ECOLOGICAL STUDIES OF WETLANDS IN SOUTH PARK, COLORADO: CLASSIFICATION, FUNCTIONAL ANALYSIS, RARE SPECIES INVENTORY, AND THE EFFECTS OF REMOVING IRRIGATION

Report Prepared for:

Park County and U.S. EPA Region VIII

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EXECUTIVE SUMMARY

Fifty three wetlands in South Park were visited in the field for study during the summer of 1990. At each wetland the functions were evaluated and data was collected on the plant communities and water chemistry. The wetland areas surveyed include the largest wetland complexes in South Park and total more than 50,000 acres. Most of these wetlands are natural, occurring along streams and at groundwater discharge sites (large springs). Large wetland areas have also been created by irrigation projects for agricultural purposes.

The wetland vegetation is classified in a hierarchical system which includes forty different community types (associations). Most of the wetland community types are common throughout the West. However, the extreme rich fens, characterized by peat soils and calcium carbonate rich water, appear to be unique to South Park in the Southern Rocky Mountains. One extreme rich fen is documented for northern Montana. Extreme rich fens occur as part or the whole of wetlands number 11, 2, 53, 49, 52, 4, 3, 54, 48 and 43. Five extreme rich fen community types are described. In addition, one other community type characterized by water sedge (Carex aquatilis) and the rare moss Scorpidium scorpioides is most likely unique to South Park. These communities should receive special management to reduce current impacts and eliminate changes of mining or drainage in the future.

Because many plant species occurring in South Park are

thought to be very rare, I documented the presence of these species wherever they occurred in the study area. Most of the rare plants occur in the extreme rich fens discussed above. The rare species documented are: Ptilagrostis porteri, Sisyrinchium pallidum, Salix myrtillifolia, Salix candida, Primula egaliksensis, Packera pauciflora, Kobresia simpliciuscula, and Trichophorum pumilum. The rarest of these species is Salix myrtillifolia which is only know from three populations. Salix candida is known from seven populations, Trichophorum pumilum from 8 populations, and Ptilagrostis porteri from six populations in the study area. The other species listed are known from more than 10 populations, however it should be remembered that while these species may be widespread in South Park, it remains the only known location for them in Colorado. Ptilagrostis porteri (Porter's feathergras) is endemic to South Park (it only occurs there) and by far the largest population occurs at the Michigan Creek Fen. However, this fen has been heavily impacted by mining and most of the world's population of this species could have already been lost. The survival of these species requires intact groundwater flow systems. Any water diversions, or groundwater pumping projects in South Park should be carefully scrutinized to determine their potential effects on these groundwater flow systems.

The most important functions performed by South Park wetlands are groundwater discharge, short-term nutrient retention, within-basin food chain support, wildlife habitat and passive recreation-heritage value as summarized in Table 8. Most wetlands perform a few high quality functions and eight wetlands perform a large number of high quality functions. A key reason for understanding which functions different wetlands perform is that it allows management decisions to be made regarding the types of activities which will not diminish these functions.

Two types of priority wetlands (those with high ecological value) are identified; (1) those which support significant biological communities, and (2) those that are essential for providing water quality functions. In the first category are extreme rich fens and willow dominated stands along streams. In the second category are wetlands where groundwater is being discharged. These wetlands should receive the attention of every planning activity, and land and water management program in the region. A list of priority wetlands is in the report text.

Wetlands have been created in many parts of South Park by the irrigation of uplands. However, to create these dry lands streams have been dewatered. Riparian wetlands, found along streamsides, have been reduced to create irrigated meadows. From the present study it is clear that the streamside wetlands provide greater ecological functions than wet meadows for streambank stabilization, wildlife habitat, fish habitat, nutrient removal and retention and food chain support. Because agricultural production is so vital to South Park's economy it should be considered that the production of hay in wetlands is an important wetland function. However, this use should not preclude or greatly diminish other wetland functions in the region. Stream restoration programs are warranted in many areas where the willow dominated vegetation has been destroyed. In addition, cattle grazing should be reduced or eliminated in the most important parts of the extreme rich fens listed above. In addition, ditches should be filled in wetlands where attempts have been made to drain the wetlands.

Current trends toward municipal purchase of agriculatural water in South Park are causing a shift in water use away from irrigation. Some wetland loss will occur. However, water that is left in the stream could help restore the natural hydrologic regime of the stream channels affected. Several points should be made regarding water use changes. First, water purchased for downstream use should be required to flow in its natural manner down rivers and through wetlands as the water has for thousands of years. No ditching of wetlands should be allowed. Second, the conversion of land from irrigated pasture to dryland by urban water developers must include the full price of land restoration. This must include both riparian and upland restoration.

The South Park wetlands provide one of the most spectacular displays of wildflowers in Colorado each summer. The bistorts, louseworts, gentians and myriad other species occur in profusion in the irrigated and natural meadows throughout the region. In many respects Park County should sell itself as the "wildflower capital of Colorado," and the preservation of wetlands and agricultural land use is essential to retain this beauty.

INTRODUCTION

Wetlands are ecosystems that, at least seasonally, have saturated or flooded soils. Being water dependant they occur in valley bottoms along streams and rivers, adjacent to ponds, lakes and reservoirs, and in sites where ground water occurs close to the soil surface. This includes sites where ground water is discharged from the underlying substrate to the ground surface. Wetland characteristics are determined to a large extent by the hydrologic regime, how long the site is saturated, how deep the water is, along with the chemical characteristics of the water. Land along rivers that frequently flood over their banks can erode and deposit sediment. These areas, called riparian wetlands are fundamentally different than other wetlands that do not have this hydrologic energy, such as those located where a high water table occurs and flooding never occurs.

While it is clear that the hydrologic regime influences the characteristics of the wetland, the wetland can also greatly influence the quality of water and the biological communities that occur in the water. For example, willow and sedge roots stabilize stream banks and lake margins and in many ways create and structure the physical characteristics of streams; for example bank height and stability. In addition, many willow and sedge leaves fall into streams and ponds in autumn and provide an important winter food source for aquatic insects which do much of the growing during the winter. Thus, streamside vegetation not only structures the habitat that aquatic organims live in, but it also feeds these organisms.

Wetlands at groundwater discharge sites create anaerobic (lacking free oxygen) environments which the groundwater must move through. The biological activity of bacteria that live in this anerobic environment results in the biochemical reduction and removal of anions such as nitrates and sulfates from the water column. These anions are pollutants when they occur in abundance. Heavy metals can also be reduced and sequestered by bacterial activity. This water cleansing is a beneficial function that occurs only in wetland environments. This benefit occurs at no cost to the public and results in cleaner water entering streams and lakes.

Even though wetlands are acknowledged as providing essential water quality benefits, wildlife habitat and other ecological functions, very little is known about Colorado's wetlands. Even the most basic knowledge, such as which plant species occur in Colorado's wetlands, is incomplete, as was demonstrated by my research in South Park during 1989 (Cooper 1989, 1991a, 1991b). Many new and interesting plant species are yet to be found. We also do not know what plant communities occur on the landscape or the hydrologic regimes and water chemistry characteristics that support them. Most fundamental questions regarding wetland management cannot be answered because we do not know what types of wetlands occur in different regions of Colorado, nor the ways in which they function.

The current research project was developed to identify and map the distribution of the major wetland complexes in South Park and to collect quantitative data to characterize the flora, plant communities, water chemistry, as well as qualitative data on the ecological functions and values of these wetlands. These data and analyses are important in clarifying where important wetlands occur in South Park, and in answering several basic questions regarding the wetlands of Colorado. Questions needing answers include: how unique is any one wetland in South Park, how unique are the wetlands in South Park, what ecological functions do the wetlands perform, how does current land use affect wetlands, and what land uses are appropriate if ecological functions are to be maintained, restored and enhanced.

The present study was performed primarily with financial support provided by the U.S. Environmental Protection Agency (EPA) Region VIII. The study goal was to identify, map and characterize existing wetlands in South Park and to evaluate their functions. The data from this study could be used by Park County to identify the most valuable wetlands in South Park for the purpose of managing them most appropriately. This management certainly does not mean the curtailment of irrigated agriculture, haying, livestock grazing or other uses, but could help land owners and local governments recognize a number of other functions that are valuable to maintain as well. The data could also be used to develop a wetland management program for South Park.

For purposes of this report, wetlands are defined as:

> "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" (33 C.F.R. Part 328.3(b); C.F.R. S230.3(t) 1986).

While this definition seems complex to the non-scientist it can be explained fairly simply. Wetlands are sites where the hydrologic regime (flooding from a river, high ground water table or other means) saturates soils for at least 10 to 14 continuous days during the growing season of most years. The saturated soils become anaerobic (lacking free oxygen) within 10-14 days because plant roots and microbes, such as bacteria, remove all free oxygen from the soil. Plant roots need oxygen and usually derive this oxygen from the soil. When the free soil oxygen is depleted only plant species (such as cattails and sedges) that have special adaptations for living in anaerobic soil conditions can survive in these sites.

Because wetlands have an abundance of water they are very productive habitats for all forms of wildlife (including plants, insects, birds, mammals and amphibians) and complex food chains are formed. This benefits not only the wildlife, but also people, from a recreational perspective. The anaerobic environment of wetlands supports a suite of geochemical processes that are vital to water quality. In addition, wetlands store water making them vital for flood attenuation and the maintenance of base flow for streams. These benefits are called functions and values. Ecological functions are processes that can be measured and quantified. For example, the number of ducks fledged, pounds of sediment retained, pounds of nitrate reduced, volume of flood water retained, and tons per acre of vegetation production. When quantified the functions of a particular wetland can be compared from wetland to wetland and from upland to wetland. Thus, it is possible to objectively describe wetlands with regard to their functions.

