to ours (drift fences in conjunction with pitfalls and funnel traps), they found no difference in total captures of herpetofauna among clearcuts, mature forest, and wildlife clearings, although herpetofaunal richness was lower in mature forest than in clearcuts and wildlife clearings. Although clearcuts can resemble reclaimed mine sites in vegetation structure, the magnitude of soil disturbance is greater on reclaimed sites.

Abundance was not different among the four treatments when species were categorized into terrestrial (F=0.81, df=3, P=0.53), aquatic (F=1.87, df=3, P=0.24), and semiaquatic herpetofauna (F=0.30, df=3, P=0.82; Table 31). Amphibian abundance also did not differ among the four treatments (F=1.09, df=3, P=0.42), nor did reptile abundance (F=2.09, df=3, P=0.20). Adams et al. (1996) found a higher abundance and species richness of reptiles in disturbed habitat (clearcuts) than in unharvested stands.

Salamander abundance was not significantly different across treatments (F=4.26, df=3, P=0.06), although it was generally higher in the 2 forested treatments (Table 31). This taxonomic group comprised 22-38% of captures in forested treatments and approximately 7% in grassland and shrub/pole treatments (Table 32). Number of species was higher in forested treatments. The red-spotted newt was the most abundant salamander and was the only salamander species found at every sampling point (Table 30). Both the red-spotted newt and the spotted salamander were found in every treatment. The only other salamander species found in reclaimed habitat was the four-toed salamander, which was captured in grassland and shrub/pole treatments. Both the spotted salamander and the four-toed salamander require moist forests, so the individuals found at a grassland point may have been migrating to a nearby wet area or forested habitat. The shrub/pole point at which a spotted salamander was captured is particularly wet compared to all other treatment points; pitfalls are often rendered nonfunctional due to the ground water pushing them up and out of the ground.

Forests tend to have cooler, moister, and more homogeneous climatic conditions than grasslands and should therefore better meet the habitat requirements of salamanders. Increased insolation and reduction in soil moisture retention associated with grassland habitat may limit the ability of a salamander to forage. Native vegetation removal alters rainfall interception rates and evapotranspiration, thereby additionally affecting soil moisture levels (Kapos 1989). In a review of 18 studies of amphibian responses to clearcutting, deMaynadier and Hunter (1995) found that amphibian abundance was 3.5 times higher in unharvested stands than in recent clearcuts. Other studies not covered in this review have found decreased abundance (Buhlmann et al. 1988, Sattler and Reichenbach 1998, Harpole and Haas 1999) or that responses are species-specific (Cole et al. 1997, Grialou 2000). Ross et al. (2000) found salamander richness and abundance to decrease as a function of increasing removal of live tree basal area. Ash (1997) observed an initial decrease in salamander abundance following clearcutting, but found that within 4-6 years, it returned to preharvesting levels and then proliferated. Because mining results in greater soil disturbance, however, salamander populations may take longer to recover on reclaimed sites than reported by Ash. Generally for salamanders, high site fidelity, small home ranges, physiological limitations, low fecundity, and the inability to traverse large distances quickly make them especially susceptible to effects of forest alterations (Pough et al. 1987, Petranka et al. 1993, Petranka et al. 1994, Blaustein et al. 1994, Droege et al. 1997, Gibbs 1998b, Ross et al. 2000).

Toads and frogs showed no difference in abundance among the treatments ($F=0.89$, $df=3$, $P=0.50$; Table 31). This taxonomic group was consistently present in the highest numbers in each treatment, comprising from 44-73% of all individuals captured within treatments (Table 32). The green frog was the only anuran species captured at every sampling point (Table 30). Both eastern American toads and pickerel frogs were captured in every treatment (Table 29). The green frog and the pickerel frog were the most abundant species in this study (Table 30), totaling 45% of all captures. Toads and frogs are more tolerant of temperature extremes than salamanders (Stebbins and Cohen 1995), and thus can occur in non-forested habitats. Ross et al. (2000) found toad and frog richness to have a positive relationship with increases in tree basal area.

Snakes varied from 12-28% of captures in each treatment (Table 30). Five species were found in all four treatments: black rat snake, eastern gartersnake, eastern milk snake, northern black racer, and northern copperhead. Snakes also showed no difference in abundance across treatments ($F=2.08$, $df=3$, $P=0.2039$; Table 31). Ross et al. (2000) found snake abundance and species richness to be inversely related to tree basal area. Forested habitat is preferred or required by four snake species captured in this study; one prefers grasslands, and four can be found in a variety of habitats (Behler and King 1995, Green and Pauley 1987, Conant and Collins 1998). The four ubiquitous species comprised the majority of snake captures (82%), which could explain why abundance was not different among treatments.

Lizards were not captured in high enough abundance to conduct statistical analyses; they made up only 2-3% of total herpetofauna captured in each treatment (Table 32). Three of the five lizard species expected to occur in our study area were captured in drift fence arrays (Table 29); they included three northern-fence lizards, eight common five-lined skinks, and two little brown skinks. While only three fence lizards were captured, this species was commonly sighted in all treatments except intact forest). Because this species is not typically found in moist forests, it may not have been abundant on the study sites prior to mining. The little brown skink is classified as an S3 species by the West Virginia Natural Heritage Program (2000) meaning that there are only 21 to 100 documented occurrences in the state and that it may be under threat of extirpation. It prefers dry, open woodlands and uses leaf litter and decaying wood for concealment and foraging (Green and Pauley 1987, Conant and Collins 1998). Captures occurred in pitfalls, one in grassland habitat and the other in intact forest (Table 29). Leaf litter is present in negligible amounts and CWD is absent from our grassland sampling points (Table 33), so grassland habitats generally would not be suitable for little brown skinks.

Turtles also were not captured in high enough abundance to conduct statistical analyses. Only one species of turtle, the eastern box turtle, was captured in the arrays (Table 29). Eastern box turtles seldom are captured in pitfall traps and may have a natural wariness of pitfalls (Pais et al. 1988). Furthermore, they are too large to fit through the entrance of funnel traps used in this study. As this species was commonly sighted as an incidental and was found in every treatment, it probably has fairly high population numbers on the study sites.

Six species had ≥ 30 individuals captured, so abundance was compared among treatments (Table 31). The northern black racer had highest abundance in the shrub/pole treatment and did not occur in the forest fragment and intact forest treatments *(F=4.79, df=3, P=0.05)*. The Florida king snake (*Lampropeltis getula floridana*) benefited from conversion of its native habitat (cypress ponds, savannah pine lands, and prairies) to sugarcane fields. This conversion increased prey density and provided additional shelter for the snakes with the creation of limestone dredge material along the banks of the irrigation canals (Pough et al. 2001). Perhaps the creation of riprap channels and rock chimneys in reclaimed habitat has served the northern black racer population on mountaintop mines in a similar way. Abundance of the eastern American toad (F=1.09, df=3, P=0.42), red-spotted newt (F=1.62, df=3, P=0.28), northern green frog (F=1.78, df=3, P=0.25), pickerel frog (F=1.30, df=3, P=0.36), and eastern gartersnake (F=0.34, df=3, P=0.80) did not differ among the four treatments. Other studies have found the red-spotted newt to be sensitive to forest fragmentation (Gibbs 1998a) and forest edge (Gibbs 1998b). However, similar to our study, deMaynadier and Hunter (1998) looked at even-aged silvicultural treatments (clearcuts and conifer plantations) and did not find a difference in newt abundance between these treatments and the bordering mature forest. Ross et al. (2000) observed a positive association of eastern garter snakes with forest stands containing negligible amounts of residual tree basal area.

Several species captured or detected during the 2 years of the study are listed as S2 or S3 status by the West Virginia Natural Heritage Program (2000). A species with S2 status is described as "very rare and imperiled," with as few as 6-20 documented cases in West Virginia. The northern leopard frog is listed as an S2 species. Drift fence arrays captured two individuals in forest fragments and two in shrub/pole habitat (Table 30). In addition, a few individuals were heard singing in a forest fragment (Table 29). S3 species documented in our study included the northern red salamander, little brown skink (discussed earlier), eastern wormsnake, timber rattlesnake, eastern hog-nosed snake, and northern rough greensnake. One of the seven timber rattlesnakes sighted was in an intact site, the other six were in or on the border of shrub/pole habitat; all were incidental sightings. One northern rough greensnake was found in shrub/pole habitat and the other in an intact forest, both as incidental sightings. Two eastern hog-nosed snakes were captured in shrub/pole habitat in funnel traps of the drift fence array. Another was captured in grassland habitat, also in a funnel trap, and there was one incidental sighting in grassland habitat. Three northern red salamanders were found at 2 intact forest sites, while a fourth was found in a forest fragment; this species was captured in both drift fence arrays and stream surveys.

Data from the 2001 stream surveys were not analyzed statistically because sample sites were not paired by stream order and structure. Therefore, these data are preliminary and will be used to more effectively design the surveys for 2002. Generally, a range of habitat conditions was sampled in the segments (Table 28).

A total of 678 stream herpetofauna of 15 species were captured in stream surveys. Total captures were higher in intact forest streams (IFS) (n = 389) than in fragmented forest streams

(FFS) (n = 289; Tables 34 and 36), although 2 extra stream segments were sampled in FFS. More species were captured in the FFS (n = 13) than in the IFS (n = 10). Salamanders comprised 97% of total captures, so toads, frogs, and snakes were excluded from abundance calculations per stream segment. Second order FFS had the highest (68.5 ± 7.5) and lowest (1.8 ± 0.97) means of stream salamanders per stream segment (Table 35). Mean abundance of herpetofauna and habitat characteristics per segment of stream sampled are summarized in Tables 35 and 36.

In summary, 6 additional species of herpetofauna were captured in 2001. Three of these (the northern rough greensnake, northern leopard frog, and northern red salamander) are listed as special status by the West Virginia Natural Heritage Program (2000) which brings the total to seven for the 2 years of the study. Overall species richness and abundance based on the array data for 2000 and 2001 did not differ among treatments. Although salamander abundance did not differ statistically among the treatments, it was generally higher within the 2 forested treatments. The only salamander species captured outside of a forested treatment in 2000 was a spotted salamander; it was found in a grassland site. This year, another spotted salamander was found in shrub/pole habitat and a four-toed salamander was found in a grassland.

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Table 1. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Dickcissels and Grasshopper Sparrows at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Dickcissel						Grasshopper Sparrow					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	1.3	0.2			0.7	0.2	1.0	0.1		
Slope (%)	13.1	1.5	21.8	6.6			8.5	2.1	16.5	1.9		
Distance to Minor Edge (m)	101.4	11.3	28.5	5.0			68.1	10.4	105.4	14.2		
Distance to Habitat Edge (m)	188.2	25.6	585.1	149.0	6.571	0.010+	87.0	14.5	290.1	40.3		
Grass/Forb Height (dm)	6.9	0.3	5.9	1.1			6.0	0.6	7.2	0.3		
Litter Depth (cm)	2.0	0.1	1.9	0.4			1.5	0.2	2.2	0.2		
Robel Pole Index	3.5	0.2	3.8	0.5	4.043	0.044+	4.2	0.3	3.2	0.2		
Elevation (m)	386.1	6.5	441.6	19.5			381.6	14.6	396.1	6.7		
Tree Density (no./ha):												
>0-2.5 cm	4050.7	885.6	175.8	137.5			8173.2	2143.6	1599.1	441.9		
>2.5-8 cm	509.5	149.5	46.9	25.7			1135.4	398.2	156.3	33.8		
>8-23 cm	60.7	13.2	0.1	0.1			143.2	29.9	14.2	5.3	19.810	<0.001-
Ground Cover (%):												
Water	0.1	0.1	0.3	0.3			0.1	0.1	0.2	0.1		
Litter	7.8	1.3	2.8	1.2			7.5	2.4	7.1	1.3		
Bareground/rock	4.4	0.7	13.8	4.1	9.611	0.002+	2.6	1.2	6.6	1.0		
Woody Debris	0.2	0.1	0.0	0.0			0.3	0.2	0.1	0.0		
Moss	1.3	0.4	1.9	1.4			2.4	1.2	0.9	0.3		
Green	84.5	2.0	80.6	3.5			82.3	4.6	84.9	1.8		
Grass	45.6	2.9	34.8	6.1			43.6	6.1	44.9	2.9		
Forb	22.7	1.9	24.8	5.9			19.6	3.0	24.4	2.3		
Shrub	17.6	2.2	20.9	8.0			22.8	3.4	15.7	2.6		
Hosmer-Lemeshow Goodness-of-Fit Test					3.368	0.909					0.796	0.851

Table 2. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Eastern Meadowlarks and Red-winged Blackbirds at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' indicate a negative relationship between presence and the habitat variables. Only significant results are reported.

	Eastern Meadowlark						Red-winged Blackbird					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	1.1	0.1			0.8	0.1	1.1	0.1		
Slope (%)	13.0	1.8	16.4	2.6			10.9	1.8	19.0	2.4		
Distance to Minor Edge (m)	88.4	11.2	105.6	23.0			98.0	14.3	87.2	15.1		
Distance to Habitat Edge (m)	161.4	30.0	373.2	61.9			176.8	28.6	308.3	61.1		
Grass/Forb Height (dm)	6.5	0.3	7.6	0.4			6.4	0.4	7.4	0.3		
Litter Depth (cm)	1.9	0.2	2.2	0.2			1.6	0.1	2.6	0.2		
Robel Pole Index	3.8	0.2	2.9	0.3			3.8	0.2	3.0	0.2		
Elevation (m)	392.3	8.4	390.4	9.4			403.8	8.1	373.0	9.9		
Tree Density (no./ha):												
>0-2.5cm	5021.8	1119.1	614.6	172.9			3883.6	1097.7	3279.2	1163.2		
>2.5-8cm	615.6	191.8	121.1	44.0	7.480	0.006-	465.4	105.3	455.2	308.0		
>8-23cm	75.6	16.5	7.6	5.3			72.7	18.3	25.7	9.7		
Ground Cover(%):												
Water	0.1	0.1	0.3	0.2			0.1	0.1	0.2	0.1		
Litter	6.6	1.3	8.7	2.3			6.1	1.5	9.0	1.8		
Bareground/rock	4.5	1.0	7.3	1.6			4.4	1.0	6.9	1.5		
Woody Debris	0.2	0.1	0.1	0.1			0.2	0.1	0.2	0.1		
Moss	1.7	0.6	0.7	0.4			1.3	0.6	1.5	0.6		
Green	84.6	2.3	82.9	3.2			86.7	2.2	80.0	3.2		
Grass	42.4	3.4	49.0	4.4			40.7	3.6	50.4	3.8		
Forb	22.2	2.1	24.4	3.7			23.0	2.3	22.7	3.1		
Shrub	21.7	2.6	9.5	3.2	4.813	0.028-	23.6	2.9	9.0	2.4	9.937	0.002-
Hosmer-Lemeshow Goodness-of-Fit Test					10.231	0.249					4.779	0.573

Table 3. Means, standard errors (SE) for the presence/absence of Horned Larks and Willow Flycatchers at point counts in grassland and shrub/pole habitats in southwestern West Virginia. No variables were chosen by stepwise logistic regression as predictors for either of these species.

	Horned Lark				Willow Flycatcher			
	Absent		Present		Absent		Present	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Aspect Code	0.9	0.1	1.0	0.2	0.9	0.1	1.2	0.2
Slope (%)	11.8	1.5	22.0	4.0	14.1	1.7	13.9	2.0
Distance to Minor Edge (m)	90.2	11.3	106.5	26.2	88.1	10.4	142.4	45.1
Distance to Habitat Edge (m)	167.9	24.4	433.3	90.1	219.7	32.5	305.3	76.1
Grass/Forb Height (dm)	6.6	0.3	7.6	0.4	6.7	0.3	8.1	0.3
Litter Depth (cm)	1.8	0.1	2.8	0.3	1.9	0.1	2.4	0.3
Robel Pole Index	3.8	0.2	2.6	0.2	3.6	0.2	2.6	0.3
Elevation (m)	392.9	7.8	387.8	10.3	393.1	7.0	379.5	13.4
Tree Density (no./ha):								
>0-2.5cm	4373.4	1007.6	1088.2	435.0	3903.1	893.1	1449.2	242.1
>2.5-8cm	562.5	170.9	104.8	33.5	494.1	150.0	179.7	63.5
>8-23cm	69.8	14.9	0.0	0.0	60.7	13.2	0.0	0.0
Ground Cover (%):								
Water	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0
Litter	6.1	1.3	11.3	2.4	7.1	1.2	8.3	3.6
Bareground/rock	4.5	0.9	8.3	1.7	5.4	0.9	5.2	2.8
Woody Debris	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.2
Moss	1.3	0.5	1.7	0.8	1.4	0.5	1.1	0.9
Green	85.7	2.2	78.6	3.2	84.0	2.0	85.3	6.4
Grass	43.6	3.3	47.5	4.4	43.2	3.0	55.2	3.6
Forb	22.8	2.1	23.3	3.6	23.1	2.0	21.3	4.5
Shrub	20.8	2.5	7.8	3.2	19.0	2.3	8.9	3.0

Table 4. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of White-eyed Vireos and Yellow-breasted Chats at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	White-eyed Vireo						Yellow-breasted Chat					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	0.8	0.2			1.0	0.1	0.9	0.1		
Slope (%)	14.4	1.7	12.9	3.1			17.7	2.3	10.1	1.7		
Distance to Minor Edge (m)	99.3	12.8	75.7	15.5			104.8	17.0	81.9	11.6		
Distance to Habitat Edge (m)	270.4	37.4	86.0	12.2			338.4	50.1	103.6	13.1	4.663	0.031-
Grass/Forb Height (dm)	6.8	0.3	6.8	0.6			7.2	0.3	6.4	0.4		
Litter Depth (cm)	2.0	0.1	2.1	0.3			2.2	0.2	1.8	0.2		
Robel Pole Index	3.3	0.2	4.2	0.4			3.1	0.2	4.0	0.3		
Elevation (m)	396.2	7.1	376.6	14.5			403.0	8.5	378.9	9.6		
<u>Tree Density (no./ha)</u>:												
>0-2.5cm	2060.9	646.4	8850.7	2373.0	8.739	0.003+	566.4	171.9	6979.7	1488.7	11.423	0.001+
>2.5-8cm	434.3	171.5	550.3	136.6			152.3	40.9	795.6	268.4		
>8-23cm	45.2	14.1	84.7	21.6			29.6	15.5	81.3	17.8		
>23-38 cm	1.6	0.9	5.2	2.6			1.1	1.1	3.9	1.5		
Snags	5.4	2.7	7.3	2.9			0.9	0.9	11.5	4.4		
<u>Ground Cover (%)</u>:												
Water	0.1	0.1	0.3	0.2			0.2	0.1	0.1	0.1		
Litter	7.1	1.4	7.8	2.1			6.6	1.7	8.0	1.6		
Bareground/rock	6.3	1.0	2.5	0.7			7.4	1.3	3.2	0.9		
Woody Debris	0.1	0.1	0.2	0.1			0.1	0.1	0.2	0.1		
Moss	1.3	0.5	1.7	0.7			1.6	0.7	1.2	0.4		
Green	83.1	2.3	87.4	2.3			84.1	2.5	84.1	2.8		
Grass	46.4	3.1	38.3	5.4			47.5	3.8	41.2	3.8		
Forb	21.6	2.1	27.2	3.5			19.5	2.4	26.6	2.6	4.526	0.033+
Shrub	16.6	2.5	22.1	4.2			17.1	3.3	18.8	2.6		
Hosmer-Lemeshow Goodness-of-Fit Test					5.037	0.656					50.074	<0.001

Table 5. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Prairie Warblers and Blue-winged Warblers at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Prairie Warbler						Blue-winged Warbler					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.1	0.1	0.8	0.1			1.0	0.1	0.8	0.2		
Slope (%)	15.9	2.3	12.0	1.8	4.872	0.027-	14.7	1.7	12.0	2.9		
Distance to Minor Edge (m)	98.4	16.1	88.8	13.3			94.8	12.0	90.5	22.1		
Distance to Habitat Edge (m)	351.7	48.8	88.4	11.2	6.040	0.014-	267.0	37.5	97.4	16.5		
Grass/Forb Height (dm)	6.6	0.4	7.0	0.4			6.9	0.3	6.7	0.6		
Litter Depth (cm)	1.9	0.2	2.1	0.2	8.658	0.003+	2.0	0.1	2.0	0.3		
Robel Pole Index	3.2	0.2	3.9	0.3			3.4	0.2	3.9	0.4		
Elevation (m)	405.2	8.2	376.4	9.6			399.0	6.8	366.8	15.3		
Tree Density (no./ha):												
>0-2.5cm	2542.2	959.5	4843.8	1299.9			2583.2	756.8	7138.9	2245.4		
>2.5-8cm	351.6	232.1	580.2	126.8			180.1	32.8	1383.7	520.3	8.766	0.003+
>8-23cm	38.8	19.5	71.3	13.3			44.2	14.0	87.9	21.8		
>23-38 cm	1.7	1.2	3.2	1.4	8.520	0.004+	1.4	0.8	5.9	2.8		
Snags	4.6	3.0	7.3	3.2			5.9	2.7	5.6	2.5		
Ground Cover (%):												
Water	0.2	0.1	0.1	0.1			0.1	0.1	0.2	0.2		
Litter	8.3	1.8	6.1	1.5			7.0	1.4	8.2	2.2		
Bareground/rock	8.2	1.4	2.3	0.6			6.1	1.0	3.0	0.8		
Woody Debris	0.1	0.1	0.2	0.1			0.1	0.1	0.2	0.1		
Moss	1.8	0.8	0.9	0.3			1.3	0.5	1.7	0.7		
Green	79.0	3.0	89.6	1.9	6.378	0.012+	84.9	2.0	81.6	4.4		
Grass	41.2	3.3	48.0	4.3			45.4	3.2	41.6	4.9		
Forb	22.1	2.5	23.7	2.7			22.5	2.1	24.2	3.9		
Shrub	17.3	3.0	18.6	3.1			17.1	2.5	20.8	4.1		
Hosmer-Lemeshow Goodness-of-Fit Test					8.395	0.396					7.755	0.170