Wetland values are more subjective than functions because they are related to human need, perception and valuation. A wetland that functions to retain floodwater may have high or low value depending upon whether or not structures of human value, such as a city, are located just below that wetland. If a city is located below the wetland, its function may be of great value. If a city is not located below, the value of that wetland function may be lower. Likewise, if a wetland is upstream of a gold medal trout fishery, its function would be of higher value than if it were downstream.

THE STUDY AREA

The study area includes South Park north of U.S. Highway 24, south of Kenosha Pass, east of the forested portions of the Mosquito Range, and west of the forested portion of the Tarryall Mountains (see Figure 1), an area of approximately 700 square miles (450,000 acres or 181,000 hectares). The study area was selected because it is the area with the largest wetland complexes in Park County and is thought to contain the most valuable wetlands. It includes areas managed by man and areas that are susceptible to land use changes initiated by water diversion projects. The study area includes Michigan Creek, Tarryall Creek, the Middle and South Forks of the South Platte River and the tributaries of all these creeks.

The South Park area is unique in Colorado for two reasons; (1) it is the highest elevation intermountain park in Colorado and physiographically is a relatively level plain (the study area ranges between 8,000 and over 10,000 feet elevation), and (2) runoff from the Mosquito Range (which forms the Park's western edge) and provides most of the surface and ground water to South Park. This water flows over and through limestone and dolomite bedrock, glacial outwash and alluvial deposits. The combination of these two factors creates a situation in which abundant carbonate rich waters flow across a relatively large flat region at high elevation.

Glacial outwash deposits of Pleistocene age, formed from the melting of glaciers 15,000 to 18,000 years ago, blanket much of

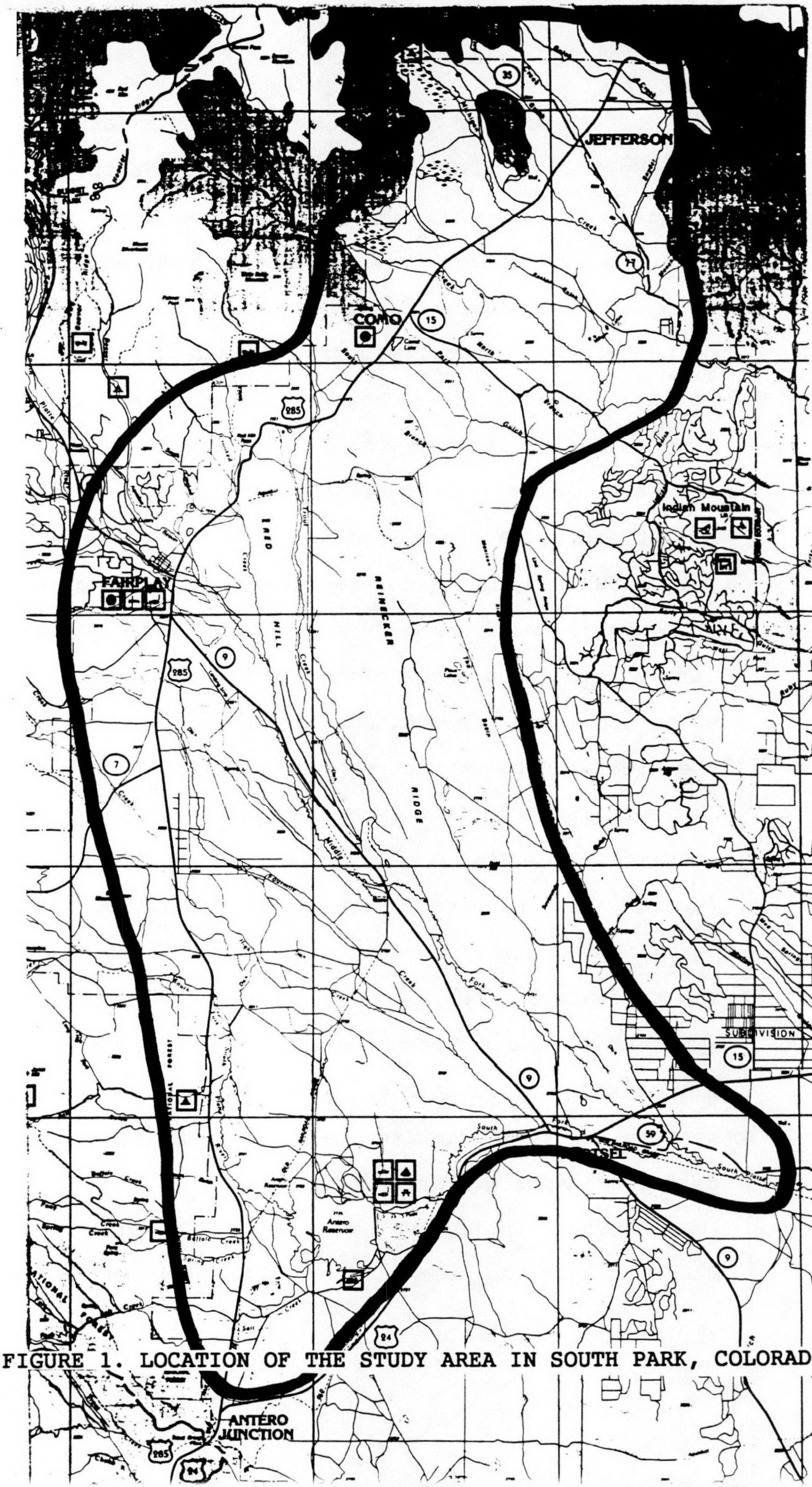


FIGURE 1. LOCATION OF THE STUDY AREA IN SOUTH PARK, COLORADO.

the western side of South Park providing a large body of unconsolidated carbonate rich material. Water flowing from the Mosquito Range reaches South Park and apparently recharges this alluvium and spreads into extensive ground water flow systems and a number of streams. The relatively flat gradient, large volumes of water, cool summer temperatures, which limits evaporation, and extensive ground water creates abundant natural wetlands.

The water chemistry of this region is varied, but in general the water is neutral to basic in reaction, calcium is the leading cation and sulfate the leading anion. Heavy metal pollution is very localized, not widespread (McBride and Cooper 1991). The concentrations of carbonates in ground water varies and most likely is a function of the bedrock composition of the basin the water flows from in addition to the geologic characteristics of the glacial outwash that the water flows through. For example, the relatively small volume, but extensive ground water discharge systems at the High Creek Fen (wetland #53) or Trout Creek Fen (wetland #43) have very high concentrations of calcium (>100 mg/l). By contrast the extensive ground water flow systems at the headwaters of Michigan Creek (wetland #1), Park Gulch (wetland #47) and others discharge larger volumes of relatively dilute water by comparison. These high and low volume flow systems and their distinctive water chemistry support very different types of wetland ecosystems.

Another distinctive aspect of the hydrologic systems in South Park is the presence of north-south trending bedrock ridges, represented by Reinecker Ridge and Red Hill, in the area south of Como. Water flowing eastward from the Mosquito Range enters the plains of South Park, meets the bedrock ridges and is deflected to the south toward Antero Reservoir. From Antero Reservoir, the water is again diverted by geologic constraints and flows east and north. Thus, a long and circuitous flow path is created allowing extensive wetland development.

It should be made clear that two different mountain ranges comprise the western edge of South Park. From Buffalo Peaks north to Hoosier Pass is the Mosquito Range, while from Silver Heels Mountain north toward Gray's Peak is an unnamed spur of the Front Range that I will call the South Park Range. The chemistry of water flowing from these different ranges is not entirely known, but what is known will be discussed later in this report. In general the South Park Range waters are dominated by sulfate anions while the Mosquito Range waters are dominated by bicarbonate anions.

METHODS

Mapping

The base maps used for this study are U.S. Geological Survey topographic maps and orthophotoquads with a scale of 1:24,000. All wetlands studied are mapped on the orthophotoquads (map pocket). Each wetland is numbered with a corresponding field data sheet for that wetland (Appendix 4). Table 1 provides a listing of all the wetlands evaluated and the orthophotoquads that they occur on. Numbers 17 and 36 were not evaluated in the field. Number 17 is a very large and important wetland, but access was denied. Time did not allow 36 to be evaluated.

The goal of field work conducted during the summer of 1990 was to identify on aerial photographs, and then visit in the field, the largest wetland complexes in the study area. Because the study area was so large, it was impossible to visit all the wetlands occurring in the study area. During the site visits the approximate wetland boundaries were delineated on the aerial photographs. The boundaries shown on the photographs are not jurisdictional wetland boundaries.

Wetland Characterization

The major plant communities occurring within each wetland were identified and described in the field using standard phytosociological methods (Mueller-Dombois and Ellenberg 1974) and follow the wetland classification work of Cooper and Cottrell (1990). A plant species list was made for each wetland and the percent coverage for each species within each community was estimated. The percentage of wetland area each community occupied was approximated for most wetlands. Notes and data on the depth to water table and soil characteristics were collected for most communities. Soil colors just below the A Horizon were listed for matrix chroma and mottle colors, where they occurred. Standard soil colors are provided from Munsell Soil Color Charts (Munsell Color, Baltimore, MD). A wetland plant species list (wetland flora) for the study area was developed and is presented in Appendix 3. All vascular plant nomenclature follows Weber (1990).

Functional Evaluation

The following functions were evaluated for each wetland: ground water recharge, ground water discharge, flood storage, shoreline anchoring, sediment trapping, nutrient retention and removal (long and short term), food chain support (downstream and within basin), habitat (fish and wildlife), active recreation, and passive recreation-heritage value. The functional evaluation is based on the national methodology developed to provide a rapid wetland functional evaluation (Adamus and Stockwell 1984) and the more recent revision (Adamus et al. 1987). The goal of this technique is to provide an objective method of evaluating whether a wetland performs any or all of the functions listed above to a high, moderate or low degree.

The national methodology is known to be accurate in predicting which functions are performed by wetlands in the eastern United States and those on the West Coast. This is because the methodology is based primarily on literature from these areas. The methodology apparently is less accurate in other portions of the country, e.g., the Rocky Mountain West, because little information is available from these areas. However, the method does provide a consistent means of evaluating wetlands and the functions they perform.

A shortened method of evaluating the functions performed by wetlands, based on the revised Adamus methodology, was recently developed for use in the Boulder Valley, the Cherry Creek basin and the Telluride area of Colorado (Cooper 1988, Cooper and Cottrell 1989, Cooper and Gilbert 1990). In addition, an overall attempt at developing a new wetland function evaluation method for the Rocky Mountain West is underway (Cooper et al. 1990). This method developed for use in Boulder, Colorado was employed in the present study because it allows rapid evaluation of a large number of wetlands in the field in a fairly short time. All data on wetland vegetation, soils, hydrology, and functions were entered on standardized forms, included in Appendix 4.

Individual wetland communities within each wetland were not separately evaluated for their functions; the entire wetland was given a single ranking. Each wetland function was evaluated on two different scales. The first scale ranks, on a scale of 1 to 5, the intensity with which that function was or could be performed by that wetland in its current condition. A ranking of

1 indicates that function was not being performed and could not be performed by that particular wetland. For example, a Juncus (rush) dominated community that never has standing water would not and could not provide fish habitat. A ranking of 2 indicates that the function was performed to a low degree. A ranking of 3 indicates that the function was performed to a medium or average degree. A ranking of 4 indicates that the function was performed to a high degree. A ranking of 5 indicates that a function was performed to an extremely high degree. For example, a pond built to detain flood waters on an intermittent stream located within an urban area would likely have a ranking of 5 for the flood storage and sediment trapping functions. A wetland that provided habitat for a very rare species or that supports a great diversity of species might also receive a ranking of 5 for habitat.

The second ranking system indicates the confidence level in the 1-5 ranking scale. This ranking system is based on a three letter scale "a", "b", "c". A rank of "c" is given if great uncertainty exists in the degree to which the function was being performed. A ranking of "b" is given if the functional ranking is relatively certain, and "a" is given if the functional ranking is very certain. For example, in ranking the fish habitat function, an "a" is given if fish were observed. This rating does not indicate the quality of the fish habitat. The quality of the habitat for fish is ranked on the 1-5 scale. If, during this investigation, non-native fish were found in a man-made impoundment, the rating for fish habitat function might be 2a. The 2 would denote a low functional value for fish habitat, and the "a" denotes certainty that the habitat does exist. If, however, the same impoundment did not have observed fish populations, the rank for the fish habitat function would be 2c.

Some functions are in conflict with each other. For example, trapping of fine sediment is often incompatible with ground water recharge and ground water discharge because sediment reduces soil permeability. Sediment trapping may also be incompatible with the flood storage and desynchronization function because sediment accumulation reduces the capacity of flood storage basins. Sediment trapping, however, is a virtual prerequisite for the nutrient retention and removal function, because nutrients (e.g., phosphorus) are generally components of sediments. Thus, each wetland must be evaluated for each function separately, and no single general rating for each wetland is applicable. However, some wetlands clearly perform more functions than others, and some wetlands clearly perform certain functions to a higher degree than other wetlands. A wetland performs functions due to its hydrologic, chemical and biological characteristics and its position in the landscape, as may be observed on the data sheets for each wetland (Appendix 4) and in the discussion section of this report. See Appendix 1 for a complete description of each wetland function evaluated in this study.

RESULTS AND DISCUSSION

Wetland Mapping

The orthophotoquads provide a broad view of where wetlands occur in South Park. The tonal quality of the orthophotos is poor and distinguishing vegetation types is not possible. The wetland maps provided should not in any way be considered wetland delineation maps. Instead they identify the major wetland complexes in South Park and are used to show where data was collected for this study (Table 1). Figure 2 is an overview map showing the locations of the study wetlands in South Park.

Wetland mapping in South Park is complicated by the fact that water has been diverted from streams and spread on the landscape for the purpose of growing hay. This has created wetlands in previously dry portions of the landscape and it has dried up other areas that had previously been wetter. Thus, the use of landscape position as an aid to wetland identification is not possible. It should be noted that wetlands created solely by irrigation are not regulated by the Federal Government. However, under current methodology for delineation of jurisdictional wetlands irrigated wetlands have all the characteristics of jurisdictional wetlands.

The most abundant plant species in the dry prairie lands of South Park are fringed sage (*Artemisia frigida*), blue grama grass (*Chondrophylla gracilis*), narrow leaf sedge (*Carex stenophylla* ssp. *eleocharis*), and western wheat grass (*Pascopyrum smithii*). These species are still dominant over large portions of South

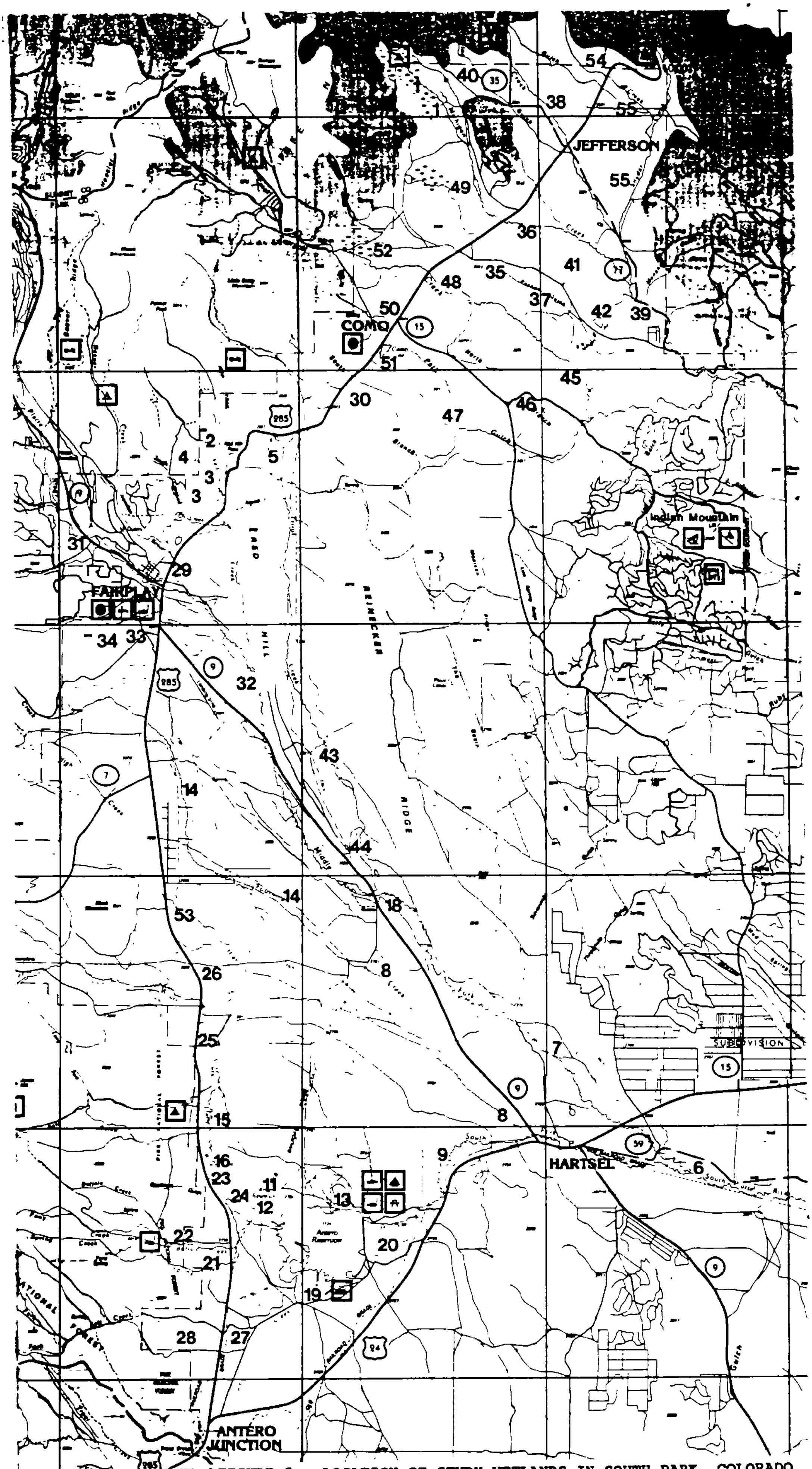


FIGURE 2. LOCATION OF STUDY WETLANDS IN SOUTH PARK, COLORADO

Park as they were in pre-settlement condition when bison roamed the Park. Where upland stands have been flood or sub-irrigated the vegetation composition has changed and arctic rush (*Juncus arcticus*), sedge (*Carex simulata*), silverweed (*Argentina anserina*) and other species have become dominant. These species also dominate naturally occurring wetlands in South Park, yet in many cases it is impossible to determine the natural wetlands from those which have been created totally by irrigation. Many wetlands are obviously natural and occur at groundwater discharge (springs) sites and areas with high water tables. These stands are dominated by water sedge (*Carex aquatilis*), elk sedges (*Kobresia simpliciuscula, K. myosuroides*) and many other species. Wetlands along streams are also natural.

TABLE 1. ORTHOPHOTOQUADS FOR SOUTH PARK WETLANDS.