Table 6. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Common Yellowthroats and Yellow Warblers at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Common Yellowthroat						Yellow Warbler					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	1.0	0.1			0.9	0.1	1.1	0.2		
Slope (%)	14.0	2.2	14.1	2.0			12.8	1.8	18.1	2.5		
Distance to Minor Edge (m)	107.0	16.3	79.5	12.6			91.9	11.9	100.0	22.5		
Distance to Habitat Edge (m)	270.1	40.3	183.4	44.8			224.2	35.0	241.7	61.3		
Grass/Forb Height (dm)	6.7	0.4	7.0	0.4			6.5	0.3	7.9	0.4		
Litter Depth (cm)	1.9	0.2	2.1	0.2			1.8	0.1	2.6	0.3		
Robel Pole Index	3.1	0.2	3.9	0.2			3.7	0.2	2.9	0.3		
Elevation (m)	409.1	7.9	373.0	9.6			404.0	7.4	353.0	8.8	8.119	0.004-
<u>Tree Density (no./ha)</u>:												
>0-2.5cm	1303.9	525.6	6182.4	1475.6	13.797	<0.001+	3413.7	949.3	4416.7	1502.7		
>2.5-8cm	186.7	48.2	758.4	269.3			365.5	86.0	776.0	507.7		
>8-23cm	48.9	20.2	60.3	12.5			55.3	14.3	51.4	21.6		
>23-38 cm	3.4	1.7	1.4	0.6	4.157	0.041-	3.2	1.2	0.0	0.0		
Snags	4.1	3.0	7.7	3.1			5.4	2.5	7.2	4.5		
<u>Ground Cover (%)</u>:												
Water	0.2	0.1	0.1	0.1			0.1	0.1	0.2	0.2		
Litter	8.0	1.9	6.5	1.3			6.0	1.2	11.3	2.7	3.953	0.047+
Bareground/rock	6.8	1.3	3.8	1.0			5.8	1.0	4.0	1.3		
Woody Debris	0.2	0.1	0.2	0.1			0.1	0.1	0.3	0.1		
Moss	1.2	0.7	1.5	0.5			1.3	0.5	1.6	0.7		
Green	83.6	2.6	84.6	2.8			85.7	1.9	79.0	4.8		
Grass	45.1	3.8	43.8	3.9			41.6	3.2	54.0	4.7		
Forb	21.0	2.7	24.9	2.5			25.2	2.2	15.4	2.6		
Shrub	17.6	3.0	18.3	3.1			19.4	2.4	13.1	4.8		
Hosmer-Lemeshow Goodness-of-Fit Test					3.636	0.726					3.605	0.891

Table 7. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Indigo Buntings and Northern Cardinals at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Indigo Bunting						Northern Cardinal					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.2	0.2	0.9	0.1			1.0	0.1	0.8	0.3		
Slope (%)	20.4	4.0	12.9	1.6			15.0	1.6	8.9	3.3		
Distance to Minor Edge (m)	107.8	35.1	91.2	10.7			97.2	11.8	75.4	20.6		
Distance to Habitat Edge (m)	364.8	81.8	199.0	31.4			255.7	34.6	75.9	13.0		
Grass/Forb Height (dm)	6.8	0.8	6.8	0.3			7.1	0.3	5.6	0.9		
Litter Depth (cm)	2.0	0.3	2.0	0.1			2.1	0.1	1.7	0.3		
Robel Pole Index	3.6	0.4	3.5	0.2			3.3	0.2	4.7	0.5		
Elevation (m)	397.7	15.0	390.4	7.2			393.4	6.4	382.3	23.6		
<u>Tree Density (no./ha)</u>:												
>0-2.5cm	1291.7	1181.8	4083.2	920.6			2932.7	699.0	7523.4	3418.8		
>2.5-8cm	119.8	77.6	524.5	158.2	4.372	0.037+	377.9	144.9	914.1	350.3	5.134	0.0235+
>8-23cm	17.7	13.1	61.2	13.9			50.4	13.8	76.0	18.6		
>23-38 cm	0.0	0.0	2.9	1.1			2.4	1.1	2.6	1.2		
Snags	1.3	1.3	6.8	2.6			6.2	2.5	4.2	2.9		
<u>Ground Cover (%)</u>:												
Water	0.2	0.2	0.1	0.1			0.2	0.1	0.0	0.0		
Litter	6.0	2.2	7.5	1.3			7.5	1.3	6.0	2.3		
Bareground/rock	11.0	3.2	4.3	0.7	5.055	0.025-	5.6	0.9	4.4	2.5		
Woody Debris	0.0	0.0	0.2	0.1			0.2	0.1	0.2	0.2		
Moss	1.5	1.0	1.4	0.5			1.6	0.5	0.2	0.2		
Green	81.3	3.5	84.6	2.1			84.0	2.0	84.8	4.9		
Grass	42.8	5.4	44.8	3.1			46.0	2.7	36.3	9.0		
Forb	19.9	4.3	23.4	2.0			22.3	2.0	26.1	4.7		
Shrub	18.5	6.1	17.8	2.3			16.7	2.3	24.7	5.9		
Hosmer-Lemeshow Goodness-of-Fit Test					9.006	0.252					5.801	0.326

Table 8. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of American Goldfinches and Song Sparrows at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '+' indicates a positive relationship between presence and the habitat variables. Only significant results are reported.

	American Goldfinch						Song Sparrow					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	0.9	0.1			0.9	0.1	1.3	0.2		
Slope (%)	14.0	2.1	14.1	2.1			13.4	1.6	17.6	4.7		
Distance to Minor Edge (m)	102.4	13.6	79.5	16.3			98.4	11.7	66.1	20.3		
Distance to Habitat Edge (m)	238.2	40.1	211.5	45.4			177.8	21.8	510.9	134.7	7.953	0.0048+
Grass/Forb Height (dm)	6.7	0.3	7.1	0.5			6.9	0.3	6.6	0.8		
Litter Depth (cm)	1.9	0.2	2.2	0.2			2.0	0.2	2.0	0.2		
Robel Pole Index	3.5	0.2	3.5	0.3			3.4	0.2	4.0	0.6		
Elevation (m)	395.5	7.8	385.2	11.3			386.6	7.0	420.3	14.7		
Tree Density (no./ha):												
>0-2.5cm	4289.7	1167.6	2586.2	902.2			3730.1	872.2	3156.3	2179.2		
>2.5-8cm	519.5	206.1	365.3	112.1			495.7	156.5	255.7	87.4		
>8-23cm	60.3	17.4	44.6	14.1			57.2	13.5	37.5	24.2		
>23-38 cm	2.5	1.1	2.4	1.7			2.7	1.1	1.1	1.1		
Snags	5.6	2.7	6.3	3.8			5.6	2.3	7.3	6.2		
Ground Cover (%):												
Water	0.2	0.1	0.0	0.0			0.2	0.1	0.0	0.0		
Litter	7.0	1.5	7.7	1.9			7.2	1.3	7.6	2.3		
Bareground/rock	5.5	1.1	5.2	1.4			5.1	0.9	7.0	2.8		
Woody Debris	0.2	0.1	0.2	0.1			0.2	0.1	0.0	0.0		
Moss	1.7	0.6	0.9	0.4			1.2	0.4	2.6	1.3		
Green	83.4	2.4	85.2	3.1			84.3	2.1	82.9	3.9		
Grass	41.4	3.3	49.5	4.6			44.9	3.0	41.6	5.5		
Forb	24.8	2.4	19.7	2.7			22.4	2.0	25.7	5.1		
Shrub	19.0	2.6	16.1	3.6			18.3	2.3	15.5	5.7		
Hosmer-Lemeshow Goodness-of-Fit Test					--	--					12.390	0.135

Table 9. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Chipping and Field Sparrows at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Only significant results are reported.

	Chipping Sparrow						Field Sparrow					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.9	0.1	0.9	0.3			1.0	0.1	0.9	0.1		
Slope (%)	14.7	1.6	9.2	3.6			17.5	2.8	11.6	1.6		
Distance to Minor Edge (m)	100.3	11.6	44.6	9.7			85.8	12.6	99.5	15.6		
Distance to Habitat Edge (m)	245.8	33.5	92.8	21.0			313.2	56.8	164.3	28.3		
Grass/Forb Height (dm)	6.8	0.3	7.2	0.8			6.6	0.4	7.0	0.3		
Litter Depth (cm)	2.0	0.1	1.8	0.2			1.9	0.2	2.1	0.2		
Robel Pole Index	3.4	0.2	4.1	0.3			3.2	0.2	3.7	0.2		
Elevation (m)	392.2	7.0	387.6	15.3			406.3	9.0	380.7	8.8		
Tree Density (no./ha):												
>0-2.5cm	2918.2	765.9	9163.2	3346.8			2414.1	1127.1	4525.7	1111.3		
>2.5-8cm	413.6	148.9	822.9	241.1			410.2	289.9	497.9	107.8	5.736	0.0166+
>8-23cm	48.5	13.4	99.3	11.8	7.952	0.0048+	46.5	23.9	60.0	11.8		
>23-38 cm	1.8	0.9	6.9	3.2			3.5	1.9	1.7	0.8		
Snags	3.5	1.9	24.3	11.1			7.0	4.3	5.0	2.1		
Ground Cover (%):												
Water	0.2	0.1	0.0	0.0			0.2	0.1	0.1	0.1		
Litter	7.5	1.3	5.7	2.2			7.4	2.0	7.2	1.4		
Bareground/rock	5.4	0.9	5.1	3.2			8.5	1.6	3.1	0.7	3.960	0.0466-
Woody Debris	0.1	0.1	0.3	0.2			0.2	0.1	0.1	0.1		
Moss	1.4	0.5	1.3	0.8			1.3	0.8	1.4	0.4		
Green	83.6	2.1	87.7	4.0			80.2	3.4	86.8	2.1		
Grass	44.3	2.8	46.1	10.8			43.0	4.1	45.5	3.6		
Forb	22.7	1.9	24.6	5.9			20.6	2.7	24.5	2.4		
Shrub	18.0	2.3	17.1	4.7			18.6	3.5	17.4	2.7		
Hosmer-Lemeshow Goodness-of-Fit Test					7.101	0.069					4.323	0.742

Table 10. Means, standard errors (SE), and stepwise logistic regression results for the presence/absence of Eastern Towhees at point counts in grassland and shrub/pole habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables.

	Eastern Towhee					
	Absent		Present			
Variable	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.1	0.1	0.7	0.2		
Slope (%)	16.4	1.9	9.5	2.2		
Distance to Minor Edge (m)	104.3	14.8	73.1	10.3		
Distance to Habitat Edge (m)	298.7	41.4	85.0	13.5		
Grass/Forb Height (dm)	7.3	0.3	5.9	0.6		
Litter Depth (cm)	2.1	0.2	1.8	0.3		
Robel Pole Index	3.1	0.2	4.3	0.4		
Elevation (m)	393.5	7.2	388.2	13.3		
Tree Density (no./ha):						
>0-2.5cm	1984.1	597.8	6912.3	1945.1		
>2.5-8cm	393.4	190.6	595.0	142.1		
>8-23cm	25.6	11.6	110.8	24.1	19.783	<0.001+
>23-38 cm	0.6	0.4	6.0	2.5		
Snags	5.3	2.8	7.0	3.4		
Ground Cover (%):						
Water	0.2	0.1	0.0	0.0		
Litter	6.6	1.3	8.5	2.3		
Bareground/rock	6.6	1.1	2.9	1.2		
Woody Debris	0.2	0.1	0.1	0.1		
Moss	1.1	0.4	1.9	1.0		
Green	83.4	2.2	85.6	3.6		
Grass	47.1	3.0	39.3	5.5		
Forb	22.8	2.3	23.0	2.9		
Shrub	15.2	2.4	23.3	4.0		
Hosmer-Lemeshow Goodness-of-Fit Test					1.072	0.784

Table 11. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of American Redstarts and Carolina Chickadees in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	American Redstart						Carolina Chickadee					
	Absent (n=45)		Present (n=40)				Absent (n=49)		Present (n=36)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	0.8	0.1	1.3	0.1	12.391	<0.001+	1.0	0.1	1.1	0.1		
Slope (%)	33.8	2.1	33.8	2.2			34.1	2.1	33.3	2.2		
Elevation	359.0	10.3	376.4	11.6			378.5	10.3	350.6	11.2		
Distance to minor edge (m)	48.1	9.3	59.9	10.6			54.1	8.5	53.1	11.8		
Distance to habitat edge (m)	630.9	122.6	1262.7	181.4			1052.9	148.9	724.0	160.6		
Canopy height (m)	22.4	0.7	22.5	0.8			22.9	0.6	21.9	0.8		
Ground Cover (%):												
Water	0.8	0.3	0.8	0.2			0.7	0.2	0.8	0.3		
Bareground/rock	8.8	0.8	6.2	0.7			7.7	0.7	7.4	0.8		
Leaf litter	53.2	1.6	48.2	2.1			49.8	1.5	52.3	2.3		
Woody debris	4.9	0.4	4.3	0.5			4.9	0.4	4.3	0.4		
Moss	2.1	0.3	1.9	0.4			2.2	0.3	1.8	0.4		
Green	30.0	1.5	38.4	2.2			34.6	1.6	33.1	2.5		
Tree Density (no./ha):												
≤2.5 cm	6628.5	732.7	4501.6	429.7			6150.5	696.5	4915.8	466.5		
>2.5-8 cm	841.7	53.4	583.6	70.5	6.919	0.008-	688.8	57.6	763.0	73.9		
>8-23 cm	305.3	23.2	283.4	22.9			263.0	18.8	338.5	27.5	5.635	0.018+
>23-38 cm	90.7	4.9	89.7	5.1			92.1	5.1	87.7	4.6		
>38-53 cm	32.8	3.0	28.6	2.6			31.0	2.6	30.6	3.1		
>53-68 cm	9.3	1.5	8.3	1.3			9.8	1.4	7.5	1.4		
>68 cm	3.6	0.7	3.4	0.8			3.2	0.6	4.0	1.0		
Snags (>8 cm)	46.1	5.3	45.1	6.2			45.2	5.2	46.3	6.3		

Table 11 cont.

Canopy Cover (%):												
>0.5-3 m	53.2	2.1	47.9	2.7			50.3	2.2	51.3	2.7		
>3-6 m	63.2	2.3	55.9	2.4			58.1	2.1	61.9	2.8		
>6-12 m	63.9	1.8	65.0	1.6			62.2	1.6	67.5	1.9		
>12-18 m	56.8	2.3	64.1	2.3			60.3	2.5	60.1	2.2		
>18 m	44.3	3.1	50.3	3.2			49.5	2.9	43.8	3.4		
>24 m	17.8	2.4	16.7	2.2			15.8	1.9	19.2	2.8		
Structural Diversity Index	59.8	1.4	60.0	1.4			59.3	1.3	60.8	1.5		
Hosmer-Lemeshow Goodness-of-fit Test					9.127	0.332					7.076	0.529

Table 12. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Northern Parulas and Carolina Wrens in forested habitats in southwestern West Virginia. The ‘-‘ and ‘+’ indicate either a negative or positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Northern Parula						Carolina Wren					
	Absent (n=62)		Present (n=23)				Absent (n=57)		Present (n=28)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.1	0.1	1.0	0.1			1.0	0.1	1.2	0.1		
Slope (%)	33.6	1.8	34.3	2.8			33.1	2.0	35.0	2.4		
Elevation	373.8	8.7	347.5	15.8			378.7	10.0	340.2	9.2	5.966	0.015-
Distance to minor edge (m)	55.9	9.2	47.6	7.6			58.2	10.1	44.4	4.8		
Distance to habitat edge (m)	1017.3	131.8	631.7	192.0			990.1	138.3	747.8	178.0		
Canopy height (m)	22.3	0.6	22.9	0.8			22.3	0.6	22.8	0.9		
Ground Cover (%):												
Water	0.6	0.2	1.3	0.3	6.815	0.009+	0.5	0.1	1.3	0.4		
Bareground/rock	7.4	0.7	7.9	0.8			7.5	0.7	7.6	0.9		
Leaf litter	50.5	1.6	51.7	2.1			53.4	1.5	45.6	2.4	5.889	0.015-
Woody debris	4.6	0.3	4.7	0.7			4.6	0.4	4.6	0.5		
Moss	1.9	0.3	2.3	0.3			2.0	0.3	2.0	0.4		
Green	34.8	1.7	31.7	2.1			31.8	1.6	38.3	2.5		
Tree Density (no./ha):												
≤2.5 cm	5594.8	554.7	5716.0	747.5			6008.2	547.9	4852.7	783.0		
>2.5-8 cm	677.4	51.4	835.6	93.1			766.4	54.5	626.1	81.0		
>8-23 cm	297.8	18.5	287.5	34.6			278.8	17.5	327.9	34.0		
>23-38 cm	91.1	4.0	87.8	7.3			90.1	4.3	90.4	6.3		
>38-53 cm	31.9	2.4	28.0	3.5			30.3	2.4	31.9	3.6		
>53-68 cm	9.7	1.2	6.5	1.7			8.3	1.1	9.8	2.0		
>68 cm	3.5	0.7	3.5	1.0			3.5	0.7	3.6	0.9		
Snags (>8 cm)	47.7	5.1	40.1	5.5			42.3	4.2	52.3	8.5		

Table 12 cont.

Canopy Cover (%):												
>0.5-3 m	49.0	2.0	55.4	3.3			51.9	2.0	48.2	3.2		
>3-6 m	56.9	1.9	67.4	2.9	8.859	0.003+	59.8	2.1	59.6	2.7		
>6-12 m	64.8	1.3	63.4	2.9	4.491	0.034-	63.7	1.5	65.9	2.1		
>12-18 m	61.5	2.0	56.8	3.2			59.7	1.9	61.4	3.3		
>18 m	48.0	2.6	44.6	4.3			51.0	2.5	39.1	4.0		
>24 m	17.3	1.9	17.1	3.2			18.9	2.0	13.9	2.7		
Structural Diversity Index	59.5	1.1	61.0	2.0			61.0	1.2	57.6	1.6		
Hosmer-Lemeshow Goodness-of-fit Test					9.761	0.282					5.656	0.686

Table 13. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Downy Woodpeckers and Tufted Titmice in forested habitats in southwestern West Virginia. The '+' indicates a positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Downy Woodpecker						Tufted Titmouse					
	Absent (n=60)		Present (n=25)				Absent (n=60)		Present (n=25)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	1.5	0.2	4.907	0.027+	1.0	0.1	1.1	0.1		
Slope (%)	33.8	1.6	33.3	5.3			33.5	1.9	34.3	2.5		
Elevation	371.3	8.6	337.7	12.4			366.5	9.7	367.7	12.1		
Distance to minor edge (m)	56.6	7.9	33.8	5.7			58.2	9.6	42.7	5.1		
Distance to habitat edge (m)	1008.6	120.4	302.8	200.1			830.9	124.1	1116.1	227.1		
Canopy height (m)	22.5	0.5	22.4	1.6			21.9	0.6	23.9	0.9		
Ground Cover (%):												
Water	0.8	0.2	0.7	0.4			0.8	0.2	0.6	0.3		
Bareground/rock	7.6	0.5	7.5	1.9			7.8	0.6	7.0	1.0		
Leaf litter	50.1	1.4	56.0	3.8			53.4	1.3	44.6	2.8		
Woody debris	4.7	0.3	4.3	0.9			4.5	0.4	5.1	0.5		
Moss	2.1	0.3	1.5	0.5			2.2	0.3	1.6	0.3		
Green	34.6	1.5	29.9	3.0			31.0	1.4	41.0	2.9	8.392	0.004+
Tree Density (no./ha):												
≤2.5 cm	5777.9	510.7	4616.5	477.9			5764.6	547.7	5298.8	796.7		
>2.5-8 cm	700.6	50.1	852.3	96.8			729.2	49.8	698.8	100.2		
>8-23 cm	286.7	16.4	351.1	61.0			300.5	21.0	281.8	23.5		
>23-38 cm	89.6	3.9	94.3	7.3			87.6	4.3	96.5	6.0		
>38-53 cm	30.2	2.2	35.2	5.1			30.8	2.5	30.8	3.0		
>53-68 cm	8.4	1.1	11.9	3.0			8.1	1.2	10.5	1.8		
>68 cm	3.4	0.6	4.5	1.7			3.0	0.6	4.8	1.2		
Snags (>8 cm)	45.8	4.5	44.9	6.2			45.3	5.0	46.5	6.7		

Table 13 cont.