ORTHOQUAD	WETLAND NUMBERS
Antero Res.	9, 12, 13, 16, 19, 20, 21, 22, 24, 27, 28
Antero Res. NE	9
Boreas Pass	1
Como	2, 3, 4, 5, 30, 50, 51, 52
Fairplay E.	17, 29, 32, 33, 43, 44
Fairplay W.	31, 33, 34
Garo	8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 23, 24, 25, 26, 43, 44, 53
Hartsel	6, 7, 8, 9, 18
Jefferson	1, 38, 40, 54, 55
Milligan Lakes	35, 36, 37, 39, 41, 42, 45, 46, 47, 48, 49, 52, 55

Size of South Park Wetlands

The size of South Park wetlands as mapped on the orthophotos were calculated with a planimeter and are listed in Table 2. Many wetlands are very large due to the combination of flat topography and abundant water. Over 50,000 acres of wetlands are delineated and characterized in South Park. Within this area some small non-wetland inclusions will also occur. In addition, a large number of small wetlands have not been mapped.

TABLE 2. ACREAGE OF STUDY WETLANDS IN SOUTH PARK

Wetland Number	Acreage	Wetland Number	Acreage
1	174	34	65
2	517	35	251
3	183	36	334
4	139	37	383
5	803	38	145
6	1317	39	97
7	3984	40	729
8	4715	41	4276
9	790	42	57
10		43	1172
11	1266	44	21
12	812	45	2163
13	118	46	761
14	1122	47	822
15	795	48	335
16	130	49	2585
18	2293	50	311
19	87	51	52
20	1255	52	2062
21	360	53	1721
22	585	54	2492
23	29	55	279
24	315	TOTAL ACREAGE	51,911
25	2386		
26	608		
27	534		
28	555		
29	230		
30	1010		
31	852		
32	1066		
33	1768		

Types of Wetlands Occurring in South Park

At each wetland visited the major plant communities were identified and sampled to quantify plant species composition and the canopy coverage of each species. Data was collected in 262 stands (the area sampled within each community is called a stand) and a classification of the vegetation developed. The classification describes the different types of wetland communities occurring in the study area and it is hierarchical, meaning that it contains more than one level, and each level branches from the one above. The classification includes 7 classes, 8 orders, 15 alliances and 40 associations according to the Braun-Blanquet system of vegetation classification (Westhoff and Maarel 1978). The first classification of this type for Colorado wetlands was presented by Cooper and Cottrell (1990) and I am following that model.

The highest level in the classification is the class which includes the major vegetation types in a region. The vegetation classes occurring in South Park wetlands are:

1. Rooted aquatics in pools with mud bottoms, these being small pools in spring-fed wetlands;

2. Rooted aquatic vegetation of slow streams and ponds;

3. Reed swamps, which are communities in standing water dominated by tall reeds such as cattail, bulrush or large sedges;

4. Salt marshes and salt flats, which are most common in the area near Antero Reservoir and are flats that usually support sparse vegetation dominated by a few halophytes (salt plants);

5. Meadows are seasonally wet, have mineral, not peat soils and are dominated by grasses, rushes, sedges and shrub cinquefoil;

6. Mires, are peatlands (fens) dominated by sedges, spikerushes and willows;

7. Forests and shrublands along floodplains of low elevation streams. Woody vegetation of cottonwood trees and sandbar willow usually dominates these ecosystems.

8. Shrublands along streams in the mountains. Dominated by tall to mid height shrubs along fast moving or beaver dammed sections of streams.

Within each of these eight classes are three subsequent levels of classification; order, alliance and association (community type). A summary of the complete classification is in Table 3.

All levels in a classification are synthetic, meaning that they are conceptualized from a number of different stands. An association is a synthesis of all stands that have similar floristic composition and similar canopy coverage by the dominant and characteristic plant species. For example, stands dominated by planeleaf willow (Salix planifolia) with an understory dominated by water sedge (Carex aquatilis) occurs in a number of different wetlands in South Park. These stands are so similar to each other in their floristic composition and the habitat occupied that I describe all of these stands as being of the planeleaf willow (Salix planifolia) - water sedge (Carex aquatilis) association.

Another closely related planeleaf willow dominated association also occurs in South Park but on considerably drier sites. Planeleaf willow dominates the overstory while the understory is dominated by canada reedgrass (Calamagrostis canadensis). I call this the planeleaf willow - canada reedgrass association. The flora, hydrologic regime, soil environment and water chemistry of these two associations is distinct from each other, however these two associations are linked by their dominance by planeleaf willow. These two associations are placed together into a single alliance, the planeleaf willow alliance. This alliance is related to another alliance, the water sedge (Carex aquatilis) - elephantella (Pedicularis groenlandica) alliance, which includes other peatlands with similar water chemistry, but dominated by sedges, not willows. These two alliances are combined into one order, the water sedge (Carex aquatilis) - elephantella (Pedicularis groenlandica) order, which includes all the rich fens. Another order of fens also occurs in South Park, but these fens are extreme rich fens, with extremely carbonate rich water. This order of rich fens is named the elk sedge (Kobresia simpliciuscula) - little bulrush (Trichophorum pumilum) order. This order along with the water sedge - elephantella order are combined into the highest level of organization in this classification, a class. This class is named the water sedge (Carex aquatilis) - elephantella (Pedicularis groenlandica) class, and includes all the peatlands of South Park and the entire Southern Rocky Mountain region.

The vegetation of the study area could be used at any level within this hierchical classification that is pertinent to the user. For example, a peat miner might view all peatlands of South Park as the same. This would be an observation at the class level. Park County officials might want to know that there are differences within South Park peatlands; particularly whether the types of peatlands in South Park occur throughout the Southern Rocky Mountains or whether there are types that are unique to Park County. These observations would be at the order level with the rich fens occurring throughout the Rocky Mountains, while the extreme rich fens are unique to South Park. Members of the Colorado Native Plant Society, the Nature Conservancy, State of Colorado Natural Areas Program, or academic botanists and ecologists could see the vegetation more definitively, probably at the alliance and association level. A hierarchical classification creates the flexibility for different users to view the vegetation at any level of detail that they choose.

A summary of the classification is presented in Table 3, and a complete description of each class, order, alliance and association is presented in Appendix 2. In addition, the raw data in completed tabular form for each association, order, alliance and class is presented in Map Pocket 2.

Table 3. Summary of the South Park Wetland Classification.

1. ROOTED AQUATICS IN MUD BOTTOMED POOLS **Class** *Utricularia vulgaris*
   1. **Order** *Utricularia vulgaris*
      1. **Alliance** *Utricularia vulgaris*
         1. **Association** *Utricularia vulgaris*
2. ROOTED AQUATICS IN SLOW STREAMS AND PONDS **Class** *Potamogeton pectinatus*
   2. **Order** *Potamogeton pectinatus*
      2. **Alliance** *Potamogeton pectinatus*
         2. **Association** *Potamogeton pectinatus*
         3. **Association** *Sparganium angustifolium*
         4. **Association** *Ceratophyllum demersum*
         5. **Association** *Hippuris vulgaris*

3. REED SWAMPS **Class** *Schoenoplectus lacustris - Sagittaria cuneata*
   3. **Order** *Schoenoplectus lacustris - Sagittaria cuneata*(Reed Swamps)
      3. **Alliance** *Schoenoplectus lacustris - Sagittaria cuneata* (Tall reed swamps)
         6. **Association** *Schoenoplectus lacustris ssp. creber*
         7. **Association** *Eleocharis palustris*
         8. **Association** *Beckmannia szygachne*
      4. **Alliance** *Carex utriculata* (Large sedge swamps)
         9. **Association** *Carex utriculata*
      5. **Alliance** *Bobloschoenus maritimus* (Brackish water reed beds)
         10. **Association** *Bolboschoenus maritimus*

4. INLAND SALT MARSHES AND FLATS **Class** *Puccinellia airoides - Triglochin maritimum*
   4. **Order** *Puccinellia airoides - Triglochin maritimum*
      6. **Alliance** *Triglochin maritimum* (Saltmarsh swards)
         11. **Association** *Distichlis stricta*
         12. **Association** *Puccinellia airoides*
         13. **Association** *Sporobolus airoides*
         14. **Association** *Amphiscirpus nevadensis*
         15. **Association** *Hordeum jubatum*
         16. **Association** *Agropyron smithii*
         17. **Association** *Triglochin maritimum*
         18. **Association** *Glaux maritimum*
      7. **Alliance** *Suaeda depressa* (Mud flats dominated by annuals)
         19. **Association** *Suaeda depressa*
         20. **Association** *Salicornia europa*

5. MEADOWS. **Class** *Juncus arcticus - Deschampsia cespitosa*
   5. **Order** *Juncus arcticus - Deschampsia cespitosa* (Meadows)
      8. **Alliance** *Juncus arcticus-Deschampsia cespitosa* (wiregrass meadows)
         21. **Association** *Deschampsia cespitosa -*
         22. **Association** *Juncus arcticus - Poa pratensis*
         23. **Association** *Muhlenbergia richardsonis -*
         24. **Association** *Salix brachycarpa -*
      9. **Alliance** *Pentaphylloides floribunda* (Shrubby cinquefoil meadows)
         25. **Association** *Pentaphylloides floribunda -*
      10. **Alliance** *Carex nebraskensis* (nebraska sedge meadows)
         26. **Association** *Carex nebraskensis*
         27. **Association** *Carex lanuginosa*

6. MIRES (FENS or PEATLANDS). **Class** *Carex aquatilis - Pedicularis groenlandica*
   6. **Order** *Carex aquatilis - Pedicularis groenlandica* (Rich fens)
      11. **Alliance** *Carex aquatilis - Pedicularis groenlandica* (Rich fens)
         28. **Association** *Carex aquatilis - Drepanocladus aduncus*
         29. **Association** *Carex simulata -*
         30. **Association** *Eleocharis quinqueflora - Pedicularis groenlandica*

31. **Association** Triglochin maritimum -
12. **Alliance** *Salix planifolia - Carex aquatilis* (planeleaf willow carrs)
32. **Association** *Salix planifolia-Carex aquatilis*
33. **Association** *Salix planifolia - Calamagrostis canadensis*
7. **Order** *Kobresia simpliciuscula - Trichophorum pumilum* (Extreme Rich Fens)
13. **Alliance** *Kobresia simpliciuscula - Trichophorum pumilum* (Extreme Rich Fens)
34. **Association** *Kobresia simpliciuscula - Trichophorum pumilum*
35. **Association** *Kobresia myosuroides - Ptilagrostis porteri*
36. **Association** *Carex scirpoidea*
37. **Association** *Juncus alpinus*
38. **Association** Trichlochin maritimum - Salix candida

7. FORESTS AND SHRUBLANDS ON LOW ELEVATION FLOODPLAINS. **Class** *Populus deltoides - Clematis ligusticifolia* (Low elevation floodplains forests and shrublands)
8. **Order** *Populus deltoides - Clematis ligusticifolia*
14. **Alliance** *Salix exigua - Poa pratensis*
39. **Association** *Salix exigua - Poa pratensis*

8. SHRUBLANDS ALONG STREAMS IN THE MOUNTAINS. **Class** Salix monticola - Calamagrostis canadensis (Tall willow carrs in the mountains)
9. **Order** *Salix monticola - Calamagrostis canadensis*
15. **Alliance** *Salix monticola - Calamagrostis canadensis*
40. **Association** *Salix monticola-Calamagrostis canadensis*
41. **Association** *Salix monticola - Carex aquatilis*

The Flora of South Park's Wetlands

The flora was studied and documented in all 53 wetlands visited during 1990. A total of 224 vascular plant species were found in these wetlands and collections of key species were made. Because many plant species that are thought to be rare occur in South Park complete collections and documentation of the ranges of these species were made to help determine how rare they are. With several notable exceptions the populations of rare plants are sizable in South Park, and many are in no immediate danger. It should be kept in mind that even though these species are common in South Park, they are not known from other areas. However, many species are known from only a few populations. Maps showing the distribution of rare species in South Park are provided in Figures 3 through 8. Specimens collected during this study are in the Herbarium at the University of Colorado, Boulder. The entire flora identified in the wetlands visited is listed in Appendix 3.

Because the study area is so large, floristic differences across the region are apparent. The region of the South Fork of the South Platte River in the area of Antero Reservoir is the most alkaline part of the study area. Several features in this area are notable including; the presence of a pond just north of Antero Reservoir fed by springs whose water has greater than 5% salt and is said to be so salty that it never freezes in winter; Salt Creek flows into the southwestern portion of Antero Reservoir and has an electrical conductance of 6,800 $mmhos/cm^2$

which would classify it as brackish water (Cowardin et al. 1979); the flats around Antero Reservoir have water with conductance greater than 50,000 umhos/cm^2 (greater than seawater); Salt Spring flows from a bedrock outcrop just below U.S. 285 west of Antero Reservoir and some of the springs have an electrical conductance of up to 26,000 mmhos/cm^2 which would classify it as polysaline; numerous other small salty springs erupt in many portions of this area. All water in this area has high conductance and salinity. The water table is also very close to the soil surface throughout much of this area creating soils that are seasonally saturated. When the water table drops in mid summer salt crusts develop on the soil surface. The salty and wet conditions greatly limit the flora to a small handful of species which are both halophytes (salt loving plants) and hydrophytes (water loving plants). The most abundant species are Glaux maritimum, Triglochin maritimum, Puccinellia airoides, Hordeum jubatum, Distyclis stricta, Pascopyrum (Agropyron) smithii, Suaeda depressa, Salicornia europa, Spartina gracilis, and Amphiscirpus nevadensis. Several plant species are known to occur almost exclusively from this area of Colorado, including Thalungiella salsuginea, Halimolobus virgata and Phlox kelseyi.

The areas where rivers and creeks exit the mountains are floristically distinct because the vegetation is dominated by willow (Salix spp.) dominated communities. From my research this summer it is clear that the major streams in South Park all had willows along their entire course prior to agricultural conversion. The willows were either removed or they have been grazed and trampled so heavily by livestock that they were killed. This can easily be seen along Tarryall, Michigan and Jefferson Creeks and the Middle Fork of the South Platte River. It is doubtful that the South Fork of the South Platte River had willows along its course downstream of where it turns east near the present day Antero Reservoir. This section may have always been too alkaline to support willows.

Extreme rich fens, which are only known to occur in the South Park region of Colorado have the most unique flora of any wetlands in Colorado. They are constantly saturated and typically have pools and hummocks among the springs. The pools support bladderworts (*Utricularia vulgaris* and *U. ochroleuca*) and other aquatics. The water tracks below springs are populated by *Triglochin maritimum*, *Eleocharis quinqueflora*, *Carex microglochin* and other species. The hummocks are the most unique feature. Their tops are always characterized by *Kobresia simpliciuscula* and in many areas are populated as well by *Trichophorum pumilum*, *Kobresia myosuroides*, *Ptilagrostis porteri*, *Carex microglochin*, *Carex dioica*, *Carex scirpoidea*, *Packera pauciflora*, *Primula egaliksensis*, *Salix myrtillifolia*, *Salix candida*, and other species.

As seen from this list, most of South Parks rare wetlands flora is limited to, or most abundant in, extreme rich fens. Ten extreme rich fens were found in South Park. The fens at Trout Creek Ranch (wetland #43), Tarryall Creek east of U.S. 285

(wetland #48), springs north of the Silver Heels Ranch on Ebel's property (wetland #2), a spring near the northeastern corner of Albert Wahl's Ranch at the base of Kenosha Pass (wetland #54), and the eastern spring on the Silver Heels Ranch (wetland #3) near the southern base of Red Hill Pass, are quite small covering only a few acres each at most. The extreme rich fens at the head of Tarryall Creek (wetland #52), Michigan Creek just west of U.S. 285 (wetland #49), the spring system on the west side of the Silver Heels Ranch (wetland #4), High Creek (wetland #53) and Antero Reservoir (wetland #11) are all large and spectacular peatlands covering many acres. High Creek is the best preserved and richest of these fens, but all five fens deserve the utmost protection. It is possible that a few more extreme rich fens may occur in South Park that were not found during this study. The extreme rich fens occur in a band along the western side of South Park, and most are fairly close to U.S. 285 as will be seen in the discussion of the plant species _Kobresia simpliciuscula_ that follows.

The Rare Plants

The South Park rare plant species each require a discussion of how rare they really are. That discussion is presented here.

Porter's feathergrass (_Ptilagrostis porteri_) is endemic (known only from) the region of South Park. The location of populations found during this study is shown in Figure 3. Populations are also known from Geneva Park northwest of Grant, East Lost Park in the Tarryall Mountains and several of the creeks draining east from the Mosquito Range. Thus, all known populations are in the northern end of South Park extending as far south and west as Fourmile and Sacramento Creeks west of Fairplay, as far east as East Lost Park in the Tarryall Mountains and north to Geneva Park. The main populations of this species are in the extreme rich fens at the headwaters of Michigan and Tarryall Creeks. The plants always occur on peat hummocks and are usually found with Kobresia myosuroides and/or Kobresia simpliciuscula. The population at Michigan Creek is particularly noteworthy for the very large number of plants and the density of plants. It may contain as many plants as all other sites combined. However, portions of this area has been subjected to peat extraction at the Universal Mine (Cooper 1990) and much of the population could already have been lost. This plant is endemic to the South Park region of Colorado and is known from a total of approximately 12 populations, many of which were found for the first time during this study. It is in need of protection since many populations are threatened by peat mining.

Little bulrush (Trichophorum pumilum) was found in seven locations during this study as shown in Figure 3. All of these locations are extreme rich fens, with calcareous ground water being discharged to the surface. The species occurs only on peat hummocks, and always occurs with the elk sedge, Kobresia simpliciuscula. Other species that commonly occur with it are Thalictrum alpinum, Carex scirpoidea, C. dioica, C. capillaris