Canopy Cover (%):												
>0.5-3 m	51.5	1.9	45.5	4.1			52.0	1.9	47.7	3.6		
>3-6 m	59.2	1.9	63.4	3.5			59.9	1.8	59.3	3.7		
>6-12 m	64.1	1.3	66.9	3.7			64.3	1.6	64.7	1.8		
>12-18 m	60.3	1.8	60.1	5.7			59.9	2.0	61.0	3.3		
>18 m	47.0	2.5	47.7	3.6			48.4	2.8	43.9	3.3		
>24 m	17.1	1.8	18.0	3.2			18.1	2.0	15.1	2.6		
Structural Diversity Index	59.8	1.1	60.3	1.9			60.5	1.2	58.3	1.5		
Hosmer-Lemeshow Goodness-of-fit Test					4.854	0.773					3.748	0.879

Table 14. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Downy Woodpeckers and White-breasted Nuthatches in forested habitats in southwestern West Virginia. The '-' indicateseither a negative relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Red-bellied Woodpecker						White-breasted Nuthatch					
	Absent (n=74)		Present (n=11)				Absent (n=65)		Present (n=20)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	1.0	0.2			1.0	0.1	1.0	0.1		
Slope (%)	32.9	1.6	39.6	5.3			32.8	1.7	36.9	3.4		
Elevation	371.1	8.3	336.0	18.3			370.6	9.6	354.1	9.7		
Distance to minor edge (m)	49.1	6.1	84.3	35.1			51.9	8.1	59.4	13.9		
Distance to habitat edge (m)	950.3	120.6	663.0	253.9			985.7	131.1	681.9	191.0		
Canopy height (m)	22.7	0.5	21.2	1.3			22.7	0.6	21.6	1.0		
Ground Cover (%):												
Water	0.8	0.2	0.7	0.5			0.8	0.2	0.6	0.3		
Bareground/rock	7.5	0.6	7.8	1.3			7.6	0.6	7.4	1.2		
Leaf litter	51.6	1.3	45.6	5.3			51.3	1.6	49.3	2.4		
Woody debris	4.7	0.3	4.0	0.8			4.6	0.4	4.7	0.5		
Moss	2.1	0.3	1.4	0.5			2.2	0.3	1.5	0.4		
Green	33.0	1.4	40.2	4.8			33.3	1.6	36.1	3.0		
Tree Density (no./ha):												
≤2.5 cm	5648.2	459.1	5488.6	1672.4			5193.8	365.5	7037.5	1485.8		
>2.5-8 cm	735.6	48.4	616.5	135.2			739.4	52.8	657.8	90.4		
>8-23 cm	285.4	15.6	359.7	69.9			297.9	19.4	285.6	29.6		
>23-38 cm	89.4	3.4	96.0	15.0			89.6	3.9	92.2	8.2		
>38-53 cm	31.2	2.1	28.4	5.7			29.2	2.3	35.9	4.1		
>53-68 cm	8.4	1.0	11.4	3.5			8.3	1.1	10.6	2.5		
>68 cm	3.8	0.6	1.7	0.9			3.2	0.6	4.7	1.2		
Snags (>8 cm)	43.4	4.1	60.3	13.6			44.9	4.4	48.2	9.4		

Table 14 cont.

Canopy Cover (%):										
>0.5-3 m	50.3	1.9	53.2	4.1			50.8	2.0	50.3	3.5
>3-6 m	59.8	1.8	59.5	4.2			60.4	1.9	57.5	3.5
>6-12 m	64.0	1.3	67.3	3.6			65.3	1.4	61.8	2.7
>12-18 m	59.6	1.8	64.2	4.4			61.8	1.9	55.1	3.2
>18 m	47.7	2.3	42.8	8.2			47.7	2.4	45.2	5.4
>24 m	18.6	1.7	8.4	3.6	5.596	0.018-	17.8	1.9	15.4	3.2
Structural Diversity Index	60.0	1.0	59.1	3.4			60.8	1.1	57.0	2.1
Hosmer-Lemeshow Goodness-of-fit Test					4.235	0.835				

Table 15. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Ovenbirds and Black-throated Green Warblers in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or positive relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Ovenbird						Black-throated Green Warbler					
	Absent (n=14)		Present (n=71)				Absent (n=70)		Present (n=15)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.2	1.0	0.1			1.0	0.1	1.3	0.1		
Slope (%)	29.0	2.9	34.7	1.7			33.0	1.6	37.4	4.7		
Elevation	360.8	16.8	368.2	8.7			358.9	7.7	406.8	23.5		
Distance to minor edge (m)	34.6	6.7	57.4	8.2			57.9	8.3	33.8	6.5		
Distance to habitat edge (m)	549.3	230.6	999.7	123.6			907.1	120.9	958.3	280.1		
Canopy height (m)	22.0	1.4	22.6	0.5			22.8	0.5	21.0	1.1		
Ground Cover (%):												
Water	0.4	0.3	0.8	0.2			0.9	0.2	0.3	0.3		
Bareground/rock	4.5	0.8	8.2	0.6	6.352	0.012+	8.1	0.6	5.3	0.8		
Leaf litter	58.8	1.8	49.2	1.5			50.2	1.5	53.7	2.1		
Woody debris	5.6	0.5	4.4	0.3			4.7	0.3	4.2	0.8		
Moss	2.6	0.6	1.9	0.3			2.0	0.3	2.2	0.6		
Green	28.1	2.1	35.1	1.6			33.9	1.6	34.1	2.6		
Tree Density (no./ha):												
≤2.5 cm	5783.5	1069.4	5596.8	499.1			5671.9	524.7	5420.8	743.4		
>2.5-8 cm	988.8	101.1	667.3	48.6			718.3	48.8	729.2	125.7		
>8-23 cm	348.2	58.0	284.5	15.8			319.0	18.2	182.9	19.1	11.820	0.001-
>23-38 cm	90.6	7.0	90.1	4.0			92.8	4.0	78.3	6.8		
>38-53 cm	26.8	5.6	31.6	2.1			29.3	2.1	37.9	5.1		
>53-68 cm	10.7	3.4	8.5	1.0			8.7	1.2	9.6	1.2		
>68 cm	3.1	1.6	3.6	0.6			3.5	0.6	3.8	1.0		
Snags (>8 cm)	48.6	12.9	45.1	4.1			50.4	4.6	24.2	4.1		

Table 15 cont.

Canopy Cover (%):												
>0.5-3 m	56.7	3.6	49.5	1.9			50.2	1.9	53.1	4.0		
>3-6 m	69.6	3.7	57.8	1.8	7.400	0.006-	60.2	1.9	57.7	3.4		
>6-12 m	70.2	3.4	63.3	1.3			65.4	1.3	59.8	3.0		
>12-18 m	55.2	4.6	61.2	1.8			59.4	1.8	64.1	4.5		
>18 m	39.6	5.9	48.6	2.4			45.3	2.5	55.7	4.7		
>24 m	18.2	3.8	17.1	1.8			17.4	1.9	16.8	3.1		
Structural Diversity Index	61.9	3.1	59.5	1.0			59.6	1.1	61.4	2.0		
Hosmer-Lemeshow Goodness-of-fit Test					13.590	0.093					6.680	0.572

Table 16. Means, standard errors (SE), and stepwise logistic regression results (Wald Chi-square statistics) for presence/absence of Pileated Woodpeckers and Yellow-throated Warblers in forested habitats in southwestern West Virginia. The '-' indicates a negative relationship between presence and the habitat variables. Logistic regression results are given for significant variables only.

	Pileated Woodpecker						Yellow-throated Warblers					
	Absent (n=75)		Present (n=10)				Absent (n=74)		Present (n=11)			
Variable	Mean	SE	Mean	SE	χ^2	*P*	Mean	SE	Mean	SE	χ^2	*P*
Aspect Code	1.0	0.1	1.3	0.2			1.1	0.1	0.5	0.2	4.630	0.031-
Slope (%)	32.9	1.6	40.1	3.8			32.3	1.6	43.6	3.5		
Elevation	368.8	8.3	350.8	20.2			367.1	8.0	364.9	27.9		
Distance to minor edge (m)	55.0	7.8	43.2	7.9			56.6	7.9	33.9	6.9		
Distance to habitat edge (m)	975.1	119.3	433.1	235.4			947.3	118.5	684.9	307.0		
Canopy height (m)	22.6	0.5	21.6	1.3			22.5	0.5	22.4	1.4		
Ground Cover (%):												
Water	0.7	0.2	1.0	0.6			0.9	0.2	0.0	0.0		
Bareground/rock	7.7	0.5	6.5	2.2			7.4	0.5	8.9	1.8		
Leaf litter	51.0	1.4	49.5	3.2			51.1	1.4	49.1	3.7		
Woody debris	4.8	0.3	3.3	0.8			4.6	0.3	5.1	0.9		
Moss	2.1	0.2	1.9	0.9			1.9	0.3	2.8	0.7		
Green	33.5	1.5	37.5	4.8			34.0	1.5	33.9	3.8		
Tree Density (no./ha):												
≤2.5 cm	5909.2	497.3	3515.6	510.7			5196.4	451.1	8528.4	1480.3		
>2.5-8 cm	736.3	47.3	600.0	156.4			709.5	50.4	792.6	96.9		
>8-23 cm	291.1	17.4	324.4	48.7			288.7	14.4	337.5	82.5		
>23-38 cm	88.5	3.8	103.1	7.9			89.9	3.8	92.0	9.4		
>38-53 cm	32.0	2.2	21.9	3.3			31.4	2.2	26.7	5.3		
>53-68 cm	9.1	1.1	6.9	2.2			8.0	1.0	14.2	2.9		
>68 cm	3.4	0.6	4.4	1.6			3.5	0.6	3.4	1.3		
Snags (>8 cm)	46.3	4.5	41.3	6.5			44.0	4.2	56.3	12.4		

Table 16 cont.

Canopy Cover (%):												
>0.5-3 m	49.4	1.8	60.9	3.8			49.9	1.9	56.1	3.9		
>3-6 m	59.0	1.8	65.6	3.6			59.9	1.8	58.4	5.1		
>6-12 m	64.2	1.4	66.0	2.6			65.3	1.2	58.8	4.8		
>12-18 m	60.5	1.8	58.6	4.3			62.8	1.7	43.2	3.5	9.061	0.003-
>18 m	48.2	2.4	39.0	6.2			49.0	2.3	34.2	6.3		
>24 m	18.7	1.7	6.4	2.5	5.499	0.019-	17.3	1.8	17.2	4.0		
Structural Diversity Index	60.0	1.1	59.3	1.5			60.8	1.0	53.6	2.6		
Hosmer-Lemeshow Goodness-of-fit Test					6.326	0.611					4.361	0.823

Table 17. Means and standard errors (SE) of habitat variables in relation to presence/absence of Summer Tanagers in forested habitats in southwestern West Virginia. No variables were chosen by stepwise logistic regression for predicting Summer Tanager presence.

	Summer Tanager			
	Absent (n=70)		Present (n=15)	
Variable	Mean	SE	Mean	SE
Aspect Code	1.1	0.1	1.0	0.2
Slope (%)	33.5	1.8	35.2	2.4
Elevation	363.6	8.3	383.5	20.9
Distance to minor edge (m)	52.6	7.4	58.4	20.1
Distance to habitat edge (m)	906.5	122.0	961.4	266 .1
Canopy height (m)	22.6	0.6	21.6	1.0
Ground Cover (%):				
Water	0.9	0.2	0.2	0.2
Bareground/rock	7.8	0.6	6.3	1.1
Leaf litter	50.4	1.5	52.6	3.1
Woody debris	4.5	0.3	5.1	0.6
Moss	1.9	0.2	2.5	0.8
Green	34.1	1.5	33.3	3.6
Tree Density (no./ha):				
≤2.5 cm	5240.2	428.8	7435.4	1541.8
>2.5-8 cm	722.8	49.4	708.3	119.8
>8-23 cm	287.1	16.5	332.1	51.2
>23-38 cm	90.9	4.1	87.1	6.7
>38-53 cm	30.6	2.0	31.7	6.4
>53-68 cm	8.4	1.1	10.8	2.7
>68 cm	3.3	0.6	4.6	1.6
Snags (>8 cm)	43.8	4.0	54.2	12.8
Canopy Cover (%):				
>0.5-3 m	50.3	1.9	52.4	3.6
>3-6 m	60.0	1.8	58.3	4.5
>6-12 m	64.8	1.4	62.9	2.9
>12-18 m	60.6	1.9	58.4	4.1
>18 m	47.3	2.5	46.2	5.2
>24 m	16.6	1.7	20.3	4.2
Structural Diversity Index	59.9	1.0	59.7	2.7

Table 18. Mist net effort and the distribution of Grasshopper Sparrows captured and banded on study sites.

Site	Males	Females	Juveniles	Total Captures	Net Hours	Captures/Net Hour
CL1	21	7	2	29	124.00	0.23
CV2	11	7	3	21	72.25	0.29
DN2	29	7	2	22	85.00	0.26
DR1	27	3	14	56	217.63	0.26
HA1	30	3	6	40	210.25	0.19
HN2	22	6	2	25	76.50	0.33
Overall	140	33	29	193	785.63	0.25

Table 19. Systematic nest search effort and mean and SE of clutch size for Grasshopper Sparrow nests in the 2001 breeding season by site.

Site	Search effort (hrs)	No. Nests Found	Nests/hr	Clutch size	
				Mean	SE
CL1	72.57	4	0.06	3.25	0.75
CV2	44.33	3	0.07	4.00	0.00
DN2	48.91	10	0.20	3.80	0.33
DO1	0.33	2	6.06	3.50	0.50
DR1	26.00	5	0.19	3.40	0.60
HA1	108.50	7	0.65	3.88	0.23
HN2	69.24	4	0.06	3.67	0.67
HO1	2.00	2	0.50	4.50	0.50
Overall	372.14	37	0.10	3.73	0.16

Table 20. Mean and standard error (SE) of nest variables and habitat variables surrounding successful (n=17) and unsuccessful (n=20) nests of Grasshopper Sparrows on MTRVF areas in 2001. One-way analysis of variance (ANOVA) was used to compare habitat variables between successful and unsuccessful nests (α=0.05).

	Successful		Unsuccessful		ANOVA	
Variable	Mean	SE	Mean	SE	*F*	*P*
Slope Aspect (degrees)	161.70	22.20	167.70	21.40	0.04	0.41
Slope (%)	12.30	2.90	8.30	3.00	0.90	0.35
Overhead Cover (%)	73.70	6.40	75.00	4.80	0.03	0.87
Side Cover (%)						
North	82.40	4.20	82.50	4.80	0.00	0.98
South	91.20	4.30	93.80	3.10	0.25	0.62
East	80.90	5.50	77.50	4.80	0.22	0.64
West	92.60	4.70	87.70	5.80	0.43	0.52
Distance to Minor Edge (m)	24.60	7.60	34.10	8.80	1.45	0.23
Ground Cover (%)						
Green	73.20	3.70	79.10	3.80	1.22	0.28
Grass	40.40	2.90	38.50	3.60	0.16	0.69
Forb	27.90	2.80	28.90	2.50	0.06	0.80
Shrub	0	0	0.01	0.01	0.85	0.36
Litter	8.30	1.20	8.30	0.90	0.00	0.97
Wood	0	0	0	0	-	-
Bare ground	20.90	3.80	18.40	3.04	0.27	0.61
Moss	2.20	0.70	2.90	1.01	0.41	0.53
Water	0	0	0	0	-	-
Robel Pole Index (dm)						
Nest	3.13	0.24	4.01	0.03	6.56	0.01
1m	3.17	0.29	4.28	0.31	6.69	0.01
3m	3.65	0.34	4.12	0.31	1.12	0.29
5m	3.71	0.30	3.88	0.32	0.14	0.71
Grass Height (dm)						
1m	2.91	0.19	3.26	0.19	2.01	0.16
3m	3.22	0.24	7.69	4.60	0.83	0.37
5m	3.27	0.23	3.24	0.23	0.002	0.96
10m	3.50	0.20	3.90	0.24	1.33	0.25
Litter depth (cm)						
1m	0.21	0.04	0.20	0.03	0.03	0.86
3m	0.30	0.05	0.25	0.04	0.66	0.42
5m	0.23	0.04	0.27	0.04	0.46	0.50
10m	0.24	0.04	0.30	0.04	1.03	0.31
Nest substrate height (veg)	3.75	0.22	4.27	0.28	0.44	0.51
Nest substrate height (repro)	7.65	0.47	7.00	0.41	1.06	0.31
Nest Clump Area (cm^2)	1,216.53	142.70	1,387.98	146.71	0.69	0.41
Distance to foliage edge (cm)	19.20	3.50	20.10	2.20	0.05	0.83
Nest depth (cm)	5.80	0.31	5.90	0.22	0.15	0.70
Nest width (cm)	6.60	0.15	6.50	0.12	0.19	0.66
Nest rim width (cm)	1.97	0.10	1.98	0.07	0.01	0.94
Nest rim height (cm)	1.80	0.27	1.50	0.23	1.05	0.31

Table 21. Mean and standard error (SE) for habitat variables measured at nests (N=37) and fixed habitat plots (N=48) sampling points. One-way analysis of variance (ANOVA) was used to compare habitat variables between successful and unsuccessful nests (α=0.05).

	Nests		Habitat Plots		ANOVA	
Variable	Mean	SE	Mean	SE	*F*	*P*
Slope Aspect	164.90	15.20	207.15	17.50	3.09	0.08
Slope (%)	10.10	2.10	10.90	2.10	0.07	0.79
Distance to Minor Edge (m)	29.73	5.89	40.67	6.98	0.63	0.43
Ground Cover (%)						
Green	76.40	0.70	87.44	2.60	574.53	<0.0001
Grass	39.40	2.30	57.55	2.60	26.25	<0.0001
Forb	28.50	1.90	27.40	2.20	0.15	0.70
Shrub	0.01	0.01	0.05	0.05	0.56	0.46
Litter	8.31	0.70	5.70	0.64	7.56	0.01
Wood	0	0	0	0	-	-
Bare ground	19.60	2.40	7.14	1.20	24.73	<0.0001
Moss	2.60	0.60	1.34	0.41	3.05	0.08
Water	0	0	0	0	-	-
Robel Pole Index (dm)						
nest	3.60	0.19	1.50	0.07	24.16	<0.0001
1m	3.77	0.22	2.16	0.08	56.14	<0.0001
3m	3.91	0.23	2.05	0.09	67.41	<0.0001
5m	3.80	0.22	2.11	0.10	56.93	<0.0001
Grass Height (dm)						
1m	3.11	0.13	5.91	2.28	1.73	0.28
3m	5.63	2.48	3.62	0.11	0.85	0.36
5m	3.25	0.16	3.80	0.11	7.79	0.01
10m	3.70	0.16	4.03	0.13	2.63	0.11
Litter depth (cm)						
1m	0.21	0.02	0.13	0.01	7.53	0.01
3m	0.27	0.03	0.17	0.03	4.68	0.03
5m	0.26	0.03	0.15	0.03	6.80	0.01
10m	0.27	0.03	0.15	0.02	15.96	<0.001

Table 22. Percentage of adult *Peromyscus* spp. individuals in reproductive condition among grassland, shrub/pole, fragmented forest, and intact forest treatments in 1999 and 2000 in southwestern West Virginia.

	Treatment								ANOVA Results		
	Grassland		Shrub/Pole		Fragmented Forest		Intact Forest				
Comparison	%	N[a]	%	N	%	N	%	N	*F*	df	*P*
Among Treatments											
1999											
Males	65.5A[b]	14	-[c]	- -	39.9B	15	25.4B	16	7.18	2	0.0026
Females	41.9A	15	-	- -	13.4B	16	4B	16	9.11	2	0.0002
Total	48.3A	16	-	- -	25B	16	12C	16	11.33	2	0.0002
2000											
Males	79.8A	19	85.3A	11	83.3A	16	82.5A	19	0.45	3	0.7179
Females	55.8A	19	68.3A	12	54.5A	19	22.6B	16	4.57	3	0.0068
Total	66.2A	20	74.7A	12	63.2A	19	52.5A	16	1.05	3	0.3802

Between Years

ANOVA Results	*F*	df	*P*	*F*	df	*P*	*F*	df	*P*	*F*	df	*P*			
Males	0.88	1	0.3586	-[c]	-	-	19.19	1	0.0002	33.73	1	<0.0001	-	-	-
Females	1.51	1	0.2302	-	-	-	14.5	1	0.0008	0.39	1	0.5360	-	-	-
Total	3.32	1	0.0795	-	-	-	17.33	1	0.0003	15.42	1	0.0007	-	-	-

[a] N= number of trapping sessions multiplied by the number of transects in a given treatment.
[b] Means followed by different letters within a row are significantly different from one another (Waller-Duncan k-ratio t-test, $P \leq 0.05$).
[c] The shrub/pole treatment was not sampled in 1999.

Table 23. Relative abundance (mammals/100 trap nights), and standard error (SE) of *Peromyscus* spp. age and sex groups in grassland, shrub/pole, fragmented forest, and intact forest treatments in southwestern West Virginia for 1999 and 2000.

	Treatment												ANOVA Results	
	Grassland			Shrub/Pole			Fragmented Forest			Intact Forest				
	Mean	SE	N[a]	Mean	SE	N	Mean	SE	N	Mean	SE	N	*F*	*P*
1999														
Adult Males	4.0A[b]	2.8	16	-[c]	-	-	1.8B	1.4	16	1.4B	1.6	16	8.20	0.0012
Adult Females	2.1A	1.4	16	-	-	-	1.9AB	1.2	16	1.0B	1.2	16	3.51	0.0404
Juvenile Males	4.5A	3.3	16	-	-	-	3.9A	1.5	16	5.3A	4.0	16	1.03	0.3656
Juvenile Females	2.2A	2.0	16	-	-	-	3.1A	2.1	16	3.6A	2.7	16	2.11	0.1356
2000														
Adult Males	6.2A	4.9	20	5.9A	3.8	12	2.3B	1.9	20	1.1B	1.8	20	13.13	<0.0001
Adult Females	5.7A	4.0	20	6.2A	4.2	12	1.8B	1.4	20	1.9B	2.1	20	14.54	<0.0001
Juvenile Males	4.6A	4.0	20	3.9AB	2.1	12	1.3C	1.2	20	2.5BC	3.0	20	5.99	0.0013
Juvenile Females	3.8A	3.7	20	2.9A	2.5	12	0.7B	1.1	20	1.2B	3.0	20	7.50	0.0003

[a] N=number of trapping sessions multiplied by the number of transects in a given treatment.
[b] Means followed by different letters within a row are significantly different from one another (Waller-Duncan k-ratio t-test, $P \leq 0.05$).
[c] The shrub/pole treatment was not sampled in 1999.