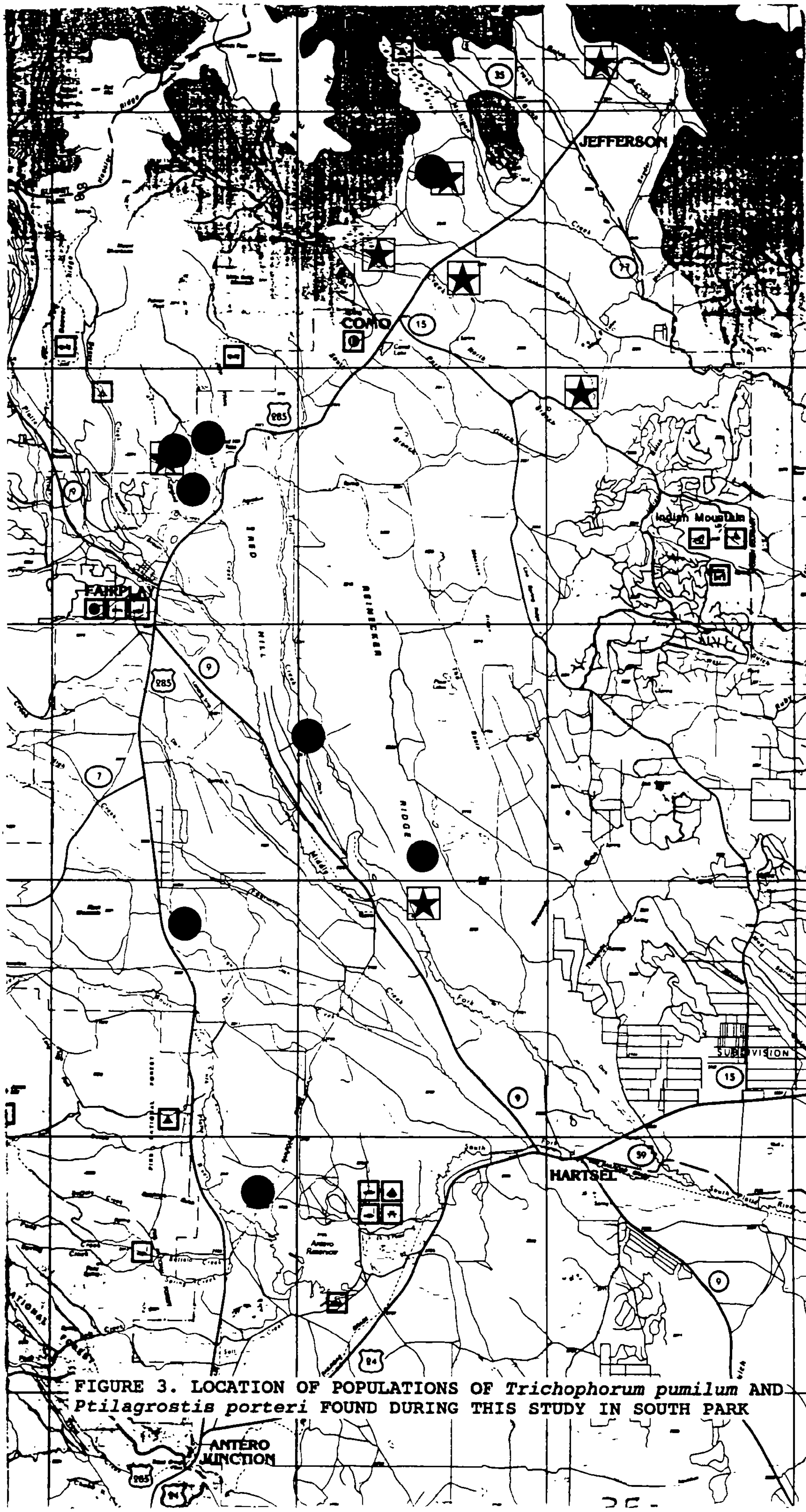


FIGURE 3. LOCATION OF POPULATIONS OF *Trichophorum pumilum* AND *Ptilagrostis porteri* FOUND DURING THIS STUDY IN SOUTH PARK

and others. Only one other population of this species, that is not documented on Figure 3 is known from Colorado, that being in the Four Mile Creek drainage. This species is in need of protection, particularly the populations at the Antero Reservoir (wetland #11) and Trout Creek (wetland #43) fens which are very heavily impacted by cattle grazing and could easily be lost. The plants from Trout Creek fen are much larger than the other populations, while the density of plants on peat hummocks at Antero Reservoir and Trout Creek is quite spectacular.

Pale blue-eyed grass (Sisyrinchium pallidum) was first described from specimens collected in South Park and most populations of this species occur in South Park. It is a Southern Rocky Mountain endemic. The distribution of the populations found during the present study is shown in Figure 4 and indicates that it occurs throughout South Park in alkaline wet meadows, particularly those dominated by Juncus arcticus. Jennings (1991) reports on finding populations of this species in South Park and also documents collections of this species from outside South Park. This species is easy to miss in the field unless it is flowering. Although it has a limited distribution, it is present in many South Park wetlands. However, its distribution could be severely reduced as dewatering of wetlands occurs in South Park.

Many of the other rare South Park plant species are mountain plants whose main range is in wetlands of boreal and arctic Canada and Alaska.

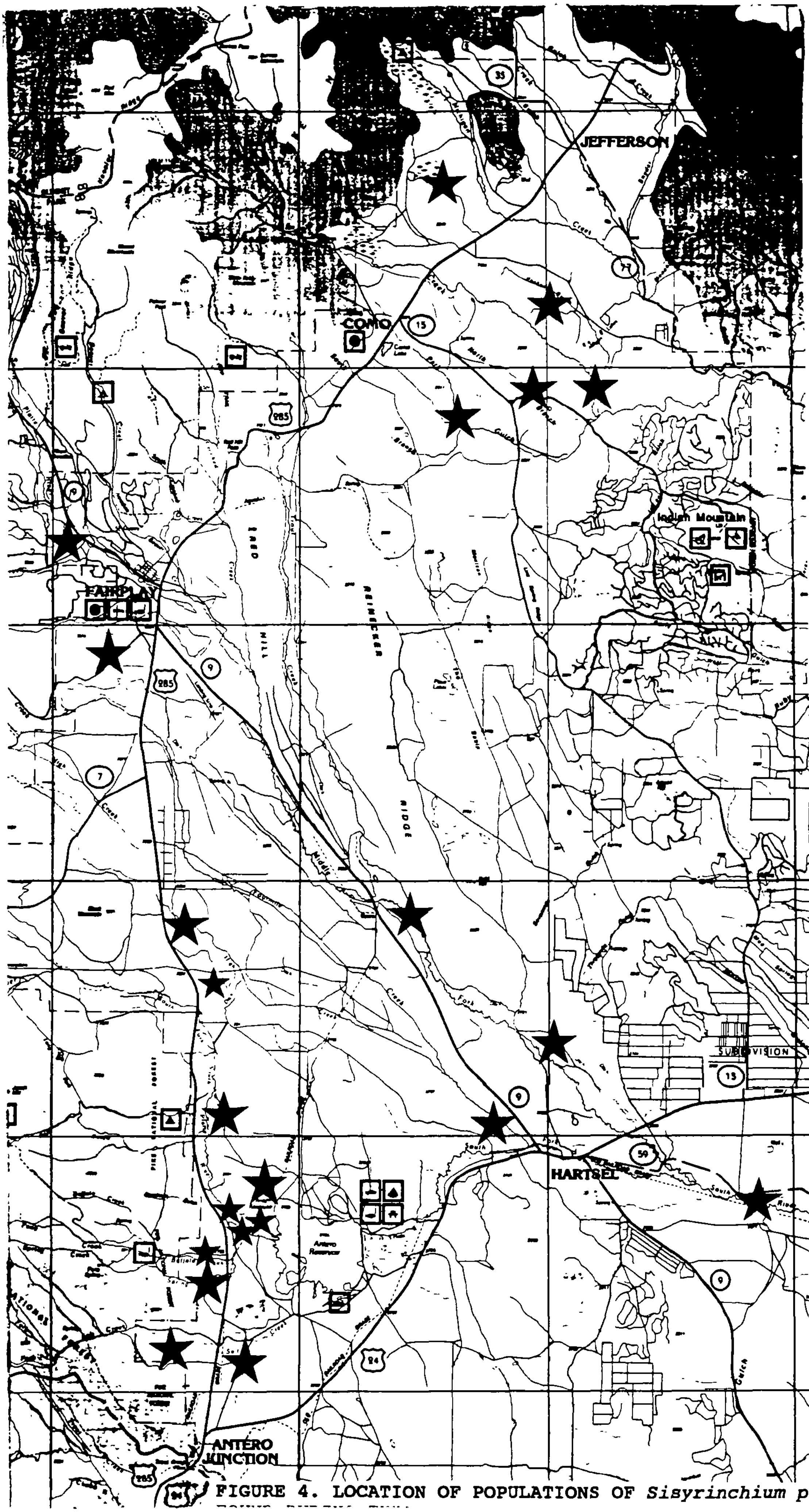


FIGURE 4. LOCATION OF POPULATIONS OF *Sisyrinchium pallidu*

The only known populations of myrtle-leaf willow (Salix myrtillifolia) in the United States are in South Park (Cooper 1991b) and its complete distribution is first documented in this report (Figure 5). Two populations are known; High Creek fen (wetland #53) and Antero Reservoir fen (wetland #11). All two fens are extraordinary sites deserving of the utmost protection. Salix myrtillifolia was not previously thought to have had populations south of the continental glaciers during the Pleistocene, since no populations were known from the U.S. (Dorn 1975). However, I think that this species, with its high calcium carbonate requirements, has been present, but with a very restricted range south of Canada. As with many other mountain and boreal species most Rocky Mountain populations were probably lost during the Hypsithermal Period (a very dry and warm period that occurred from approximately 3,000 to 6,000 years ago) when many wetlands disappeared throughout the Rocky Mountains. Populations of Salix myrtillifolia survive today only in the three sites with very strong and constant springs and very calcareous ground water. This species is by far the rarest of the rare plants in South Park and is absolutely in need of protection.

Hoary willow (Salix candida) has its main Colorado populations in South Park, but it was not known to occur in South Park until 1989 (Cooper 1990). Seven populations of the plant are known in South Park from the present study and are shown in Figure 5 (wetlands # 53, 11, 52, 2, 4, 43, 55). In addition,