Table 24. Results of multiple linear regression of mammal species richness, total abundance, and *Peromyscus* spp. abundance on habitat and environmental variables for shrub/pole, fragmented forest, and intact forest treatments. Significant variables in the model are listed below the dependent variable.

Variable	Parameter Estimate	*F*	*P*	Partial R^2	Model R^2
Richness					
Low Temp.	-0.0912	8.61	0.0044	0.0995	0.0995
Precip.	-0.2039	9.43	0.0030	0.0982	0.1977
Bare ground (%)	1.0570	4.60	0.0351	0.0458	0.2435
Total Abundance					
Canopy Cover >0.5-3 m	-16.4071	21.03	<0.0001	0.2123	0.2123
Canopy Height	-0.5107	8.82	0.0040	0.0809	0.2932
Precipitation	-2.0173	9.88	0.0024	0.0813	0.3745
Bare ground (%)	16.6469	11.43	0.0011	0.0827	0.4572
Low Temp.	-0.6224	9.16	0.0034	0.0598	0.5170
Peromyscus spp. abundance					
Canopy Cover >0.5-3 m	-17.0509	34.86	<0.0001	0.3088	0.3088
Canopy Height	-0.4884	12.35	0.0007	0.0955	0.4044
Bare ground (%)	12.2341	7.32	0.0084	0.0523	0.4567
Precip.	-1.3118	8.11	0.0057	0.0530	0.5098

Table 25. Results of multiple linear regression of mammal species richness, total abundance, and *Peromyscus* spp. abundance on habitat and environmental variables for grassland treatment. Significant variables in the model are shown below the dependent variable.

Variable	Parameter Estimate	*F*	*P*	Partial R^2	Model R^2
Richness					
Average grass height	0.2297	10.60	0.0026	0.2376	0.2376
Total Abundance					
Green groundcover	99.9693	5.19	0.0295	0.3699	0.3699
Precipitation	2.1868	5.79	0.0221	0.0673	0.4372
Bareground	-44.4321	4.08	0.0518	0.0637	0.5009
Peromyscus spp. abundance					
Bare ground (%)	-73.4487	15.88	0.0004	0.4454	0.4454
Precipitation	2.1953	7.11	0.0119	0.0942	0.5396
Shrub	3.0591	5.77	0.0223	0.0703	0.6099

Table 26. Results of logistic regression of short-tailed shrew, woodland jumping mouse, and chipmunk abundance on habitat and environmental variables within the shrub/pole, fragmented forest, and intact forest treatments.

Variable	Parameter Estimate	χ^2	*P*
Short-tailed shrew			
Bareground	4.36	4.2922	0.0383
Model		1.2314	0.8729
Woodland jumping mouse			
Moon illumination	-2.81	5.2752	0.0216
Water	7.84	4.0787	0.0434
Canopy Cover >0.5-3 m	8.33	3.625	0.0569
Model		8.5362	0.3829
Eastern Chipmunk			
Water	-22.14	9.0245	0.0027
Bareground	8.92	5.8598	0.0155
Canopy cover >12 m	6.25	5.6034	0.0179
Tree density >8-38 cm	0.01	8.378	0.0038
Model		32.8363	<0.0001

Table 27. Average mammalian species richness (# species/array), relative abundance (mammals/100 trap nights), and standard errors (SE) in grassland,shrub/pole, fragmented forest, and intact forest treatments in southwestern West Virginia in 2000 and 2001.

	Treatment												ANOVA Results	
	Grassland			Shrub/Pole			Fragmented Forest			Intact Forest				
	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	*F*	*P*
Species Richness	39	2.85A[a]	0.25	39	2.74A	0.21	39	2.82A	0.28	41	1.88B	0.24	5.58	0.0014
Relative Abundance														
Total	39	10.37A	1.19	39	9.39A	1.11	39	9.48A	1.64	41	4.82B	0.85	5.70	0.0012
Peromyscus spp.	39	4.52A	0.73	39	3.61AB	0.74	39	3.20AB	0.73	41	1.77B	0.48	3.31	0.0229
Woodland jumping mouse	39	0.03B	0.03	39	0.05B	0.04	39	0.53A	0.14	41	0.08B	0.08	7.53	0.0001
Southern bog lemming	39	1.45A	0.34	39	0.98A	0.25	39	0.20B	0.09	41	0.00B	0.00	9.51	<0.0001
Woodland vole	39	0.09B	0.05	39	0.36AB	0.12	39	0.44AB	0.13	41	0.57A	0.20	2.34	0.0778
Meadow vole	39	0.21A	0.08	39	0.17A	0.09	39	0.30A	0.11	41	0.05A	0.04	1.72	0.1674
Microtus spp. [b]	39	0.58A	0.17	39	0.62A	0.17	39	1.18A	0.32	41	0.85A	0.30	1.45	0.2317
Short-tailed shrew	39	0.45B	0.20	39	0.51B	0.15	39	2.66A	0.81	41	0.52B	0.16	10.58	<0.0001
Masked shrew	39	2.20AB	0.44	39	2.94A	0.71	39	1.14BC	0.37	41	0.97C	0.24	4.74	0.0038
Smoky shrew	39	0.27A	0.10	39	0.12A	0.06	39	0.14A	0.07	41	0.23A	0.10	0.79	0.5008
Pygmy shrew	39	0.06AB	0.04	39	0.03B	0.03	39	0.26A	0.09	41	0.17AB	0.07	2.51	0.0630
Sorex spp.[c]	39	3.28A	0.56	39	3.62A	0.76	39	1.69B	0.41	41	1.55B	0.32	4.73	0.0039

[a] Means followed by different letters within a row are significantly different (Waller-Duncan k-ratio t-test, $P<0.05$).
[b] Combines woodland voles, meadow voles, and unidentified *Microtus* spp.
[c] Combines masked shrews, smoky shrews, pygmy shrews, and unidentified *Sorex* spp.

Table 28. Habitat characteristics at forest fragment streams (n=4) and intact forest streams (n=3) by stream order.

Site No.	Segment	Substrate Type [a]	Channel Type [a]	No. of Coarse Woody Debris Sampled	No. of Rocks Sampled
Forest Fragment Streams – Second Order					
5	1	SR, RG	RI	21	689
	2	SR, RG	RI	7	480
	3	SR, RG	RI	12	137
	4	SR, RG, BA	RI	6	1554
	5	SR, RG, BA	RI	19	821
44	1	SR, RG, WD	PO, RU	24	67
	2	SR, RG, WD	RU	74	71
	3	SR, RG, WD	RU	39	98
	4	SR, RG, BA, WD	RI, PO, RU	95	75
	5	SR, RG, BA, WD	RI, PO, RU	104	127
173	1	SR, RG, BA, WD	RI, PO	19	3012
	2	SR, RG, BA	RI	0	1495
Forest Fragment Streams – Third Order					
131	1	SR, RG, LR	RA	5	758
	2	SR, RG, LR	RA	5	457
	3	SR, RG, LR, BL	RA, PO	0	343
	4	SR, RG, BA, LR	RI	6	1266
	5	SR, RG, BA	RI, PO	25	1935
Intact Forest Streams – Intermittent					
112	1	SR, LR	RI, PO, CA	25	638
	2	SR, LR	DR	37	527
	5	SR, LR, BA	DR	28	1144
Intact Forest Streams – First Order					
21	1	SR	RI	67	392
	2	SR	RI	38	579
	3	SR, RG, WD	RI	18	345
	4	SR, WD	RI, PO	61	1473
	5	SR, WD	RI, PO	3	1219
165	1	SR, LR	RI, PO	13	157
	2	SR, WD	PO	46	140
	3	SR, WD	DR	70	34
	4	SR, BA, WD	DR, PO	16	223
	5	SR, BA, WD, LR	DR, PO	111	698
Intact Forest Streams – Second Order					
112	3	SR, R/G	RI, PO	9	342
	4	SR, R/G, BA	RI, PO	3	2928

[a] Habitat characteristics assessed qualitatively using a protocol modified from USGS Patuxent Wildlife Research Center (Jung et al. 1999).

BA = bank (river edge, soil, lacks rocks)
BL = boulder (> 1.5 m in diameter)
LR = large rocks (0.5-1.5 m in diameter)
SR = small rocks (0.1-0.5 m in diameter)
RG = rubble / gravel (< 0.1 m in diameter)
WD = woody debris

RU = run (smooth current)
RA = rapid (fast current broken by obstructions)
PO = pool (standing water)
CA = cascade (water flowing over slanting rocks)
RI = riffle (ripples and waves)
DR = dry (no visible moisture or water)

Table 29. Species expected (Exp) to occur in grassland, shrub/pole, fragmented forest, and intact forest treatments in our study area in southwestern West Virginia based on Green and Pauley (1987) and personal communication with T. Pauley, compared to those actually observed (Obs) in drift fence surveys (a), stream searches (s), and from incidental sightings (i), March – October 2000 and 2001.

	Grassland		Shrub/ pole		Fragmented Forest		Intact Forest	
Species	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
<u>Terrestrial species</u>								
Salamanders								
Cumberland Plateau Salamander (*Plethodon kentucki*)					x		x	a,s,i
Southern Ravine Salamander (*Plethodon richmondi*)					x		x	
Eastern Red-backed Salamander (*Plethodon cinereus*)		i			x	i	x	a,s,i
Northern Slimy Salamander (*Plethodon glutinosus*)					x	a	x	a
Wehrle's Salamander (*Plethodon wehrlei*)					x		x	
Lizards								
Broad-headed Skink (*Eumeces laticeps*)					x		x	
Common Five-lined Skink (*Eumeces fasciatus*)	x		x	a	x	a	x	a
Little Brown Skink (*Scincella lateralis*)		a			x		x	a
Coal Skink (*Eumeces anthracinus*)	x		x		x		x	
Northern Fence-lizard (*Sceloporus undulatus hyacinthinus*)	x	a,i		a,i		i		
Snakes								
Eastern Black Kingsnake (*Lampropeltis getulus niger*)	x		x		x		x	
Black Rat Snake (*Elaphe o. obsoleta*)	x	a,i	x	a,i	x	a	x	i
Eastern Smooth Earthsnake (*Virginia v. valeriae*)	x		x		x		x	
Eastern Gartersnake (*Thamnophis s. sirtalis*)	x	a	x	a	x	a,i	x	a,i
Eastern Hog-nosed Snake (*Heterodon platirhinos*)	x	a,i		a				
Eastern Milksnake (*Lampropeltis t. triangulum*)	x	a	x	a	x	a	x	a,i
Smooth Greensnake (*Opheodrys vernalis*)	x			i				i
Eastern Wormsnake (*Carphophis a. amoenus*)	x		x		x		x	a
Northern Black Racer (*Coluber c. constrictor*)	x	a,i	x	a		i		i
Northern Brownsnake (*Storeria d. dekayi*)	x		x		x		x	
Northern Copperhead (*Agkistrodon contortrix mokasen*)		a		a	x	a	x	a,i
Northern Red-bellied Snake (*Storeria o. occipitomaculata*)	x		x		x	a	x	a,i
Northern Ring-necked Snake (*Diadophis punctatus edwardsii*)					x	s	x	i
Northern Rough Greensnake (*Opheodrys a. aestivus*)	x		x	i	x		x	i
Timber Rattlesnake (*Crotalus horridus*)[a]				i	x		x	i
Turtles								
Eastern Box Turtle (*Terrapene c. carolina*)	x	i	x	i	x	a,i	x	a,i
<u>Semiaquatic species</u>								
Salamanders								
Jefferson Salamander (*Ambystoma jeffersonianum*)					x		x	
Marbled Salamander (*Ambystoma opacum*)					x		x	
Spotted Salamander (*Ambystoma maculatum*)		a,i		a	x	a	x	a
Green Salamander (*Aneides aeneus*)					x		x	
Four-toed Salamander (*Hemidactylium scutatum*)		a			x	a	x	
Red-spotted Newt (*Notophthalmus v. viridescens*)		a,i		a,i	x	a,s,i	x	a,s,i
Toads and Frogs								
Eastern American Toad (*Bufo a. americanus*)	x	a,i	x	a,i		a,i		a,i
Fowler's Toad (*B. fowleri*)[b]		a	x			s,i		

Table 29. Continued.

Species	Grassland		Shrub/ pole		Fragmented Forest		Intact Forest	
	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs
Toads and Frogs (cont'd)								
Eastern Spadefoot (*Scaphiopus holbrookii*)					x		x	
Cope's Gray Treefrog (*Hyla chrysoscelis*)				a,i	x	i	x	i
Northern Spring Peeper (*Pseudacris c. crucifer*)		i		a,i	x	i	x	i
Mountain Chorus Frog (*Pseudacris brachyphona*)				i	x		x	i
Wood Frog (*Rana sylvatica*)					x	a	x	a,i
Northern Leopard Frog (*Rana pipiens*)	x		x	a	x	a,i	x	
Pickerel frog (*Rana palustris*)	x	a	x	a,i	x	a,s,i	x	a,s,i
<u>Aquatic species</u>								
Salamanders								
Seal Salamander (*Desmognathus monticola*)					x	a,s,i	x	a,s,i
Northern Dusky Salamander (*D.fuscus*)					x	a,s,i	x	s,i
Eastern Hellbender (*Cryptobranchus a. alleganiensis*)					x		x	
Midland Mud Salamander (*Pseudotriton montanus diastictus*)					x		x	
Common Mudpuppy (*Necturus m. maculosus*)	x		x		x		x	
Northern Red Salamander (*Pseudotriton r. ruber*)	x		x		x	s	x	a,s
Southern Two-lined Salamander (*Eurycea cirrigera*)					x	a,s,i	x	s,i
Long-tailed Salamander (*Eurycea l. longicauda*)	x		x		x	s,i	x	
Northern Spring Salamander (*Gyrinophilus p. porphyriticus*)					x	s	x	s,i
Toads and Frogs								
American Bullfrog (*Rana catesbeiana*)	x	a,i	x	a,i	x	a,s	x	s
Northern Green Frog (*Rana clamitans melanota*)	x	a,i	x	a,i	x	a,s,i	x	a,i
Snakes								
Common Watersnake (*Nerodia s. sipedon*)	x	a	x	a	x	s,i	x	
Queen Snake (*Regina septemvittata*)					x		x	
Turtles								
Eastern Snapping Turtle (*Chelydra s. serpentina*)	x	i	x	i	x	i	x	
Eastern Spiny Softshell Turtle (*Apalone s. spinifera*)[c]	x		x		x		x	
Midland Painted Turtle (*Chrysemys picta marginata*)	x		x		x		x	
Stinkpot (*Sternotherus odoratus*)	x		x		x		x	

[a] One incidental sighting of a timber rattlesnake was also found on the edge between shrub/pole and fragmented forest habitats.

[b] One incidental sighting of a Fowler's toad was also found on the edge between shrub/pole and fragmented forest habitats.

[c] One incidental sighting of an eastern spiny softshell turtle was also found on the edge between grassland and fragmented forest habitats.

Table 30. Number of individuals of herpetofauna species captured in drift fence arrays and percent of points at which a species was captured in grassland (n = 3), shrub/pole (n = 3), fragmented forest (n = 3), and intact forest treatments (n = 4)[a] on reclaimed MTMVF areas in southwestern West Virginia, March - October, 2000 and 2001.

	Grassland		Shrub/pole		Fragmented Forest		Intact Forest	
Species	No. indivs	% of points	No. indivs	% of points	No. indivs	% of points	No. indivs	% of points
Salamanders								
Seal Salamander					1	33	1	25
Cumberland Plateau Salamander							12	75
Four-toed Salamander	1	33			1	33		
Southern Two-lined Salamander					2	33		
Northern Dusky Salamander					1	33		
Northern Red Salamander							2	50
Eastern Red-backed Salamander							5	25
Red-spotted Newt	9	100	13	100	26	100	22	100
Northern Slimy Salamander					5	33	2	25
Spotted Salamander	1	33	1	33	1	33	1	25
Toads and frogs								
American Bullfrog	2	33	4	100	2	66		
Eastern American Toad	9	66	35	100	3	66	20	75
Fowler's Toad	2	33						
Cope's Gray Treefrog			2	33				
Northern Green Frog	52	100	46	100	44	100	6	75
Northern Leopard Frog			2	33	2	33		
Northern Spring Peeper			1	33				
Pickerel Frog	43	100	25	66	48	100	19	50
Unidentified Frog	5	66	2	33			1	25
Unidentified Toad					1	33		
Wood Frog					2	66	5	75
Lizards								
Common Five-lined Skink			2	66	4	33	2	50
Little Brown Skink	1	33					1	25
Northern Fence-Lizard	2	66	2	33				
Snakes								
Black Ratsnake	5	66	6	100	1	33		
Eastern Gartersnake	6	66	6	66	10	100	8	25
Eastern Hog-nosed Snake	1	33	2	33				
Eastern Milksnake	4	33	3	66	4	66	1	25
Eastern Wormsnake							2	25
Northern Black Racer	9	100	27	100				
Northern Copperhead	1	33	8	100	4	66	5	25
Northern Red-bellied Snake					1	33	1	25
Common Watersnake	1	33	1	33				
Turtles								
Eastern Box Turtle					2	66	1	25

[a] A 4th drift fence array was installed in one of the intact forest points and opened for trapping in September and October, 2001.

Table 31. Herpetofaunal species richness and relative abundance from drift fence arrays in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in southwestern West Virginia, March - October 2000 and 2001 (adjusted for trap effort per 100 array nights).

	Grassland		Shrub/pole		Fragmented Forest		Intact Forest	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Species richness	1.04	0.28	1.13	0.26	1.20	0.32	1.07	0.25
Abundance								
Total	4.46	1.20	5.41	0.96	5.29	0.83	3.41	0.43
Amphibians	3.33	1.17	3.59	0.93	4.41	0.77	2.80	0.43
Reptiles	0.99	0.23	1.77	0.29	0.85	0.19	0.58	0.16
Terrestrial Species	0.95	0.21	1.73	0.09	1.03	0.22	1.26	0.28
Aquatic Species	1.51	0.74	1.41	0.37	1.59	0.51	0.25	0.09
Semi-aquatic Species	1.86	0.83	2.22	0.73	2.64	0.43	1.87	0.36
Salamanders	0.33	0.12	0.44	0.13	1.20	0.25	1.09	0.20
Toads and frogs	3.00	1.15	3.15	0.92	3.20	0.67	1.31	0.28
Snakes	0.90	0.22	1.64	0.27	0.67	0.14	0.46	0.15
Red-spotted Newt	0.26	0.10	0.41	0.13	0.83	0.20	0.69	0.27
Eastern American Toad	0.26	0.12	0.98	0.49	0.10	0.06	0.52	0.13
Northern Green Frog	1.40	0.74	1.25	0.35	1.40	0.47	0.15	0.06
Pickerel Frog	1.22	0.67	0.67	0.27	1.52	0.30	0.48	0.20
Eastern Gartersnake	0.19	0.10	0.17	0.09	0.36	0.12	0.22	0.09
Northern Black Racer	0.32	0.11 AB	0.84	0.17 A	0.00	0.00 B	0.00	0.00 B

[a] Within a row, means with the same letter are not different at $\alpha = 0.05$ (Waller Duncan K-ratio t Test).

Table 32. Number of individuals and species of herpetofaunal groups captured in drift fence arrays in grassland, shrub/pole, fragmented forest, and intact forest treatments on reclaimed MTMVF areas in southwestern West Virginia, March-October, 2000 and 2001.

	Grassland				Shrub/pole				Fragmented Forest				Intact Forest			
	Individuals		Species		Individuals		Species		Individuals		Species		Individuals		Species	
Taxonomic Group	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Salamanders	11	7.1	3	17.6	14	7.4	2	11.1	37	22.4	7	35.0	45	38.4	7	36.8
Toads and frogs	113	73.4	5	29.4	118	62.4	7	38.9	102	61.8	6	30.0	51	43.6	4	21.1
Lizards	3	2.0	2	11.8	4	2.1	2	11.1	4	2.4	1	5.0	3	2.6	2	10.5
Snakes	27	17.5	7	41.2	53	28.1	7	38.9	20	12.1	5	25.0	17	14.5	5	26.3
Turtles	0	0.0	0	0.0	0	0.0	0	0	2	1.2	1	5.0	1	0.9	1	5.3

Table 33. Mean and standard error (SE) for habitat variables measured at grassland (n=3), shrub/pole (n=3), fragmented forest (n=3), and intact forest (n=3) sampling points [a].