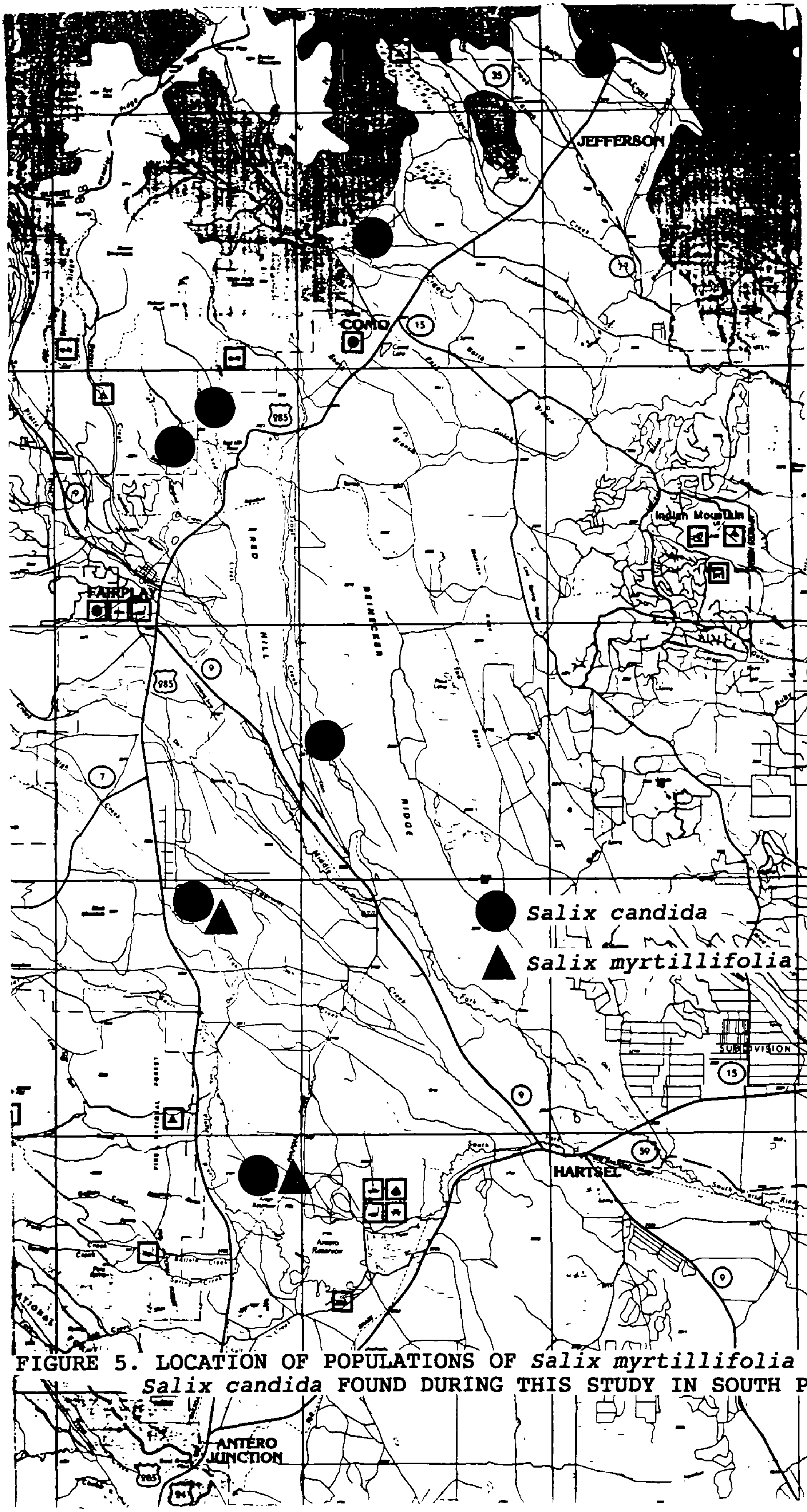


FIGURE 5. LOCATION OF POPULATIONS OF *Salix myrtillifolia* AND *Salix candida* FOUND DURING THIS STUDY IN SOUTH PARK.

during the summer of 1990 I found a population of this species in Geneva Park on the south side of Guanella Pass. The species occurs only in extreme rich fens and is in need of protection.

The species that best indicates the location of extreme rich fens is elk sedge, Kobresia simpliciuscula. It dominates the tops of peat hummocks that only occur in fens fed by a constant supply of carbonate rich ground water and is characteristic of all fens of this type seen in South Park. The distribution of the 10 known populations of this species, and thus of the 10 extreme rich fens known from South Park, is shown in Figure 6.

The populations of Greenland primrose, Primula egaliksensis, found during the course of this field study are shown in Figure 7. The plant is present, along with Primula incana in many of the alkaline wet meadows and peatlands in South Park, and was found from Antero Reservoir north to Jefferson. While it is not rare in South Park, this is the only place where the species is known to occur in Colorado. The only other location in the lower 48 states is from northwestern Wyoming (Dorn 1988).

Packera (Senecio) pauciflora, which was not known to occur in Colorado until 1989 (Cooper 1990), occurs through most of South Park. It is particularly common in the southern, more alkaline portion of the Park as is shown in Figure 8. This species is known from throughout boreal North America with its closest known population in northern Wyoming.

The wetlands that each rare species were found in during the summer of 1990 are listed in Table 4. The collection number for

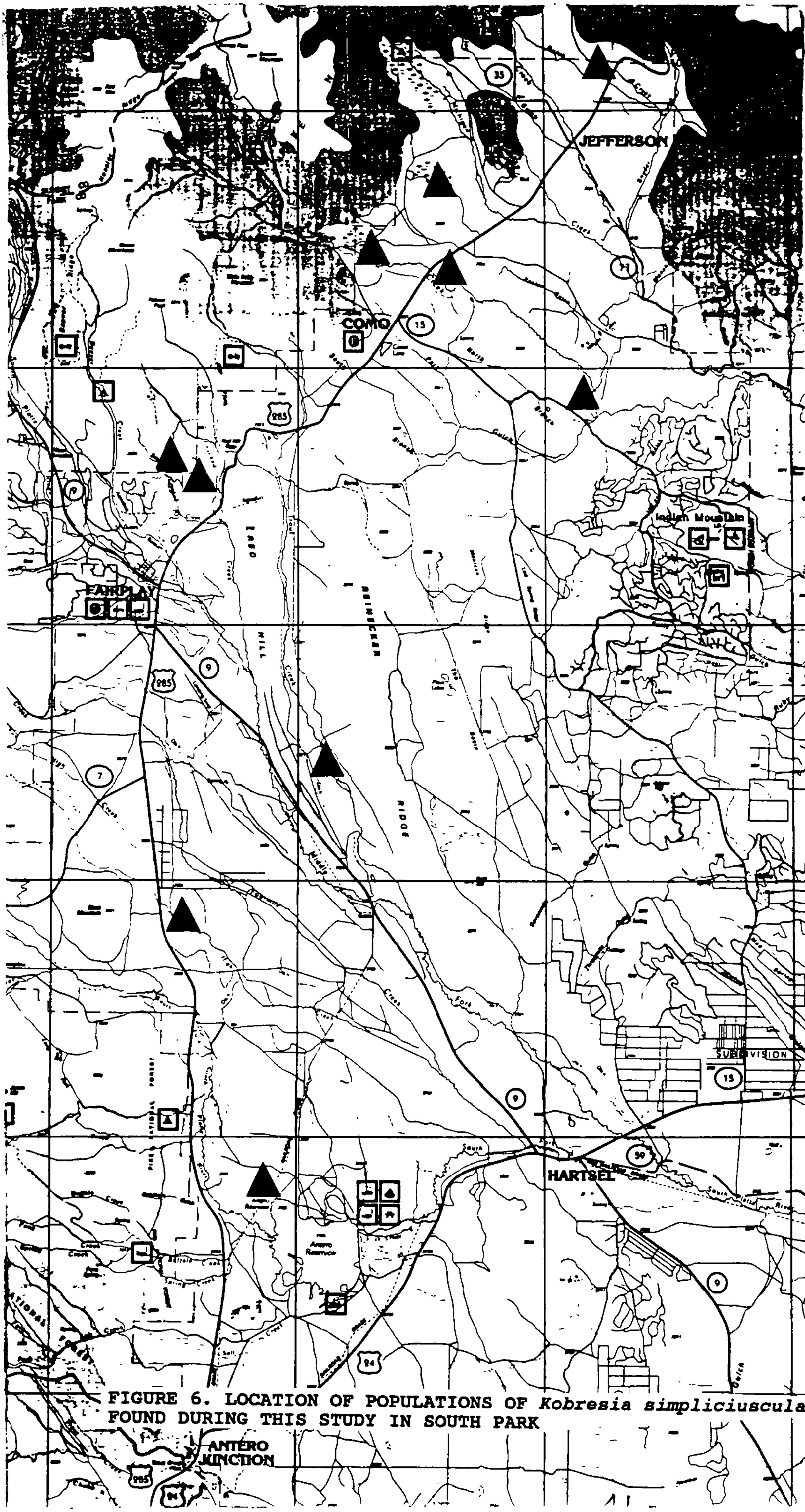


FIGURE 6. LOCATION OF POPULATIONS OF *Kobresia simpliciuscula* FOUND DURING THIS STUDY IN SOUTH PARK