	Treatment							
	Grassland		Shrub/Pole		Fragmented Forest		Intact Forest	
Variables	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Slope (%)	20.67	8.97	4.42	4.42	28.42	7.53	22.58	9.38
Aspect Code	1.62	0.06	0.60	0.57	0.73	0.14	0.68	0.13
Grass/Forb Height (dm)	6.80	1.69	4.09	1.91	-- [b]	--	--	--
Litter Depth (cm)	2.60	1.04	1.06	0.33	--	--	--	--
Elevation (m)	413.67	37.95	412.00	39.53	335.00	20.95	444.67	66.23
Distance to Minor Edge (m)	94.00	48.19	61.00	8.79	54.92	19.44	118.75	91.04
Distance to Habitat Edge (m)	408.73	324.42	68.8	15.66	175.87	77.46	1744.97	562.73
Distance to Forest/Mine Edge (m)	535.12	267.58	271.11	187.46	175.87	77.46	1744.97	562.73
Robel Pole Index	3.07	0.71	4.98	0.40	--	--	--	--
Canopy Height (m)	--	--	3.40	0.75	22.9	1.59	22.4	1.85
Ground Cover (%)								
Water	0.00	0.00	0.33	0.22	0.42	0.30	0.08	0.08
Bareground	1.33	0.79	0.5	0.14	0.83	0.08	1.83	0.71
Litter	2.42	1.53	1.67	1.67	11.50	0.63	10.58	1.23
Woody Debris	0.00	0.00	0.00	0.00	0.75	0.14	0.58	0.17
Moss	0.00	0.00	0.75	0.63	0.17	0.08	1.17	0.58
Green	16.25	1.26	15.08	2.93	6.33	0.30	5.75	0.90
Forb Cover	5.75	2.75	6.17	0.60	--	--	--	--
Grass Cover	6.75	2.38	4.42	2.19	--	--	--	--
Shrub Cover	3.75	3.63	4.50	1.13	--	--	--	--
Stem Densities (no./ha)								
<2.5 cm	42.00	41.50	5156.25	2044.75	2854.17	1464.90	6843.75	1043.18
>2.5-6 cm	0.00	0.00	406.25	62.5	562.50	118.31	343.75	160.36
>8-23 cm	0.00	0.00	85.42	33.53	225.00	71.90	275.00	74.56
>23-38 cm	0.00	0.00	0.00	0.00	68.75	25.26	81.25	19.09
>38-53 cm	0.00	0.00	0.00	0.00	33.33	11.60	10.42	2.08
>53-68 cm	0.00	0.00	0.00	0.00	2.08	2.08	2.08	2.08
>68 cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canopy Cover (%)								
>0.5-3 m	--	--	5.58	1.34	9.92	2.05	10.75	2.22
>3-6 m	--	--	4.00	2.08	13.00	1.44	10.42	1.52
>6-12 m	--	--	1.58	1.46	12.67	2.35	13.33	0.36
>12-18 m	--	--	0.00	0.00	10.17	0.79	14.67	1.45
>18-24 m	--	--	0.00	0.00	6.33	3.17	10.17	2.34
>24 m	--	--	0.00	0.00	3.83	2.00	2.75	2.38
Structural Diversity Index	--	--	11.17	4.69	55.92	2.42	62.08	5.60

[a] This table does not include habitat variables for the most recently added intact sampling point (herp data collection started September 2001 for this point).
[b] Variables were not measured in this treatment.

Table 34. Number of individuals and species of herpetofauna groups captured in stream surveys in fragmented forest streams and intact forest streams on reclaimed MTMVF areas in southwestern West Virginia, May-October, 2001.

	Fragmented Forest Streams				Intact Forest Streams			
	Individuals		Species		Individuals		Species	
Taxonomic Group	n	%	n	%	n	%	n	%
Salamanders	270	93.4	7	53.8	386	99.2	8	80.0
Toads and frogs	16	5.5	4	30.8	3	0.8	2	20.0
Lizards	0	0.0	0	0.0	0	0.0	0	0.0
Snakes	3	1.1	2	15.4	0	0.0	0	0.0
Turtles	0	0.0	0	0.0	0	0.0	0	0.0

Table 35. Mean number of individuals and standard error (SE) of stream salamanders per segment of fragmented forest streams and intact forest streams on reclaimed MTMVF areas in southwestern West Virginia, May–October 2001.

Treatments							
Fragmented Forest Streams				Intact Forest Streams			
Site No.	No. Segments Sampled	Mean	SE	Site No.	No. Segments Sampled	Mean	SE
Second Order				Intermittent			
5	5	5.4	0.93	112	3	21.0	6.11
44	5	1.8	0.97				
173	2	68.5	7.50	First Order			
				21	5	16.0	2.74
Third Order				165	5	30.6	9.08
131	5	19.4	7.53				
				Second Order			
				112	2	45.0	25.00

Table 36. Number of individuals for species of herpetofauna captured during stream surveys in southwestern West Virginia, May-October, 2001.

Species	Fragmented Forest Second Order	Fragmented Forest Third Order	Intact Forest Intermittent	Intact Forest First Order	Intact Forest Second Order
Salamanders					
Cumberland Plateau Salamander			1		
Eastern Red-backed Salamander			8		
Seal Salamander	7	8	34	57	17
Northern Dusky Salamander	76	42		102	47
Desmognathus spp. (Seal or N. Dusky)	7	8	8	22	8
Southern Two-lined Salamander	57	15	8	21	7
Long-tailed Salamander	1	1			
Northern Spring Salamander	2		1	2	1
Red-Spotted Newt	6	2		1	4
Northern Red Salamander		1	1		
Unidentified Salamander	20	20	2	28	6
Total	176	97	63	233	90
Toads and Frogs					
Fowler's Toad	1				
American Bullfrog	1			1	
Northern Green Frog	5				
Pickerel Frog	3			1	
Rana spp.	3				
Unidentified Frog				1	
Total	13	0	0	3	0
Snakes					
Northern Ring-necked Snake	1				
Common Watersnake	1	1			
Total	2	1	0	0	0
Grand Total	191	98	63	236	90

Appendix A-1

Changes to the Wood and Edwards 2001 MTMVF terrestrial report January 2002

Habitat and songbird data were reanalyzed and sections of the original report (Wood and Edwards 2001) were modified as follows:

habitat data -- stem densities were recalculated and density of snags was added to the tables and analyses

Table 6. Means and standard errors for stem densities were corrected and snag densities added.

Tables 7-9. The new ANOVA statistics for stem densities and snags are reported.

Changes were also made to the text under the Results and Discussion section for the habitat measurements.

songbirds -- after we modified the stem density values and added snag data, we re-analyzed songbird habitat preferences using stepwise logistic regression rather than forward logistic regression. Changes were made to the text in the Methods, Results and Discussion sections and to Tables 16-20. These sections are attached below and should replace the sections and tables in the original report. Changes in the logistic regression results for individual species are briefly summarized here:

<u>Cerulean Warbler</u>
Previously they were related to elevation and canopy cover >6-12m (both positive relationships), but stepwise logistic regression chose no variables for predicting Cerulean Warbler presence.

<u>Louisiana Waterthrush</u>
The only variable chosen by stepwise logistic regression for predicting Louisiana Waterthrush was density of trees <2.5 cm (negative) (forward logistic regression chose bareground cover, moss cover, and density of trees >2.5-8cm).

<u>Worm-eating Warbler</u>
Forward logistic regression chose 5 variables to predict this species' presence. Stepwise logistic regression chose 1 variable: aspect code (negative relationship).

<u>Kentucky Warbler</u>
In the new model Kentucky Warblers are related to elevation and density of stems >8-23 cm (both negative), and green ground cover (positive).

<u>Wood Thrush</u>
In the forward model Wood Thrush were related to elevation (negative) and density of stems >23-38 cm (positive). The stepwise model chose both of these variables with the addition of canopy cover >24 m (positive).

<u>Acadian Flycatcher</u>
The forward model chose 7 variables for inclusion in the model. In the stepwise model, Acadian Flycatchers were negatively related to litter cover, and density of stems <2.5 cm and >8-23cm. They were positively related to bareground/rock cover.

<u>Hooded Warbler</u>

In the forward model they were positively related to woody debris and density of stems >2.5-8 cm. Stepwise logistic regression found green cover and density of stems <2.5 cm to be positively related to Hooded Warbler presence.

Yellow-throated Vireo
Seven variables were included in the forward model for this species, whereas the stepwise model did not choose any.

Black-and-white Warbler
The forward model included 6 variables, whereas the stepwise model included only water cover (negative).

Scarlet Tanager.
Six variables were included in the forward model, whereas only 3 were in the stepwise model (elevation, distance to mine, and density of stems >8-23 cm – all positive).

Yellow-billed Cuckoo
Forward logistic regression included woody debris cover (positive), and elevation and aspect (both negative) in the model. The stepwise model only included elevation.

Modified Text:

Methods

Songbird Abundance

Partners in Flight (PIF) identified 15 songbird species as priority species for conservation in the upland forest community of the Ohio Hills and Northern Cumberland Plateau physiographic areas, the 2 areas within which our study sites fall (Table 5; Rosenberg 2000, R. McClain, personal communication). The Cerulean Warbler in particular is listed as being at Action level II (in need of immediate management or policy rangewide) by PIF. The Louisiana Waterthrush and Eastern Wood-pewee are other species of concern, listed at Action level III (management needed to reverse or stabilize populations). The other 12 species are at Action level IV (long-term planning to ensure stable populations needed). We developed logistic regression models for the 11 listed species (Cerulean Warbler, Louisiana Waterthrush, Worm-eating Warbler, Kentucky Warbler,Acadian Flycatcher, Wood Thrush, Yellow-throated Vireo, Hooded Warbler, Scarlet Tanager, Black-and-white Warbler, and Yellow-billed Cuckoo) that were found at >5% of point counts (Table 5).

We used stepwise logistic regression (Neter et al. 1996) to examine the relationship between habitat characteristics and the presence/absence of these 11 forest songbirds using habitat data from fragmented and intact forest point counts. The significance level chosen for entry and retention in the model was 0.10. We used presence/absence as the dependent variable because at most point counts only 1 individual of a species was detected within 50 m (Hagan et al. 1997). This technique was chosen because it has been used by other researchers examining the effects of landscapes on songbird species (Hagan et al. 1997, Villard et al. 1999), and because predictor variables do not need to follow a joint multivariate normal distribution (Neter et al. 1996). The Hosmer and Lemeshow goodness-of-fit test was used to determine if the data fit the specified model. Models were rejected if the p-value for the goodness-of-fit test was <0.10, indicating that we should not reject the null hypothesis that our data fit the specified model (Cody and Smith 1997).

Results and Discussion

Habitat at Sampling Points

Habitat variables were measured at all sampling points in 1999 and 2000 (Table 6). Nineteen variables were measured in all treatments. Means for all habitat variables by treatment and mine are found in Appendix 4

Stem densities of saplings, poles, and trees in 5 size classes all differed significantly among treatments (Table 7). Densities of trees >8-23 cm were higher in fragmented and intact forest than in the grassland and shrub/pole treatments and also higher in the shrub/pole treatment than in the grassland treatment. Density of trees >53-68 cm and >68cm were greater in fragmented forest and intact forest than in grassland and shrub/pole treatments. Statistical analysis revealed treatment by mine interactions for saplings, poles, snags, and trees >23-38cm and trees >38-53 cm (Table 7); therefore treatments were compared on individual mines, and mines were compared in individual treatments. Specific ANOVA results for all variables exhibiting interactions are found in Tables 8 and 9.

Ground cover variables differed significantly among treatments. Although water cover was highest in the fragmented forest treatment than in the other 3 treatments and higher in the intact forest treatment than in the grassland or shrub/pole treatment (Table 7), cover of standing water averaged <1.2%. Moss cover was higher in fragmented and intact forest than in the grassland and shrub/pole treatments. Green cover was higher in the shrub/pole treatment than in the other 3 treatments, and higher in the grassland treatment than in the fragmented forest or intact forest treatments (Table 7). Bareground cover, litter cover, and woody debris cover had significant treatment by mine interactions (Tables 8 and 9).

Slope, aspect code, elevation, and distances to nearest minor, habitat, and mine/forest edges also were compared among all 4 treatments (Table 7). Distance to nearest minor edge was greater in the grassland treatment than in the other 3 treatments (Tables 6-7). There were significant mine x treatment interactions for slope, aspect code, elevation, distance to closest habitat edge, and distance to nearest mine/forest edge. The differences among treatments and mines for these variables are found in Tables 8-9.

Six variables were compared between grassland and shrub/pole treatments and mines. Litter depth was higher on the Hobet mine than the Cannelton and Daltex mines and higher in the Daltex mine than the Cannelton mine (Table 7). The Robel pole index was higher on the Cannelton mine than the other two mines and higher on the Daltex mine than the Hobet mine (Table 7). Forb cover was higher on the Cannelton and Daltex mines than on the Hobet mine (Table 7). The other variables all showed significant treatment by mine interactions. Grass height was higher at the Hobet mine than at the Daltex and Cannelton mines in the grassland treatment and higher at the Hobet mine than the Cannelton mine in the shrub/pole treatment (Table 9). Ground cover of grass and shrubs differed among mines, but not between grassland and shrub/pole treatments (Table 8-9).

Canopy height, percent canopy cover in 6 layer classes, and the structural diversity index were compared among the fragmented forest, intact forest, and shrub/pole treatments (Table 7). Percent canopy cover in 5 layer classes differed among treatments but not among mines (Table 7). There were treatment by mine interactions for canopy height and cover from >3-6 m. Canopy height was higher at the Cannelton mine than the Daltex and Hobet mines in the fragmented forest treatment, and was higher at the Daltex mine than the Hobet mine in the intact treatment (Table 8). Canopy cover from >3-6 m was higher at the Cannelton and Daltex mines than the Hobet mine in the intact forest treatment (Table 8). This cover layer also differed among treatments at the Cannelton and Hobet mines (Table 9). It was higher in the fragmented and intact forest treatments than the shrub/pole treatment at the Cannelton mine. At the Hobet mine it was highest in the intact forest, followed by fragmented forest and shrub/pole treatments (Table 9).

Species-specific Logistic Regression Models

The presence/absence of 11 forest-dwelling songbird species of conservation priority for the region were related to specific habitat variables. Logistic regression models were fit for each species and none were rejected due to lack-of-fit (Hosmer and Lemeshow goodness-of-fit tests, P>0.10),

The presence/absence of 11 forest-dwelling songbird species of conservation priority for the region were related to specific habitat variables. Logistic regression models were fit for each species and none were rejected due to lack-of-fit (Hosmer and Lemeshow goodness-of-fit tests, P>0.10),

<u>Cerulean Warbler</u>
The Cerulean Warbler, with the highest conservation priority rating (Table 5), was not found to be related to any of the microhabitat variables we measured (Table 16). The Ohio Hills and Northern Cumberland Plateau physiographic provinces where MTMVF mining is prominent are within the core area for the Cerulean Warbler. It is estimated that 46.8% of this species' population is found within the Ohio Hills province alone (Rosenburg 2000). This species prefers large tracts of mature forests with large, tall trees (P. Hamel, unpub. rept.). Based on previous knowledge of habitat preferences, it is reasonable to conclude that continued MTMVF mining will negatively impact Cerulean Warbler abundance in southwestern West Virginia.

<u>Lousiana Waterthrush</u>
The Lousiana Waterthrush, with the second highest conservation rating, was negatively related to sapling density (Table 16). This species is found in large tracts of mature forest and nests on the ground along stream banks (Whitcomb et al. 1981, Ehrlich et al. 1988). Bushman and Therres (1988) suggested that wooded streambanks and ravines be protected in order to maintain this species. Given valleys and streams are covered by MTMVF operations and reduces mature forest cover, it is logical to conclude that this species also will be negatively affected by loss of streamside forest habitat from this type of mining.

<u>Worm-eating Warbler</u>
This species was negatively related to aspect code (Table 17). Worm-eating Warblers typically are found on dry ravines and hillsides in deciduous woods where they nest on the ground in leaf litter (Ehrlich et al. 1988, Dettmers and Bart 1999). They are most abundant in mature forests, although they may be found in young- and medium-aged forest stands as well (Bushman and Therres 1988). Robbins (1980) and Whitcomb et al. (1981) suggested that this species requires large tracts of mature forest and may have a low tolerance for fragmentation. The greatest threat to this species from MTMVF is the loss and fragmentation of forested habitat.

<u>Kentucky Warbler</u>
Kentucky Warblers were present at points with a high percent of green ground cover and a low density of trees from >8-23cm and also were present more often at lower elevations (Table 17). Kentucky Warblers prefer rich, moist forests and bottomlands with well-developed ground cover (Bushman and Therres 1984). This species appears to be moderately affected by fragmentation and may be found in small woodlots, but in Maryland the highest frequency of occurrence for this species was in forests from 130-700 ha in size (Bushman and Therres 1988). Loss of wooded ravines and bottomlands could negatively affect this species.

<u>Acadian Flycatcher</u>
This species was one of our most abundant birds and abundance was correlated to several habitat variables (Table 18). It was negatively related to density of saplings and trees >8-23 cm dbh,

indicating an association with mature forests. It also was negatively associated with leaf litter cover. Acadian Flycatchers prefer moist ravines and stream bottoms. Dettmers and Bart (1999) considered this species to be a habitat "specialist" at the microhabitat (i.e. territory or home range) level. Bushman and Therres (1988) found that Acadian flycatchers prefer forests with high canopy cover, large trees, and an open understory. This species prefers large blocks of mature contiguous forest for breeding, and appears to avoid edges. We found this species to be more abundant in intact forest, which could indicate that MTMVF mining is detrimental to this species.

Wood Thrush

Wood Thrush were positively related to density of trees >23-38 cm dbh and canopy cover >24m and negatively associated with elevation (Table 18). Wood Thrush are found in deciduous and mixed coniferous-deciduous forest, with highest densities occurring in the Appalachian Mountain region (James et al. 1984). They prefer mature forests with some small trees in the understory for nesting and a moist, leafy litter layer for foraging (James et al. 1984).

Yellow-throated Vireo

Presence of this species was not related to any microhabitat variables. It is most abundant in mature forests and appears to prefer stream borders and bottomland forests (Bushman and Therres 1988). Yellow-throated Vireos appear to have a low tolerance for forest fragmentation (Whitcomb et al. 1981). MTMVF mining could potentially reduce abundance of in this species because of its preference for mature forest along streams, which may be lost due to mining.

Hooded Warbler

Hooded Warblers were positively related to percent green ground cover and sapling density (Table 19). Hooded Warblers typically are found in moist deciduous forests and ravines with a well-developed understory (Ehrlich et al. 1988), but also may be found along ridges with a high density of shrub stems (Dettmers and Bart 1999). It is suspected that this species is fragmentation-sensitive (Bushman and Therres 1988), and we found it to occur at higher abundances in intact than fragmented forest sites.

Scarlet Tanager

This species was positively associated with percent slope, density of trees from >38-53 cm, and distance to mine edge (Table 20). This species may be found in a wide range of successional stages of forests, but is most abundant in mature woods with a dense canopy (Bushman and Therres 1988). This species does not appear to be as fragmentation-sensitive as other forest interior species, and may tolerate smaller forests and edges (Bushman and Therres 1988); however, it was more abundant in our intact than fragmented forest sites during 1 year of the study, and was more common at points further away from mine/forest edge.

Black-and-white Warbler

Black-and-white Warblers were negatively associated with percent water cover. This species nests on the ground in deciduous and mixed forests (Ehrlich et al. 1988). It appears to prefer pole-stage stands (Bushman and Therres 1988), but it is fragmentation-sensitive and was not found breeding in forests <70 ha in size in Maryland (Whitcomb et al. 1981).

Yellow-billed Cuckoo

The Yellow-billed Cuckoo was negatively associated with elevation (X^2=6.46, P=0.01). This species is a PIF priority species for the region (Rosenberg 2000), but we observed it at only 9 sampling points in the 2 years of the study. Less than 1% of the population occurs in this region (Rosenberg and Wells 1999), and MTMVF is not likely to severely impact the population as a whole.

Other Species

The Swainson's Warbler, a species of concern in the region and a rare species in West Virginia (West Virginia Wildlife and Natural Heritage Program 2000), is typically, in West Virginia, found only in areas of dense rhododendron (Buckelew and Hall 1994). We observed this species in the Twentymile Creek watershed along Hughes Fork. Further MTMVF in this watershed could impact this species, but the effect on the population as a whole will be minimal, since <2% of the population is found in the Ohio Hills province and West Virginia is on the periphery of its range (Table 5) . The Eastern Wood-pewee is a species of conservation priority (Action level III) in the region, but we only observed it at 1.2% of our forested point counts. The Black-billed Cuckoo is a PIF priority species for this region (Rosenberg 2000), but it appears to be relatively rare; it was only observed incidentally in early successional habitat during this study and was not detected during point count surveys.

Table 6. Mean and standard error (SE) for habitat variables measured at grassland (n=44), shrub/pole (n=33), fragmented forest (n=36), and intact forest (n=49) sampling points.

	Treatment							
	Grassland		Shrub/Pole		Fragmented Forest		Intact Forest	
Variables	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Slope (%)	16.96	2.10	10.16	1.93	33.78	2.28	33.75	2.07
Aspect Code	1.05	0.10	0.78	0.13	1.05	0.12	1.02	0.08
Grass/Forb Height (dm)	7.29	0.27	6.20	0.48	--[a]	--	--	--
Litter Depth (cm)	2.26	0.19	1.64	0.17	--	--	--	--
Elevation (m)	400.93	7.19	378.85	11.53	332.08	7.11	389.58	10.87
Distance to Minor Edge (m)	113.02	16.75	68.14	8.23	38.71	3.88	64.61	11.57
Distance to Habitat Edge (m)	335.46	45.26	79.16	11.06	128.61	12.52	1430.66	145.32
Distance to Forest/Mine Edge (m)	347.35	44.30	253.98	34.46	128.61	12.52	1430.66	145.32
Robel Pole Index	2.93	0.17	4.30	0.27	--	--	--	--
Canopy Height (m)	--	--	4.67	0.45	21.70	0.72	22.90	0.67
<u>Ground Cover (%)</u>								
Water	0.14	0.10	0.15	0.12	1.15	0.32	0.48	0.17
Bareground	7.73	1.18	2.22	0.92	7.71	0.95	7.45	0.59
Litter	8.14	1.54	6.06	1.78	54.24	1.88	48.32	1.75
Woody Debris	0.06	0.04	0.30	0.12	4.20	0.42	4.95	0.41
Moss	1.04	0.38	1.83	0.86	2.01	0.32	2.04	0.34
Green	82.78	2.00	85.86	3.47	30.35	1.74	36.61	1.99
Forb Cover	23.63	2.39	21.89	2.86	--	--	--	--
Grass Cover	45.05	2.71	43.70	5.26	--	--	--	--
Shrub Cover	14.13	2.72	22.99	3.23	--	--	--	--
<u>Stem Densities (no./ha)</u>								
<2.5 cm	777.70	207.52	7475.38	1646.08	4935.76	450.55	6135.84	702.59
>2.5-6 cm	73.15	18.79	979.17	292.52	901.04	65.86	587.37	55.71
>8-23 cm	0.03	0.02	126.89	22.66	339.76	34.12	262.12	11.43
>23-38 cm	0.00	0.00	5.68	2.02	89.41	5.20	90.82	4.82
>38-53 cm	0.00	0.00	0.00	0.00	30.38	3.22	31.12	2.55
>53-68 cm	0.00	0.00	0.00	0.00	9.90	1.71	8.04	1.18
>68 cm	0.00	0.00	0.00	0.00	3.99	0.87	3.19	0.71
Snags >2.5 cm	0.00	0.00	14.03	4.88	41.87	3.99	48.55	6.37
<u>Canopy Cover (%)</u>								
>0.5-3 m	--	--	29.70	2.94	54.90	2.33	47.63	2.33
>3-6 m	--	--	22.88	2.86	66.63	2.42	54.67	2.06
>6-12 m	--	--	14.37	2.59	63.06	2.38	65.46	1.24
>12-18 m	--	--	2.84	0.86	56.01	2.68	63.34	2.07
>18-24 m	--	--	0.11	0.08	41.39	2.97	51.28	3.06
>24 m	--	--	0.00	0.00	16.15	2.48	18.06	2.14
Structural Diversity Index	--	--	13.98	1.47	59.63	1.29	60.09	1.39

[a] Variables were not measured in this treatment.

Table 7. Two-way ANOVA results comparing habitat variables among treatments and mines.

	Factor Levels															
	Treatment			Waller-Duncan[a]				Mine			Waller-Duncan[b]			Treatment x Mine		
Variables	F	df	P	GR	SH	FR	IN	F	df	P	Can.	Dal.	Hob.	F	df	P
Slope (%)	39.79	3	<0.01	B	C	A	A	26.55	2	<0.01	B	A	A	5.26	5	<0.01
Aspect Code	2.27	3	0.08					0.04	2	0.96				1.81	5	0.11
Elevation (m)	24.94	3	<0.01	A	B	C	A	106.18	2	<0.01	A	B	C	4.63	5	<0.01
Grass Height (dm)	3.82	1	0.06					20.78	2	<0.01	C	B	A	4.26	1	0.04
Litter Depth (cm)	3.56	1	0.06					25.07	2	<0.01	C	B	A	2.31	1	0.13
Distance to minor edge (m)	4.69	3	<0.01	A	B	B	B	0.35	2	0.70				2.08	5	0.07
Distance to habitat edge (m)	708.60	3	<0.01	B	C	C	A	188.61	2	<0.01	B	A	C	189.17	5	<0.01
Distance to mine/forest edge (m)	577.33	3	<0.01	B	B	C	A	142.21	2	<0.01	B	A	C	172.35.	5	<0.01
Robel Pole Index	20.66	1	<0.01					11.09	2	<0.01	B	A	C	0.00	1	0.94
Canopy Height (m)	222.33	2	<0.01	--	B	A	A	1.02	2	0.36				7.66	3	<0.01
<u>Ground Cover (%):</u>																
Water	4.19	3	<0.01	B	B	A	B	0.25	2	0.78				1.48	5	0.20
Bareground	13.19	3	<0.01	A	B	A	A	0.11	2	0.89				4.71	5	<0.01
Litter	230.03	3	<0.01	C	C	A	B	0.31	2	0.73				10.06	5	<0.01
Woody Debris	144.45	3	<0.01	B	B	A	A	0.88	2	0.42				2.77	5	0.02
Moss	5.48	3	<0.01	B	B	A	A	0.02	2	0.98				1.04	5	0.40
Green	130.34	3	<0.01	B	A	C	C	0.92	2	0.40				1.79	5	0.12
Forb	0.11	1	0.74					5.02	2	0.01	A	A	B	3.96	1	0.05
Grass	1.47	1	0.23					24.22	2	<0.01	C	B	A	5.25	1	0.02
Shrub	3.95	1	0.05					15.65	2	<0.01	A	B	B	4.68	1	0.03
<u>Stem Density (no./ha)</u>:																
<2.5 cm	67.03	3	<0.01	B	A	A	A	2.86	2	0.06				5.71	5	<0.01
>2.5-8 cm	79.55	3	<0.01	C	AB	A	B	1.28	2	0.28				2.43	5	0.04
>8-23 cm	484.80	3	<0.01	C	B	A	A	2.99	2	0.06				0.95	5	0.45
>23-38 cm	495.00	3	<0.01	C	B	A	A	1.24	2	0.29	B	A	B	3.70	5	<0.01
>38-53 cm	420.46	3	<0.01	B	B	A	A	0.03	2	0.97				3.83	5	<0.01
>53-68 cm	38.74	3	<0.01	B	B	A	A	0.66	2	0.52				1.43	5	0.22
>68 cm	11.95	3	<0.01	B	B	A	A	2.80	2	0.06				1.83	5	0.11
Snags	43.86	3	<0.01	C	B	A	A	0.60	2	0.55				3.69	5	0.01

Table 7. Continued.

	Factor Levels																
	Treatment			Waller-Duncan[a]				Mine			Waller-Duncan[b]			Treatment x Mine		
Variables	F	df	P	GR	SH	FR	IN	F	df	P	Can.	Dal.	Hob.	F	df	P
Canopy Cover (%):																
0.5-3 m	25.16	2	<0.01	--	C	A	B	0.70	2	0.50				0.98	3	0.40
>3-6 m	75.63	2	<0.01	--	C	A	B	0.18	2	0.84				3.40	3	0.02
>6-12 m	148.67	2	<0.01	--	B	A	A	1.57	2	0.21				3.74	3	0.01
>12-18 m	280.81	2	<0.01	--	C	B	A	1.60	2	0.21				2.59	3	0.06
>18-24 m	180.95	2	<0.01	--	C	B	A	4.83	2	<0.01	B	A	B	2.92	3	0.04
>24 m	36.62	2	<0.01	--	B	A	A	0.28	2	0.76				2.67	3	0.05
Structural Diversity Index	339.75	2	<0.01	--	B	A	A	1.75	2	0.18	B	A	B	6.09	3	<0.01

[a] Waller-Duncan k-ratio t-test. Treatments with different letters differ at P<0.05 ('A' indicates highest value). GR=grassland; SH=shrub/pole; FR=fragmented forest; IN=intact forest.
[b] Waller-Duncan k-ratio t-test. Mines with different letters differ at P<0.05 ('A' indicates highest value). Can.=Cannelton; Dal.=Daltex; Hob.=Hobet.

Table 8. ANOVA results comparing habitat variables among mines within individual treatments for variables with treatment x mine interactions.

	Treatment/Mine																						
	Grassland			Waller-Duncan[a]			Shrub/pole			Waller-Duncan		Fragmented Forest			Waller-Duncan			Intact Forest			Waller-Duncan		
Variables	F	df	P	Can.	Dal.	Hob.	F	df	P	Can.	Hob.	F	df	P	Can.	Dal.	Hob.	F	df	P	Can.	Dal.	Hob.
Slope (%)	2.30	2	0.11	B	A	AB	120.21	1	<0.01	B	A	6.40	2	<0.01	B	A	A	4.72	2	0.01	B	B	A
Elevation (m)	19.53	2	<0.01	A	A	B	127.50	1	<0.01			14.40	2	<0.01	A	B	C	37.36	2	<0.01	A	B	C
Distance to minor edge (m)	1.09	2	0.35				0.80	1	0.38			1.39	2	0.26				2.88	2	0.07	B	A	B
Distance to habitat edge (m)	11.77	2	<0.01	B	A	B	3.40	1	0.07	A	B	3.60	2	0.04	AB	B	A	426.79	2	<0.01	A	A	B
Distance to forest/mine edge (m)	10.00	2	<0.01	B	A	B	11.33	1	<0.01	B	A	3.60	2	0.04	AB	B	A	426.79	2	<0.01	A	A	B
Grass Height (dm)	5.42	2	<0.01	B	AB	A	31.76	1	<0.01	B	A	--	--	--				--	--	--			
Canopy Height (m)	--	--	--				1.22	1	0.28			7.34	2	<0.01	A	B	A	3.17	2	0.05	AB	A	B
Ground Cover (%):																							
Bareground	3.75	2	0.03	AB	A	B	0.77	1	0.39			6..94	2	<0.01	B	B	A	0.80	2	0..46			
Litter	12.35	2	<0.01	C	B	A	22.97	1	<0.01	A	B	4.28	2	002	A	AB	B	4.07	2	0.02	A	B	B
Woody debris												0.76	2	0.47				4.11	2	0.02	A	B	AB
Grass	10.77	2	<0.01	B	B	A	27.34	1	<0.01	B	A	--	--	--				--	--	--			
Forb	1.22	2	0.31				10.87	1	<0.01	A	B	--	--	--				--	--	--			
Shrub	12.95	2	<0.01	A	B	C	7.15	1	0.01	A	B	--	--	--				--	--	--			
Stem Density (no./ha):																							
<2.5cm	5.81	2	<0.01	B	A	A	0.00	1	0.98			0.74	2	0.49				0.55	2	0.58			
>2.5-8 cm	--	--	--									3.26	2	0.05	AB	A	B	0.78	2	0.46			
>23-38cm	--	--	--				3.47	1	0.07	A	B	1.25	2	0.30				0.37	2	0.69			
>38-53cm	--	--	--									8.75	2	<0.01	B	A	A	5.37	2	<0.01	B	A	A
Snags	--	--	--															1.41	2	0.25			
Canopy Cover (%):																							
>3-6m	--	--	--				2.63	1	0.12			1.76	2	0.19				3.27	2	0.05	A	B	AB
>6-12m	--	--	--				1.95	1	0.17			4.26	2	0.02	B	A	B	3.42	2	0.04	A	B	B
>12-18m	--	--	--				2.07	1	0.16			2.57	2	0.09				1.64	2	0.21			
>18-24m	--	--	--				0.04	1	0.84			0.73	2	0.49				5.30	2	0.01	A	B	B
>24m	--	--	--				--	--	--			0.66	2	0.52				2.53	2	0.10			
Structural Diversity Index	--	--	--				1.18	1	0.28			1.98	2	0.15				7.85	2	<0.01	A	B	B

[a] Waller-Duncan k-ratio t-test. Mines with different letters differ at P<0.05 ('A' indicates highest value). Can.=Cannelton; Dal.= Daltex; Hob.=Hobet.

Table 9. ANOVA results comparing habitat variables among treatments at individual mines for variables with treatment x mine interactions.

	Mine/treatment																			
	Cannelton			Waller-Duncan[a]				Daltex			Waller-Duncan			Hobet			Waller-Duncan			
Variables	F	df	P	GR	SH	FR	IN	F	df	P	GR	FR	IN	F	df	P	GR	SH	FR	IN
Slope (%)	39.47	3	<0.01	B	C	A	A	1.77	2	0.19				22.80	3	<0.01	B	B	A	A
Elevation (m)	11.28	3	<0.01	AB	B	C	A	9.18	2	<0.01	A	B	A	11.93	3	<0.01	A	BC	C	B
Distance to minor edge (m)	1.73	3	0.18					1.05	2	0.36				8.61	3	<0.01	A	B	B	B
Distance to habitat edge (m)	759.76	3	<0.01	B	B	B	A	213.54	2	<0.01	B	C	A	24.67	3	<0.01	B	C	B	A
Distance to forest/mine edge (m)	660.78	3	<0.01	B	B	B	A	213.54	2	<0.01	B	C	A	10.19	3	<0.01	B	D	C	A
Grass Height (dm)	4.25	1	0.05					--	--	--				0.01	1	0.91				
Canopy Height (m)	97.45	1	<0.01	--	B	A	A	25.97	1	<0.01				124.13	2	<0.01	--	B	A	A
Ground Cover (%):																				
Bareground	7.33	3	<0.01	A	B	A	A	1.58	2	0.22				8.94	3	<0.01	B	C	AB	A
Litter	97.60	3	<0.01	C	B	A	A	106.39	2	<0.01	C	A	B	86.51	3	<0.01	B	C	A	A
Woody debris	51.28	3	<0.01	C	C	B	A	42.68	2	<0.01	B	A	A	67.25	3	<0.01	C	C	B	A
Forb	1.42	1	0.24					--	--	--				3.07	1	0.09	B	A	--	--
Grass	4.45	1	0.05	A	B	--	--	--	--	--				0.73	1	0.40				
Shrub	0.02	1	0.89					--	--	--				13.16	1	<0.01	B	A	--	--
Stem Densities (no./ha):																				
<2.5cm	47.81	3	<0.01	B	A	A	A	21.94	2	<0.01	B	A	A	15.18	3	<0.01	B	A	A	A
>2.5-8	105.52	3	<0.01	C	B	A	AB	22.93	2	<0.01	B	A	A	23.25	3	<0.01	B	A	A	A
>23-38cm	61.04	3	<0.01	C	B	A	A	711.84	2	<0.01	B	A	A	422.26	3	<0.01	C	B	A	A
>38-53cm	312.17	3	<0.01	C	C	A	B	89.21	2	<0.01	B	A	A	238.71	3	<0.01	C	C	B	A
Snags	4.92	3	0.01	C	B	A	A	5.28	2	0.03	B	A	A	57.20	3	<0.01	C	B	A	A
Canopy Cover (%):																				
>3-6m	23.10	2	<0.01	--	B	A	A	22.26	1	<0.01				42.37	2	<0.01	--	B	A	A
>6-12m	54.35	2	<0.01	--	B	A	A	12.94	1	<0.01				69.97	2	<0.01	--	B	A	A
>12-18m	147.00	2	<0.01	--	B	A	A	1.39	1	0.25				113.82	2	<0.01	--	B	A	A
>18-24m	197.41	2	<0.01	--	C	B	A	4.08	1	0.06				59.06	2	<0.01	--	B	A	A
>24m	82.98	2	<0.01	--	C	B	A	0.49	1	0.49				12.56	2	<0.01	--	B	A	A

Table 9 continued

Structural Diversity Index	157.86	2	<0.01	--	C	B	A	10.64	1	<0.01	143.36	2	<0.01	--	B	A	A

[a] Waller-Duncan k-ratio t-test. Treatments with different letters differ at P<0.05 (‘A’ indicates highest value). GR=grassland; SH=shrub/pole; FR=fragmented forest; IN=intact forest.

Table 16. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Cerulean Warbler and Louisiana Waterthrush at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Cerulean Warbler						Louisiana Waterthrush					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	0.98	0.08	1.17	0.13			1.03	0.08	1.15	0.16		
Slope (%)	31.75	2.02	37.28	2.15			33.08	1.71	37.21	3.74		
Elevation (m)	376.11	9.44	361.90	14.52			376.76	8.94	341.36	15.48		
Distance to mine (m)	979.76	146.84	916.64	194.49			994.39	128.28	765.79	282.99		
Distance to closest minor edge (m)	61.98	10.52	39.11	4.73			54.74	8.27	48.07	6.52		
Canopy Height (m)	21.70	0.62	22.62	0.79			22.04	0.53	22.04	1.88		
Ground Cover (%)												
Water	0.79	0.23	0.73	0.24			0.85	0.20	0.36	0.28		
Litter	49.88	1.73	52.46	2.00			49.98	1.50	55.09	2.29		
Bareground	7.89	0.68	6.98	0.81			7.66	0.62	7.05	0.65		
Woody Debris	4.63	0.39	4.64	0.46			4.58	0.33	4.91	0.70		
Green	34.24	1.83	33.47	2.15			34.45	1.59	31.43	2.57		
Moss	2.06	0.29	1.98	0.42			2.04	0.26	1.96	0.55		
Stem Densities (no./ha)												
<2.5 cm	5827.55	663.50	5279.23	440.98			5619.72	505.43	5667.41	986.35	4.92	0.03-
>2.5-8 cm	697.92	54.73	759.07	81.40			706.87	47.67	787.95	137.40		
>8-23 cm	291.20	20.02	301.61	28.41			292.43	18.40	308.04	34.26		
>23-38 cm	93.17	4.73	85.08	5.04			90.14	3.87	90.63	8.86		
>38-53 cm	28.94	2.40	34.07	3.50			30.19	2.19	33.93	4.93		
>53-68 cm	9.38	1.30	7.86	1.53			8.98	1.10	8.04	2.40		
>68 cm	3.36	0.63	3.83	1.03			3.43	0.61	4.02	1.24		
Snags >2.5cm	44.24	5.19	48.15	6.27			43.04	3.88	58.51	13.93		
Canopy Cover (%)												
0.5-3 m	49.42	2.07	52.94	2.99			50.35	1.85	52.50	4.49		
>3-6 m	60.63	2.05	58.19	2.96			59.00	1.74	63.48	5.19		
>6-12 m	64.86	1.27	63.71	2.58			64.35	1.43	64.91	1.84		
>12-18 m	59.05	2.13	62.30	2.75			60.23	1.91	60.27	3.43		
>18-24 m	46.04	2.92	48.91	3.37			47.92	2.35	42.86	6.39		
>24 m	16.13	2.05	19.19	2.62			18.06	1.83	13.13	3.11		
Structural Diversity Index	59.23	1.31	61.05	1.35			59.98	1.02	59.43	2.90		

Table 17. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Worm-eating Warbler and Kentucky Warbler at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Worm-eating Warbler						Kentucky Warbler					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	1.14	0.08	0.73	0.10	5.76	0.02-	1.02	0.08	1.12	0.11		
Slope (%)	34.58	1.69	31.10	3.46			33.05	1.87	35.68	2.53		
Elevation (m)	374.57	8.97	359.10	17.53			383.23	9.51	337.78	12.44	8.30	<0.01-
Distance to mine (m)	996.20	137.73	828.48	215.34			1028.68	139.65	762.82	208.64		
Distance to closest minor edge (m)	54.66	8.02	50.31	14.49			53.11	8.25	55.07	13.37		
Canopy Height (m)	21.91	0.56	22.46	1.01			21.83	0.58	22.60	0.89		
Ground Cover (%)												
Water	0.73	0.20	0.88	0.35			0.71	0.19	0.92	0.36		
Litter	50.35	1.59	52.38	2.18			49.25	1.63	55.05	1.90		
Bareground	8.06	0.62	5.94	0.86			8.10	0.64	6.09	0.83		
Woody Debris	4.98	0.35	3.50	0.51			4.64	0.36	4.62	0.51		
Green	34.00	1.70	33.81	2.23			35.22	1.79	30.54	1.67	7.36	<0.01+
Moss	2.10	0.26	1.81	0.58			1.90	0.25	2.39	0.57		
Stem Densities (no./ha)												
<2.5 cm	5859.62	559.47	4873.44	584.25			5605.34	566.10	5687.50	680.87		
>2.5-8 cm	712.50	53.81	745.31	84.99			671.88	51.77	850.54	90.42		
>8-23 cm	279.81	17.82	344.38	36.79			270.26	15.48	361.68	41.04	5.28	0.02-
>23-38 cm	88.27	3.98	96.56	7.61			90.12	4.38	90.49	5.67		
>38-53 cm	31.35	2.36	29.06	3.66			29.74	2.22	33.70	4.34		
>53-68 cm	9.71	1.21	5.94	1.40			8.17	1.03	10.60	2.40		
>68 cm	3.75	0.65	2.81	0.96			3.43	0.59	3.80	1.29		
Snags >2.5 cm	42.88	4.79	54.39	6.73			40.23	4.20	59.81	8.89		
Canopy Cover (%)												
0.5-3 m	48.83	1.96	56.81	3.13			49.92	2.01	52.83	3.25		
>3-6 m	58.08	1.90	65.13	3.43			57.96	1.85	64.51	3.63		
>6-12 m	64.12	1.30	65.50	3.15			64.03	1.39	65.54	2.63		
>12-18 m	61.06	1.93	57.56	3.47			61.73	2.01	56.20	2.97		
>18-24 m	49.21	2.54	40.19	4.28			50.99	2.46	36.58	4.15		
>24 m	18.58	1.93	12.94	2.62			17.70	1.86	16.03	3.27		
Structural Diversity Index	59.97	1.14	59.63	1.85			60.47	1.12	58.34	1.92		

Table 18. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Wood Thrush and Acadian Flycatcher at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Wood Thrush						Acadian Flycatcher					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	1.04	0.10	1.05	0.09			0.85	0.18	1.09	0.07		
Slope (%)	31.86	2.53	35.23	1.87			33.94	3.58	33.72	1.70		
Elevation (m)	387.24	9.89	358.35	11.67	4.92	0.03-	385.06	17.80	367.65	8.94		
Distance to mine (m)	1049.47	180.64	885.26	153.19			711.22	239.19	1013.67	132.67		
Distance to closest minor edge (m)	58.52	11.58	49.88	8.63			80.72	23.55	47.36	6.53		
Canopy Height (m)	22.10	0.70	21.99	0.68			20.93	1.07	22.30	0.54		
<u>Ground Cover (%)</u>												
Water	0.54	0.27	0.94	0.22			0.23	0.17	0.89	0.21		
Litter	47.09	2.23	53.70	1.47			46.48	3.54	51.83	1.39	4.62	0.03-
Bareground	7.33	0.89	7.73	0.63			7.89	1.42	7.48	0.56	5.80	0.02+
Woody Debris	4.39	0.41	4.82	0.42			4.22	0.57	4.73	0.34		
Green	38.07	2.44	30.78	1.47			39.77	3.85	32.61	1.44		
Moss	1.96	0.37	2.08	0.31			2.11	0.67	2.01	0.25		
<u>Stem Densities (no./ha)</u>												
<2.5 cm	5139.36	557.89	6003.91	671.25			6421.88	1442.45	5443.39	446.38	7.52	<0.01-
>2.5-8 cm	602.20	65.65	811.20	60.12			671.88	101.66	731.43	51.16		
>8-23 cm	268.24	22.68	315.63	22.75			278.52	32.69	298.82	18.68	4.51	<0.03-
>23-38 cm	87.84	5.76	92.06	4.43	5.81	0.02+	86.33	7.95	91.12	3.95		
>38-53 cm	34.63	2.90	27.86	2.68			38.28	4.70	29.08	2.17		
>53-68 cm	6.93	1.30	10.29	1.42			8.59	2.41	8.88	1.10		
>68 cm	3.72	0.82	3.39	0.74			5.08	1.30	3.17	0.60		
Snags >2.5 cm	46.20	7.19	45.24	4.49			39.46	6.96	47.13	4.67		
<u>Canopy Cover (%)</u>												
0.5-3 m	47.40	2.61	53.26	2.21			46.48	4.03	51.68	1.88		
>3-6 m	54.22	2.22	63.98	2.28			56.09	3.58	60.58	1.90		
>6-12 m	64.59	1.94	64.32	1.61			64.61	2.62	64.40	1.40		
>12-18 m	63.04	2.56	58.07	2.21			62.73	3.50	59.66	1.91		
>18-24 m	50.10	3.35	44.77	2.95			51.80	4.23	46.00	2.54		
>24 m	16.05	2.51	18.18	2.12	5.45	0.02+	20.47	3.89	16.50	1.77		
Structural Diversity Index	59.08	1.52	60.52	1.26			60.44	1.79	59.76	1.12		

Table 19. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Hooded Warbler and Yellow-throated Vireo at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Hooded Warbler						Yellow-throated Vireo					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	1.00	0.09	1.13	0.11			1.03	0.07	1.11	0.19		
Slope (%)	33.04	2.09	34.91	2.17			32.98	1.77	36.91	2.80		
Elevation (m)	358.47	9.26	391.56	14.09			370.03	9.44	374.53	13.42		
Distance to mine (m)	780.70	136.97	1248.30	203.05			1040.72	134.30	620.81	213.49		
Distance to closest minor edge (m)	55.17	8.25	51.09	12.70			55.09	8.64	47.84	5.13		
Canopy Height (m)	21.25	0.67	23.28	0.63			22.40	0.56	20.59	0.88		
Ground Cover (%)												
Water	0.85	0.24	0.63	0.22			0.77	0.19	0.74	0.40		
Litter	49.67	1.70	52.73	2.07			49.87	1.53	54.63	2.27		
Bareground	7.78	0.69	7.19	0.81			7.63	0.56	7.28	1.44		
Woody Debris	4.79	0.35	4.38	0.53			4.83	0.34	3.82	0.59		
Green	34.83	1.85	32.50	2.11	12.49	<0.01+	34.74	1.63	30.81	2.42		
Moss	2.19	0.33	1.76	0.33			1.97	0.27	2.28	0.52		
Stem Densities (no./ha)												
<2.5 cm	4939.86	573.57	6766.60	690.85	5.49	0.02+	5478.86	453.27	6222.43	1360.03		
>2.5-8 cm	658.02	53.40	823.24	80.34			672.79	46.25	909.93	125.68		
>8-23 cm	299.53	21.18	287.50	25.79			287.41	17.38	325.37	43.03		
>23-38 cm	93.63	4.69	84.57	5.17			91.36	3.74	85.66	9.52		
>38-53 cm	29.01	2.48	33.79	3.34			29.23	2.12	37.13	5.13		
>53-68 cm	9.79	1.40	7.23	1.23			9.10	1.08	7.72	2.49		
>68 cm	2.95	0.57	4.49	1.10			3.31	0.56	4.41	1.59		
Snags >2.5 cm	41.84	4.48	52.04	7.57			46.10	4.61	43.78	7.78		
Canopy Cover (%)												
0.5-3 m	52.62	2.09	47.54	2.89			50.40	1.89	51.91	4.01		
>3-6 m	60.99	2.01	57.66	2.99			59.41	1.91	61.03	3.64		
>6-12 m	65.97	1.25	61.91	2.51			64.41	1.31	64.56	3.35		
>12-18 m	62.52	2.22	56.45	2.43			59.39	1.95	63.60	3.13		
>18-24 m	48.23	2.96	45.20	3.29			46.95	2.52	47.65	4.75		
>24 m	15.26	2.09	20.55	2.46			16.82	1.73	18.97	4.23		
Structural Diversity Index	61.12	1.16	57.86	1.67			59.48	1.12	61.54	1.84		

Table 20. Means, standard errors (SE), and forward logistic regression results (Wald chi-square statistics) for the presence/absence of the Black-and-white Warbler and Scarlet Tanager at point counts in forested habitats in southwestern West Virginia. The '-' and '+' indicate either a negative or a positive relationship between abundance and the habitat variables.

	Black-and-white Warbler						Scarlet Tanager					
	Absent		Present				Absent		Present			
Variable	Mean	SE	Mean	SE	X^2	P	Mean	SE	Mean	SE	X^2	P
Aspect Code	1.04	0.08	1.05	0.12			1.10	0.09	0.98	0.11		
Slope (%)	32.56	2.16	35.57	2.01			30.77	1.99	37.30	2.25	8.45	<0.01+
Elevation (m)	370.14	10.18	372.12	13.03			356.13	10.31	388.38	11.99		
Distance to mine (m)	1022.10	158.37	858.70	170.12			696.48	140.22	1263.70	182.72	11.06	<0.01+
Distance to closest minor edge (m)	58.47	9.79	46.39	9.48			59.46	12.10	46.77	5.30		
Canopy Height (m)	21.89	0.63	22.26	0.78			21.62	0.70	22.53	0.67		
<u>Ground Cover (%)</u>												
Water	0.78	0.24	0.74	0.24	6.98	<0.01-	0.65	0.24	0.90	0.25		
Litter	50.47	1.69	51.36	2.13			50.00	1.76	51.79	2.00		
Bareground	8.41	0.69	6.29	0.76			7.42	0.63	7.72	0.87		
Woody Debris	4.90	0.41	4.23	0.41			4.43	0.39	4.87	0.45		
Green	34.44	1.66	33.24	2.47			35.11	1.62	32.60	2.37		
Moss	1.86	0.31	2.28	0.38			2.04	0.34	2.02	0.34		
<u>Stem Densities (no./ha)</u>												
<2.5 cm	5855.39	656.44	5285.85	551.49			5618.89	663.50	5637.82	601.06		
>2.5-8 cm	673.41	59.55	790.44	69.93			658.29	55.66	793.27	73.52		
>8-23 cm	270.22	15.70	332.17	32.60			289.81	23.09	301.12	23.13	3.92	0.05+
>23-38 cm	88.97	4.29	92.10	6.10			92.39	5.25	87.66	4.60		
>38-53 cm	28.80	2.28	33.82	3.61			31.93	2.66	29.49	3.04		
>53-68 cm	10.05	1.35	6.99	1.42			9.78	1.57	7.69	1.11		
>68 cm	2.57	0.59	4.96	1.01			3.94	0.79	3.04	0.76		
Snags >2.5 cm	47.85	5.77	42.49	5.14			41.21	4.79	50.66	6.54		
<u>Canopy Cover (%)</u>												
0.5-3 m	50.44	2.32	51.10	2.50			48.07	2.18	53.81	2.63		
>3-6 m	58.01	2.08	62.32	2.80			57.28	2.07	62.63	2.70		
>6-12 m	62.23	1.39	67.76	2.18			64.89	1.59	63.91	1.94		
>12-18 m	59.53	2.22	61.29	2.60			63.32	2.22	56.60	2.48		
>18-24 m	46.91	2.83	47.35	3.62			48.61	2.91	45.29	3.42		
>24 m	16.25	2.07	18.75	2.59			16.96	2.23	17.60	2.36		
Structural Diversity Index	58.68	1.18	61.71	1.63			59.83	1.23	59.97	1.54		

APPENDIX F

FEDERALLY LISTED T&E, CANDIDATE AND SPECIES OF CONCERN

APPENDIX F: T & E SPECIES TABLE

Threatened, endangered, candidate and species of concern known to inhabit the proposed project area were identified through correspondence with the appropriate regional United States Fish and Wildlife Field Office. Responses to these letters included lists broken down by county. These responses and habitat information are summarized in Table F-1.

Table F-1
Federally Listed and Species of Concern

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Fishes			
Ashy darter	*Etheostoma cinereum*	SOC	VA - Scott Habitat: Found in larger rivers and streams of Cumberland and Tennessee River drainages. Prefers such cover as boulders and undercut banks in little or moderate current.
Blackside dace	*Phoxinus cumberlandensis*	T	VA -Lee TN - Campbell, Claiborne, and Scott KY - Bell, Harlan, Knox, Laurel, Letcher, McCreary, Pulaski, Whitley Habitat:Found in approximately 30 separate streams in the Upper Cumberland River system. Inhabits riffles in cool, small (7-15') streams upland streams with moderate flows. Generally associated with undercut banks and large rocks within relatively stable, well-vegetated watersheds with good riparian vegetation. Habitat has been greatly degraded by siltation from surface mining.
Blotchside darter	*Percina burtoni*	SOC	VA - Russell, Scott, Tazwell Habitat: Found in the mountains and uplands of the Cumberland and Tennessee drainages in medium-sized, warm, usually clear streams of moderate gradient. It occupies riffles, runs, and pools with gravel to boulder strewn bottoms lacking major siltation.
Bluestone sculpin	*Cottus sp. 1*	SOC	VA - Tazwell WV - Mercer County
Candy darter	*Etheostoma osburni*	SOC	WV - Nicholas, Webster (Gauley River Basin) Mercer (Bluestone River)
Clinch sculpin	*Cottus sp. 4*	SOC	VA - Tazwell
Crystal darter	*Crystallaria asprella*	SOC	WV - Kanawha. (Elk River) Habitat: Found in the Mississippi River system in moderate to swift rivers over sand, gravel, or rocks. Can occasionally be found in pools. Has been eliminated from much of its range due to canalization and dams.

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Cumberland johnny darter	*Etheostoma nigrum susanae*	C	KY - Harlan, Letcher, McCreary, Whitley TN - Campbell, Scott
Duskytail darter (Dusky darter)	*Etheostoma percnurum*	E	TN - Scott VA - Scott KY - McCreary Habitat: Historically known in the middle reaches of the Cumberland River and upper reaches of the Tennessee River. Insectivore found near the edges of gently flowing, shallow pools, eddy areas, and slow runs; usually in clear water of large creeks and moderately large rivers (33 to 264'). They prefer a heterogeneous mixture of rock sizes from pea gravel, rubble/cobble, slabrock, and bolder substrates. Also often found associated with detritus and sometimes slightly silted substrates.
Eastern sand darter	*Ethoeostoma pellucidum*	SOC	WV - Braxton, Clay, Kanawha (Elk River) Boone. (Big and Little Coal Rivers) Habitat: Found in streams and rivers ranging in size from small creeks to large rivers with a bottom of sand, silt, mud, or gravel. The sandy raceways of large rivers are preferred.
Kanawha minnow	*Phenacobius teretulus*	SOC	WV - Greenbrier, Nicholas, Webster (Gauley River headwater tributaries) Habitat: Occurs in swift, rocky streams of the New River drainage.
Longhead darter	*Percina macrocephala*	SOC	VA - Scott WV - Braxton, Clay, Kanawha, Webster (Elk River) Habitat: Prefers clean, fast, rocky riffles or clear pools in medium-sized, unpolluted streams with moderate current.
Paddlefish	*Polyodon spathuia*	SOC	WV - Kanawha. (Elk and Kanawha Rivers) Habitat: Mississippi River system in large free-flowing rivers rich in zooplankton, but frequents impoundments with access to spawning sites.
Palezone shiner	*Notropis sp*	E	KY - McCreary, Wayne TN - Campbell Habitat: Cumberland and Tennessee River drainages. Found in flowing pools and runs of upland streams that have permanent flow, clean clear water, and substrates of bedrock, cobble, and gravel mixed with clean sand. Food habits are unknown.

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Popeye shiner	*Notropis ariommus*	SOC	VA - Lee, Russell, Scott
Slender chub	*Erimystax cahni* (=*Hybopsis*)	T	VA - Lee, Russell, Scott: **Critical habitat in Lee and Scott** TN - Claiborne, Cumberland, Fentress, Morgan Habitat: Benthic feeder that eats insects and mollusks. Found in moderate to large size (30-125 meter-wide) warm water streams with fine gravel substrates swept clean by moderate to swift currents. Critical habitat includes the Clinch and Powell Rivers.
Snail darter	*Percina tanasi*	T	TN - Marion Habitat: Adults prefer the swifter portions of shoals with clean gravel substrate in cool, low-turbidity water. Historically known near gravel shoals in the main channel of the Little Tennessee River. Juveniles utilized downstream nursery sites located in the Tennessee River (Watts Bar Reservoir headwater). Populations have also been found in S. Chickamauga Creek and Sewee Creek.
Spotfin chub	*Cyprinella monacha* (=*Hybopsis*)	T	VA - Scott: **Critical habitat in Scott** TN - Claiborne, Cumberland, Fentress, Morgan Habitat: Insectivore (mainly Dipterans) found in the Tennessee River Drainage. Prefers moderate to large streams (15-70 meters wide) with good current, clear water, and cool to warm temperatures. These streams have pools frequently alternating with riffles. This species has been found in a variety of substrates but rarely, if ever, from significantly silted substrates.
Spotted darter	*Etheostoma maculatum*	SOC	WV - Braxton, Webster. (Elk River above Sutton Lake) Habitat: This species requires large unpolluted streams, spending most of its time in deep riffles, or pools downstream where a gravel-rubble bottom predominates and the bottom velocity is low.
Tennessee Dace	*Phoxinus tennesseensis*	SOC	VA - Lee
Tippecanoe Darter	*Etheostoma tippecanoe*	SOC	VA - Russell, Scott
Western sand darter	*Ammocrypta clara*	SOC	VA - Lee, Scott Habitat: Found in medium to large rivers in the Ohio River drainage with moderate to slow current over sand. This darter spawns from July through August. It has been found an inch or more below the surface of the sand.

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Yellowfin madtom	*Noturus flavipinnis*	T	VA - Lee, Russell, Scott (Species has not been documented): **Critical habitat in Lee and Scott** TN - Claiborne Habitat: Nocturnal benthic fish that feeds on aquatic insect larvae. Found in warm streams of small to moderate size (8-40 meters wide) streams with moderate gradient and clear water with little siltation. Prefers quiet sections of pools and backwaters.
Amphibian			
Hellbender	*Cryptobranchus alleganiensis*	SOC	WV - Boone, Braxton, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Nicholas, Raleigh, Webster, Wyoming. Habitat: Nocturnal & completely aquatic. Hides under rocks or submerged logs, boulders, snags, and other large loose debris. Found in fast-moving, mid-sized streams and the channels of rivers with clear water. Eats crayfish & snails.
Mammals			
Eastern small-footed bat	*Myotis leibii*	SOC	VA - Dickenson, Lee, Tazwell, Wise WV - Greenbrier Habitat: Found in caves and abandoned mine shafts in the Allegheny Mountains with a possible preference for caves located in hemlock-covered foothills near water. This bat is a solitary hibernator that hibernates closer to cave openings than other bats.
Eastern woodrat	*Neotoma floridana*	SOC	WV - Boone, Braxton, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Nicholas, Raleigh, Webster, Wyoming Habitat: Nocturnal rodent that prefers secluded rock strewn sites in the Appalachian Mountains; usually on mountain tops and valley sides. Under tree canopy, the large rocks and boulders provide caves and a network of subsurface crevices that shelter the rat.
Gray bat	*Myotis grisecens*	E	KY - Carter, Lee, Pulaski, Wayne TN - Anderson, Bledsoe, Campbell, Claiborne, Fentress, Marion, Overton, Sequatchie VA - Lee, Scott Habitat: Food is mainly aquatic insects. In the summer it uses caves located within a km of a river or reservoir. In winter gray bat colonies are found in deep, vertical caves or cave-like habitat.

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Indiana bat	*Myotis sodalis*	E	KY - Bell, Carter, Elliott, Estill, Greenup, Harlan, Jackson, Lee, Letcher, McCreary, Morgan, Pulaski, Rockcastle, Whitley, Wolfe TN - Campbell, .Claiborne, Fentress, Marion. VA - Buchanan, Dickenson, Lee, Russell, Scott, Tazwell, Wise. WV - Boone, Braxton, Clay, Fayette, Greenbrier, Lincoln, Logan, Kanawha, McDowell, Mercer, Mingo,Nicholas, Raleigh, Webster, Wyoming. Habitat: Eats insects. Females and juveniles forage in the airspace near the foliage of riparian and floodplain trees. Males forage the densely wooded area at tree top height. Creeks are apparently not used if riparian trees have been removed. In summer, maternity colonies are mainly found under loose bark or in hollows of trees. A few individuals under bridges & old buildings. Limestone caves are used in winter months. Greenbrier and Mercer counties in WV have caves which serve as hibernacula for the Indiana Bat.
Southeastern big-eared bat	*Corynorhinus rafinesquii*	SOC	WV - Boone, Fayette, Lincoln, Logan, McDowell, Mingo, Nicholas, Raleigh, Wyoming. Habitat: Hibernates in caves in the northern part of its range, but it is often a species of the hollow of trees or buildings in wooded areas. Some populations live in caves or mines all year round. This species emerges late and it feeds mostly on adult months. Breeding occurs in fall or winter and one young per year is produced.
Southern rock vole	*Microtus chrotorrhinus carolinensis*	SOC	WV - Greenbrier, Nicholas, Webster Habitat: Rock voles in WV represent a relict population and they currently exist in small isolated areas of habitat. Therefore, this species is vulnerable to localized extirpation. In the central Appalachians, this vole is primarily a high elevation species, occurring in cool, rocky, boulder-strewn, coniferous, deciduous, and mixed deciduous-coniferous forests. In WV, it has been found in moss-covered rock areas in beech-maple-oak forests, among rock outcrops associated with nearby water in both northern hardwoods and mixed red spruce-northern hardwood forests; in recent red spruce and mixed red spruce clearcuts; and in 100+ year old northern hardwood stands greater than 3,020 feet in elevation.

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Southern water shrew	*Sorex palustris punctulatus*	SOC	WV - Greenbrier, Nicholas, Webster Habitat: Usually associated with high elevation northern hardwood forests with yellow birch, beech, red spruce, red maple, and hemlock trees in the overstory. Dense rhododendron, mountain laurel, and other shrubs are in the understory. This animal is typically found along mountain streams characterized by cut banks, rocks, fallen logs, and abundant moss and leaf litter. Clear, relatively pure water that harbors an abundance of aquatic insects seems to be an essential part of its habitat.
Virginia big-eared bat	*Corynorhinus townsendii virginianus*	E	KY - Estill, Jackson, Lee, Morgan, Rockcastle, Wolfe. VA - Lee, Tazwell Habitat: Eats butterflies, flies, beetles, and mayflies. Utilize caves year-round.
Virginia northern flying squirrel	*Glaucomys sabrinus fuscus*	E	WV - Greenbrier,Webster (with proclamation boundaries of Monongahela National Forest. Habitat: Populations are restricted to isolated areas at higher elevations. Use the transition zone between coniferous and N. hardwood forest. During cooler months, they nest in tree cavities and woodpecker holes. In summer, they construct leaf nests. There is evidence that they sometimes enter burrows in the ground. They are not as aggressive as the southern flying squirrel.

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Avian			
Cerulean warbler	*Cendroica cerulea*	SOC	WV - Boone, Braxton, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Nicholas, Raleigh, Webster, Wyoming. Habitat: Insectivore and Neo-tropical migrant. Concentrated in oak and hickory forests at elevations below 600 meters along the Ohio and Monongahela rivers in WV. Prefers tall, mature trees near river bottoms, along lakes, and river shores, or on river islands. Highly sensitive to forest fragmentation. Studies suggest that a minimum of 700 hectares is needed for viable population.
Invertebrates			
Alabama lamp pearly mussel	*Lampsilis virescens*	E	TN - Anderson, Morgan. Habitat: Sand and gravel substrates of shoals; small to medium-sized rivers.
Anthony's river snail	*Athearnia anthonyi*	E	TN - Anderson, Marion. Habitat: Gravel to large boulder and log substrates; moderate to fast-flowing current; small to large rivers (mostly large).
Aquatic cavesnail	*Holsingeria unthanksensis*	SOC	VA - Lee.
Appalachian monkeyface pearlymussel	*Quadrula sparsa*	E	VA - Lee, Scott Habitat: Clean fast-flowing water in areas that contain relatively firm rubble, gravel, and sand substrate, swept free of silt.
Beartown perlodid stonefly	*Isoperla major*	SOC	VA - Tazwell
Big Cedar Creek millipede	*Brachoria falcifera*	SOC	VA - Russell.
Birdwing pearly mussel	*Conradilla caelata*	E	TN - Anderson, Claiborne. Habitat: Sand and gravel substrate; moderate to fast current; riffles of small to medium rivers. VA - Lee, Russell, Scott, Wise.
Brown supercoil	*Paravitrea septadens*	SOC	VA - Dickenson.
Burkes Garden cave beetle	*Pseudanophthalmus hortulanus*	SOC	VA - Tazwell.

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Cave beetle	*Pseudanophthalmus seclusus*	SOC	VA - Scott.
Cave beetle	*Pseudanophthalmus sp. 4*	SOC	VA - Scott.
Cave beetle	*Pseudanophthalmus sp. 9*	SOC	VA - Russell.
Cave beetle	*Pseudanophthalmus sp. 10*	SOC	VA - Russell.
Cave beetle	*Pseudanophthalmus vicarius*	SOC	VA - Tazwell.
Cave dipluran	*Litocampa sp.* 4	SOC	VA - Scott.
Cave dipluran	*Litocampa sp. 5*	SOC	VA - Tazwell.
Cave lumbriculid worm	*Stylodrilus beattiei*	SOC	VA - Tazwell.
Cave mite	*Rhagidia varia*	SOC	VA - Scott.
Cave pselaphid beetle	*Arianops jeanneli*	SOC	VA - Lee.
Cave pseudo-scorpion	*Kleptochthonius binoculatus*	SOC	VA - Scott.
Cave pseudo-scorpion	*Kleptochthonius gertschi*	SOC	VA - Lee.
Cave pseudo-scorpion	*Kleptochthonius lutzi*	SOC	VA - Lee.
Cave pseudo-scorpion	*Kleptochthonius proximosetus*	SOC	VA - Lee.
Cave pseudo-scorpion	*Kleptochthonius regulus*	SOC	VA - Tazwell.
Cave pseudo-scorpion	*Kleptochthonius similis*	SOC	VA - Lee.
Cave pseudo-scorpion	*Microcreagris valentinei*	SOC	VA - Lee.
Cave spider	*Nesticus paynei*	SOC	VA - Scott.
Cave spider	*Nesticus tennesseensis*	SOC	VA - Tazwell.
Cave springtail	*Oncopodura hubbardi*	SOC	VA - Lee

Common Name	Scientific Name	Status	Distribution
SOC = Species of Concern	T = Threatened	E = Endangered	C = Candidate
Cave springtail	Arrhopalites commorus	SOC	VA - Tazwell
Cave springtail	Arrhopalites carolynae	SOC	VA - Lee
Cave springtail	*Pseudosinella hirsuta*	SOC	VA - Lee.
Cedar millipede	*Brachoria cedra*	SOC	VA - Lee.
Chandler's planarian	*Sphalloplana chandleri*	SOC	VA - Tazwell.
Cherokee clubtail	*Stenogomphus consanguis*	SOC	VA - Scott
Clubshell	*Pleurobema clava*	E	KY - McCreary. WV - Braxton, Clay, Kanawha. (Elk River) Habitat: Medium to large rivers in gravel or mixed gravel and sand.
Cracking pearly mussel	*Hemistena lata*	E	VA - Lee, Russell, Scott KY - McCreary, Wayne. Habitat: Medium to large rivers in mud, sand, or gravel.
Crayfish	*Cambarus veteranus*	SOC	WV - McDowell, Mingo, Raleigh, Wayne,Wyoming.
Cumberland bean pearly mussel (Cumberland bean)	*Villosa trabalis*	E	KY - Jackson, Laurel, McCreary, Pulaski, Rockcastle, Wayne, Whitley. TN - Scott. VA -Russell, Scott, Taz well
Cumberland Cave amphipod	*Stygobromus cumberlandus*	SOC	VA - Lee, Scott, Wise
Cumberlandian combshell	*Epioblasma brevidens*	E	KY - Laurel, McCreary, Pulaski, Wayne. TN - Claiborne, Scott. VA - Lee, Scott.
Cumberland elktoe	*Alasmidonta atropurpurea*	E	KY - Jackson, laurel, McCreary, Rockcastle, Whitley. TN - Fentress, Morgan, Scott.

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Cumberland monkeyface pearlymussel	*Quadrula intermedia*	E	TN - Claiborne, Lincoln, Maury. VA - Lee, Scott Habitat: Clean fast-flowing water in areas that contain relatively firm rubble, gravel, and sand substrate, swept free of silt.
Deceptive cave beetle	*Pseudanophthalmus deceptivus*	SOC	VA - Lee.
Delicate cave beetle	*Pseudanophthalmus delicatus*	SOC	VA - Lee.
Diana fritillary butterfly	*Speyeria diana*	SOC	VA - Buchanan, Dickenson, Lee, Scott, Tazwell, Wise o. WV - Boone, Braxton, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Nicholas, Raleigh, Webster, Wyoming. Habitat: Mainly found in the Appalachian Mountains in moist, well-shaded forests with rich soils. Can be found nectaring along woodland edges and small openings. Larval host plant is woodland violets.
Dromedary pearlymussel	*Dromus dromas*	E	VA - Lee, Scott.
Elktoe mussel	*Alasmidonta marginata*	SOC	WV - Braxton, Clay, Kanawha. (Elk River)
Fanshell mussel	*Cyprogenia stegaria*	E	KY - Boyd, Carter, Greenup, Lawrence, Wayne VA - Scott. WV - Fayette. (Kanawha River) Habitat: Found in medium to large rivers primarily in relatively deep water with moderate current over gravelly substrate.
Fine-rayed pigtoe	*Fusconaia cuneolus*	E	TN - Anderson, Claiborne, Sequatchie. VA - Lee, Russell, Scott, Tazwell, Wise.
Fluted kidneyshell	Ptychobranchus subtentum	C	KY - Jackson, laurel, McCreary, Pulaski, Rockcastle, Whitley. TN - Claiborne. VA - Lee, Russell,Scott, Tazewell, Wise.
Funnel supercoil	*Paravitrea mira*	SOC	VA - Buchanan, Dickenson.

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Greenbrier cavesnail	*Fontigens turritella*	SOC	WV - Greenbrier.
Greenbrier Valley cave beetle	*Pseudanophthalmus fuscus*	SOC	WV - Greenbrier.
Greenbrier Valley cave pseudo-scorpion	*Kleptochthonius henroti*	SOC	WV - Greenbrier.
Ground beetle	*Cyclotrachelus incisus*	SOC	VA - Dickenson.
Green-blossom pearly mussel	*Epioblasma torulosa gubernaculum*	E	VA - Scott. Habitat: Medium to large rivers in gravel riffles.
Green-faced clubtail	Gomphus viridifrons	SOC	VA - Dickenson, Scott, Wise.
Hoffman's xystodesmid millipede	*Brachoria hoffmani*	SOC	VA - Dickenson.
Holsinger's cave spider	*Nesticus holsingeri*	SOC	VA - Lee, Scott, Wise. Habitat: Constant natural air temperature, air flow and humidity
Holsinger's cave beetle	*Pseudanophthalmus holsingeri*	C	VA - Lee. Habitat: Constant natural air temperature, air flow and humidity
Hubricht's cave beetle	*Pseudanophthalmus hubrichti*	SOC	VA - Russell. Habitat: Constant natural air temperature, air flow and humidity
Lee County cave amphipod	Stygobromus leensis	SOC	VA - Lee.
Lee County cave beetle	*Pseudanophthalmus hirsutus*	SOC	VA - Lee. Habitat: Constant natural air temperature, air flow and humidity
Lee County cave isopod	*Lirceus usdagalun*	E	VA - Lee. Habitat: Constant natural air temperature, air flow and humidity
Little Kennedy cave beetle	*Pseudanophthalmus cordicollis*	SOC	VA - Wise. Habitat: Constant natural air temperature, air flow and humidity

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Little-wing pearlymussel	*Pegias fabula*	E	KY - Jackson, Laurel, McCreary, Pulaski, Rockcastle, Wayne. TN - Scott. VA - Lee Russell, Scott, Tazewell
Long-headed cave beetle	*Pseudanophthalmus longiceps*	SOC	VA - Lee. Habitat: Constant natural air temperature, air flow and humidity
Maiden Spring cave beetle	*Pseudanophthalmus virginicus*	SOC	VA - Tazwell. Habitat: Constant natural air temperature, air flow and humidity
Millipede - No common name	*Brachoria dentata*	SOC	VA - Lee.
Millipede - No common name	*Buotus carolinus*	SOC	VA - Tazwell.
Millipede - No common name	*Dixioria fowleri*	SOC	VA - Tazwell.
Millipede - No common name	*Pseudotremia alecto*	SOC	VA - Tazwell.
Millipede - No common name	*Pseudotremia armesi*	SOC	VA - Tazwell.
Millipede - No common name	*Pseudotremia tuberculata*	SOC	VA - Tazwell.
No common name	*Arrhopalites carolynae*	SOC	VA - Lee, Wise.
No common name	*Arrhopalites commorus*	SOC	VA - Lee.
No common name	*Arrhopalites marshall*	SOC	VA - Scott.
No common name	*Arrhopalites pavo*	SOC	VA - Scott.
No common name	*Oncopodura hubbardi*	SOC	VA - Dickenson.

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No common name	*Pseudosinella erehwon*	SOC	VA - Scott.
No common name	*Pseudosinella extra*	SOC	VA - Scott.
No common name	*Typhlogastruta valentini*	SOC	VA - Scott.
Northern riffleshell	*Epioblasma torulosa rangiana*	E	WV - Kanawha. (Elk River) Habitat: Medium to large rivers in gravel riffles.
Ohio river pigtoe	*Pleurobema cardatum*	SOC	VA - Scott.
Overlooked cave beetle	*Pseudanophthalmus praetermissus*	SOC	VA - Scott.
Oyster mussel	*Epioblasma capsaeformis*	E	KY - Laurel, McCreary, Pulaski, Wayne, Whitley. TN - Claiborne, Scott. VA - Lee, Russell, Scott, Tazwell.
Pale lilliput pearly mussle	*Toxolasma cylindrella*	E	TN - Marion.
Pink mucket pearly mussel	*Lampsilis abrupta* (=orbiculata)	E-EX	VA - Scott KY - Green, Greenup, McCraken, Marshall. TN - Hardin, Hawkins, Meigs, Roane, Trousdale. WV - Fayette (Kanawha River), Kanawha (Elk River). Habitat: Lower Mississippi and Ohio Rivers and their larger tributaries in gravel or sand. Medium to large rivers in habitats ranging from silt to boulders, rubble, gravel, and sand substrates.
Powell Valley planarian	*Sphalloplana consimilis*	SOC	VA - Lee.
Powell Valley terrestrial cave isopod	*Amerigoniscus henroti*	SOC	VA - Lee. Habitat: Constant natural air temperature, air flow and humidity
Purple bean	*Villosa perpurpurea*	E	TN - Cumberland, Morgan, Scott. VA - Lee,Russell, Scott, Tazewell

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Purple lilliput	*Toxolasma lividus*	SOC	VA - Russell, Scott. Habitat: Lakes and small streams in gravel.
Pyramid pigtoe	*Pleurobema rubrum*	SOC	VA - Scott.
Rayed bean mussel	*Villosa fabilis*	SOC	WV - Braxton, Clay, Kanawha. (Elk River)
Regal fritillary	*Speyeria idalia*	SOC	VA - Buchanan, Lee, Russell, Tazwell. Habitat: Found in tall prairie and other large grasslands adjacent to marshes, bogs, or wet meadows. May prefer grasslands in higher elevations. Larval host plant is violet.
Ring pink	*Obovaria retusa*	E	KY - Greenup. Habitat: Large rivers in gravel or sand.
Rotund cave beetle	*Pseudanophthalmus rotundatus*	SOC	VA - Lee. Habitat: Constant natural air temperature, air flow and humidity
Rough pigtoe	Pleurobema plenum	E	KY - Warren VA - Scott. TN - Hardin, Trousdale Habitat: Medium to large rivers in sand and gravel substrates.
Rough rabbitsfoot	Quadrula cylindrica strigillata	E	TN - Claiborne, Hancock. VA - Lee, Russell,Scott, Tazewell.
Rove beetle	*Atheta troglophila*	SOC	VA - Lee.
Royal marstonia snail	*Marstonia ogmoraphe*	E	TN - Marion.
Royal syarinid pseudo-scorpion	*Chitrella regina*	SOC	WV - Greenbrier. Habitat: Constant natural air temperature, air flow and humidity. Associated with limestone geology.
Rye cove isopod	Lirceus culveri	SOC	VA - Scott.
Saint Paul cave beetle	*Pseudanophthalmus sanctipauli*	SOC	VA - Rusell, Scott.

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Sequatchie caddisfly	Glyphopsyche sequatchie	C	TN - Marion
Sheepnose	*Plethobasus cyphyus*	SOC	VA - Lee, Russell, Scott.
Shiney pigtoe	*Fusconaia cor*	E	TN - Anderson, Campbell, Claiborne. VA - Lee, Russell, Scott, Wise.
Sidelong supercoil	*Paravitrea ceres*	SOC	WV - Nicholas. Habitat: Constant natural air temperature, air flow and humidity
Silken cave beetle	*Pseudanophthalmus sericus*	SOC	VA - Scott. Habitat: Constant natural air temperature, air flow and humidity
Slabside pearlymussel	*Lexingtonia dolabelloides*	C	VA - Lee, Russell, Scott, Tazewell
Skillet clubtail	*Gomphus ventricosus*	SOC	VA - Scott.
Snuffbox mussel	*Epioblasma triquetra*	SOC	VA - Lee, Scott. WV - Braxton, Clay, Kanawha. (Elk River) Habitat: Medium to large rivers in clear, gravel riffles.
Spectacle case	*Cumberlandia monodonta*	SOC	VA - Russell, Scott, Tazwell.
Spiny riversnail	Io fluvialis	SOC	VA - Lee, Russell, Scott, Tazwell.
Tan riffleshell	*Epioblasma florentina walkeri*	E	KY - Pulaski, Wayne. TN - Scott VA - Russell, Tazwell.
Tennessee clubshell	*Pleurobema oviforme*	SOC	VA - Lee, Russell, Scott, Tazwell.
Tennessee heelsplitter	*Lasmigona holstonia*	SOC	VA - Lee, Russell, Scott, Tazwell, Wise.
Tennessee pigtoe	*Fusconaia barnesiana*	SOC	VA - Lee, Russell, Scott, Tazwell, Wise.
Thomas' cave beetle	*Pseudanophthalmus thomasi*	SOC	VA - Scott. Habitat: Constant natural air temperature, air flow and humidity
White wartyback	Plethobasus cicatricosus	E	TN - Anderson

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Yellow-blossom	*Epioblasma florentina florentina*	E	TN - Claiborne.
Plants			
Vascular Plants			
A bittercress	*Cardamine flagellifera*	SOC	VA - Dickenson.
American hart's tongue fern	*Asplenium americana*	T	TN - Marion. Habitat: Requires deep shade, a continuously high humidity, moist soil, and the presence of dolomitic limestone outcrops with a high magnesium concentration.
Appalachian bugbane	*Cimicifuga rubifolia*	SOC	VA - Lee, Russell, Scott, Tazwell, Wise. Habitat: Moist woods.
Barbara's buttons	*Marshallia grandiflora*	SOC	WV - Nicholas, Webster. Habitat: Perennial plant that blooms from June-July. Grows in crevices of flood-scoured rock shelves and cobble/sand banks of rivers (e. g. , Youghiogheny). The regular flood cycles of the river may be necessary to prevent competing grasses and shrubs from taking over and outcompeting the *Marshallia*.
Bog bluegrass	*Poa paludigena*	SOC	VA - Russell, Scott, Tazwell. Habitat: Small grass found in sphagnum bogs, tamarack swamps, and cold spring heads.
Box huckleberry	*Gaylusscaia brachycera*	SOC	VA - Dickenson. Habitat: Long-lived perennial thought to spread through asexual reproduction by rhizomes. The rhizomes spread very slowly at the rate of about 6" per year. Found on north-facing slopes over acidic shale bedrock.

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Butternut	*Juglans cinera*	SOC	WV - Boone, Braxton, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Nicholas, Raleigh, Webster, Wyoming. Habitat: Shade-intolerant, fast-growing tree characteristic of deep, moist, fertile soils of lower slopes, coves, river banks, and floodplains. Also grows on dry, rocky limestone soils in fewer numbers. Populations are declining because of infection with a fungus that causes trunk and branch cankers and subsequent crown dieback.
Canby's mountain-lover	*Paxistima canbyi*	SOC	VA - Lee, Russell, Scott, Tazwell, Wise. WV - Greenbrier, Mercer. Habitat: Grows on rocky, well-drained upland soils. The branches spread along the ground and sprout where favorable. Flowers in April and May.
Carey saxifrage	*Saxifraga careyana*	SOC	VA - Buchanan, Russell. Habitat: Found in the mountains of WV. Grows on moist rocks and wet spots on rock outcrops and cliffs. Flowers in May and June.
Gray's saxifrage	*Saxifraga caroliniana*	SOC	VA - Russell. WV- Boone, Braxton, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Nicholas, Raleigh, Webster, Wyoming. Habitat: Found in the mountains of WV, VA, NC, and TN. Grows on wet spots in moist rocky woods. Flowers in May and June.
Chaffseed	*Schwalbea americana*	E	KY - McCreary Habitat: Moist to dry pinelands, oak woods or clearings.
Cumberland rosemary	*Conradina verticillata*	T	KY - McCreary. TN - Cumberland, Fentress, Morgan, Scott. Habitat: Grows along rivers in close proximity to the Cumberland Plateau. Always found in close association with the floodplain of watercourses. Prefers open to slightly shaded, moderately deep, well-drained soils, and topographic features that protect the plants from the full force of flooding. Specific areas supporting this species include boulder, sand, and gravel bars, terraces of sand on gradually sloping river banks, and islands.

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Cumberland sandwort	*Arenaria cumberlandensis*	E	KY - McCreary. TN - Fentress, Morgan, Scott. Habitat: Known in a limited portion of the Cumberland Plateau. Restricted to shady, moist rockhouse floors, overhanging ledges, and solution pockets in sandstone rock faces. Needs the correct combination of shade, high moisture, cool temperatures, and high humidity. Flowers in late June to early July.
Eggert's sunflower	*Helanthus eggertii*	T	KY - Jackson. TN - Marion.
Glade spurge	*Euphorbia purpurea*	SOC	VA - Russell, Tazwell. Habitat: Flowers from July to September. Found in rich seepage wetlands and thickets. Sprouts from a short, thick underground stem. Threatened by habitat destruction and water quality degradation.
Green pitcher plant	*Sarracenia oreophila*	E	TN - Cumberland
Long stalked holly	Ilex collina	SOC	VA - Tazwell
Large-flowered skullcap	*Scutellaria montana*	E	TN - Marion, Sequatchie. Habitat: Mint found only at the southern end of the Ridge and Valley Physiographic Province in Georgia and Tennessee. It occurs on dry to slightly moist rock slopes under a canopy of mature (70-200 years old) hardwoods (primarily oaks and hickories). All known sites show little or no disturbance due to logging activities or grazing by livestock.
Ovate catchfly	*Silene ovata*	SOC	VA - Lee. Habitat: Perennial plant found in rich woods. Flowers in August.
Piratebush	*Buckleya distichophylla*	SOC	VA - Tazwell. Habitat: Found in moist woods with hemlocks. May be parasitic on hemlocks.
Price's potato bean	*Apios priceana*	T	TN - Marion. Habitat: Found in woods and thickets. Flowers from July through September.
Running buffalo clover	*Trifolium stoloniferum*	E	KY - Jackson

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Running glade clover	*Trifolium calcaricum*	SOC	VA - Lee, Scott. Habitat: Limestone glades.
Schweinitz's sedge	*Carex schweinitzii*	SOC	VA - Lee, Russell, Scott, Tazwell, Wise. Habitat: Open, calcareous wetlands.
Small whorled pogonia	*Isotria medeoloides*	T	VA - Lee, Wise. WV - Greenbrier. Habitat: Open, dry deciduous woods with acid soil. Flowers from mid-May to mid-June. Does not necessarily flower annually.
Smoke hole bergomot	*Monarda fistulosa ssp. brevis*	SOC	WV - Mercer (Along Bluestone Ridge, Pipestem Gorge)
Sweet pine sap	*Monotropsis odorata*	SOC	VA - Dickenson. Habitat: Forested habitats.
Virginia spiraea	*Spirea virginiana*	T	KY - Laurel, Pulaski, Rockcastle, Whitley TN - Cumberland, Morgan, Scott, Fentress, Sequatchie, VA - Buchanan, Dickenson, Lee, Russell, Scott, Tazwell, Wise WV - Fayette, Nicholas, Mercer, Raleigh, and Greenbrier (Known along the Gauley, Meadow, Bluestone Rivers and Beaver Creek) Habitat: Typically found on rocky, flood-scoured riverbanks in gorges or canyons. Flood scouring is essential to the survival of this plant. Grows best in full sun, but can tolerate some shade. The bedrock surrounding this species is primarily sandstone and the soils are acidic.
White fringeless orchid	*Platanthera integrilabia*	C -Ex C	C-KY - Laurel, McCreary, Pulaski, Rockcastle C-Ex, VA - Lee. C-TN - Cumberland, Fentress, Marion, Sequatchie Habitat: Flowers from July to September. It grows in the wet peaty soils of swamps, bogs, and in pine barrens.

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White-haired goldenrod	*Solidago albopilosa*	T	KY - Wolfe. Habitat: Grows in rock shelters on the upper slopes of the Red River Gorge between 800-1,300 feet mean sea level in elevation. Can occur on any slope aspect, but plants growing in north to northwest exposures are smaller than average. Found almost exclusively in partial shade behind the dripline of rockshelters. Rarely found on rock ledges or in sandy soil along the side of a hiking trail.
Yarrow-leaved ragwort	*Senecio millefolium*	SOC	VA - Lee, Scott. Habitat: Grows on wet or dry rock in the southwest mountains of VA. Flowers from May to early June.