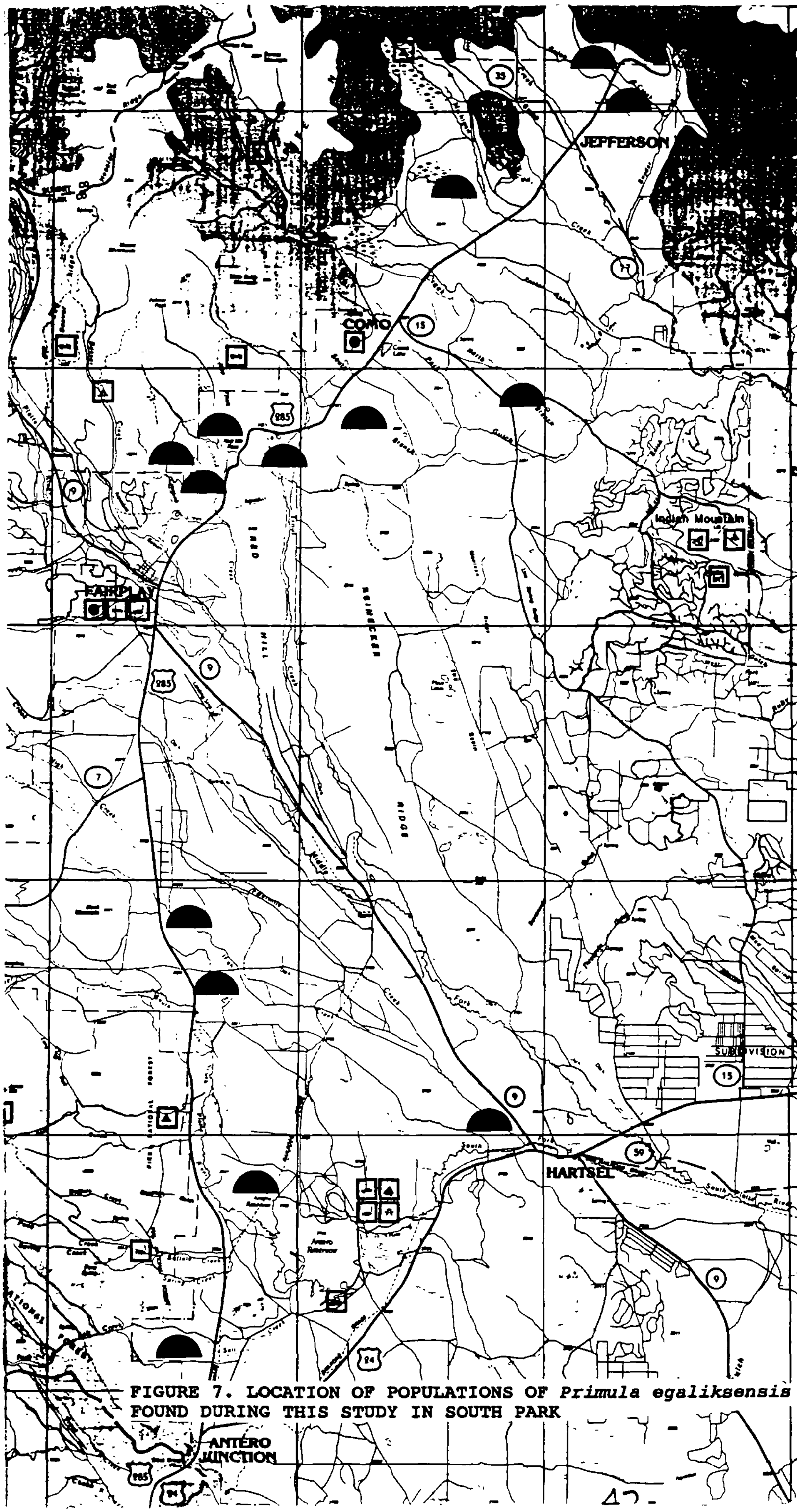


FIGURE 7. LOCATION OF POPULATIONS OF *Primula egaliksensis* FOUND DURING THIS STUDY IN SOUTH PARK

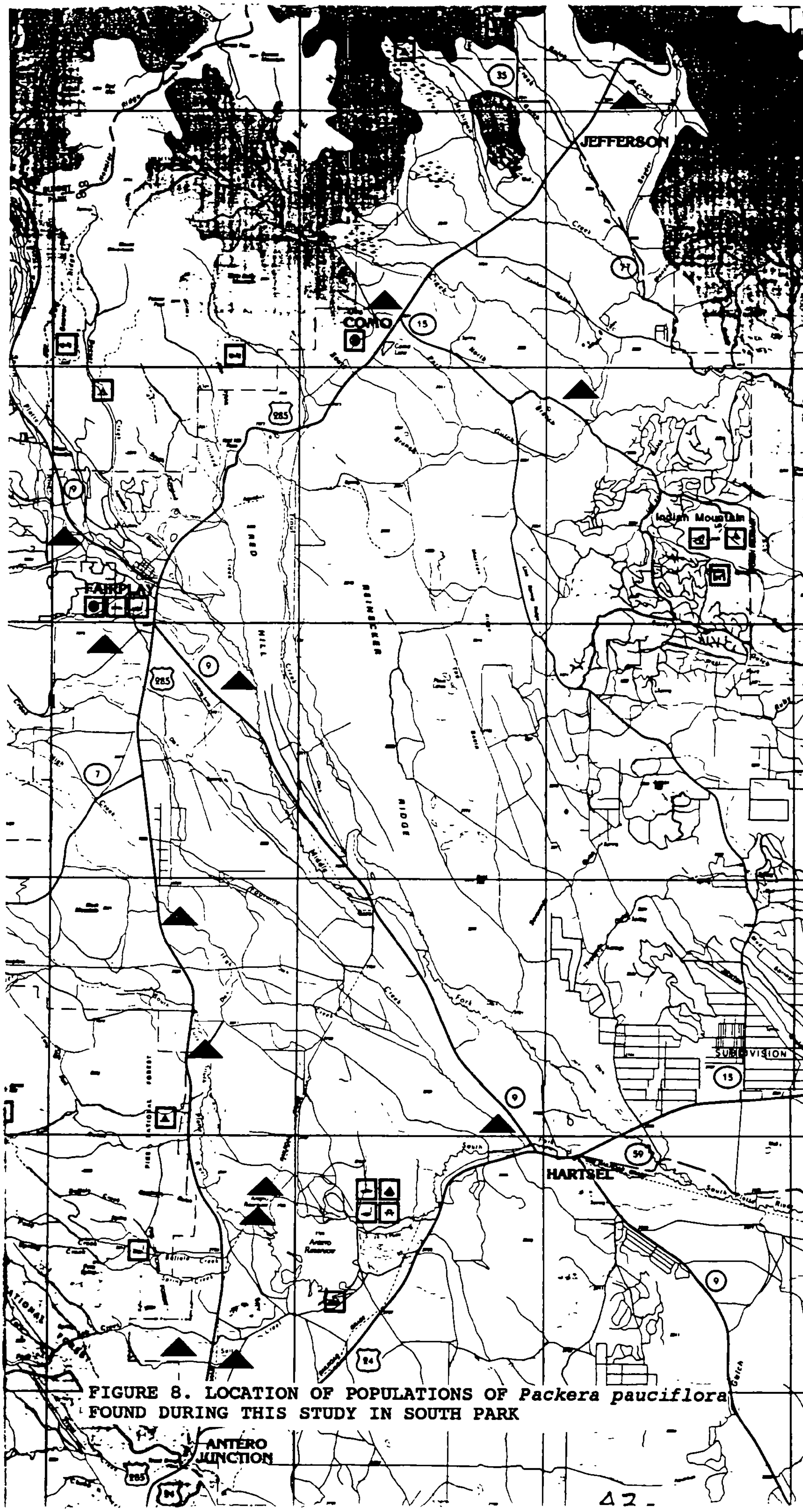


FIGURE 8. LOCATION OF POPULATIONS OF *Packera pauciflora* FOUND DURING THIS STUDY IN SOUTH PARK

specimens deposited in the University of Colorado, Boulder herbarium are in Table 5.

It may seem from looking at Table 5 that species such as Sisyrichium pallidum and Packera pauciflora are not rare, because they occur in many South Park wetlands. However, it should be remembered that these species have nearly their entire Southern Rocky Mountain populations in South Park, where the species are characteristic of the calcareous wetlands found there. Also, species such as Carex dioica, which was found in only a few South Park wetlands, appears very rare, but this species is more widespread in Colorado, but generally at higher elevations than the study wetlands.

Table 4. South Park wetlands that support populations of rare plant species. An * indicates that this was the largest population of that particular species found in South Park that is or known for Colorado.

Species	Wetland Number
Carex dioica	4
Carex microglochin	4,53*
Carex scirpoidea	3,11,30,34,53*
Eriophorum gracile	4,40,52
Kobresia simpliciuscula	3,4,11,43,45,48,49,52,53,54
Packera pauciflora	8,11*,12,25,27,28,31,32,34,45,50,53,55
Primula egaliksensis	2,3,4,5,8,11,26,28,30,46,49,53,54,55
Ptilagrostis porteri	4,45,48,49*,52,54
Salix candida	2,4,11*,43,52,53,54
Salix myrtillifolia	4,11,53*
Scorpidium scorpioides	53*
Sisyrhinchium pallidum	6,7,11,12,15,18,21,22,23,24,26,27,28,31, 32,34,37,45,46,47,53
Trichophorum pumilum	2,3,4,11,43*,52,53

Table 5. Collection numbers for rare plant species in South Park wetlands. All specimens are in the herbarium, University of Colorado, Boulder.

Species	Wetland #
Carex dioica	1739
Carex microglochin	1740
Carex scirpoidea	1828, 1847,
Eriophorum gracile	1743
Kobresia simpliciuscula	1839, 1911
Packera pauciflora	1736, 1785, 1817, 1872
Primula egaliksensis	1832
Ptilagrostis porteri	1788, 1940, 1942
Salix candida	1756, 1909
Salix myrtillifolia	1757
Sisyrinchium pallidum	1742, 1744, 1761, 1775, 1781, 1801, 1831, 1881, 1888, 1891, 1916, 1922,
Trichophorum pumilum	1738, 1746, 1807, 1834, 1910

Functions and Values of South Park Wetlands

The South Park study wetlands were evaluated for 13 different functions and values using the methodology described in this report. These functional evaluations for each wetland are on the field forms (Appendix 5). A wetland which performs a function to a high degree is given a rating of 4 or 5 for that function. The field evaluations of the high quality functions performed by each wetland are summarized in Table 6. The total number of high quality functions provided by each wetland is summarized in Table 7. The number of wetlands that perform each function to a high degree is presented in Table 8. In Table 9 the number of wetlands that perform a certain number of high quality functions are summarized.

The most important functions performed by South Park wetlands are ground water discharge, short-term nutrient retention, within-basin food chain support, wildlife habitat, and passive recreation-heritage value, as is summarized in Table 8. Several functions are not performed by most South Park wetlands, including groundwater recharge and active recreation. Only two wetlands do not perform any high quality functions, and this is because they have been hydrologically modified. Most wetlands perform at least a few high quality functions and eight wetlands perform at least 10 high quality functions. A key reason for understanding which functions different wetlands are performing is that it allows management decisions to be made regarding the types of activities that will not diminish these functions.

TABLE 6. High quality functions performed by each wetland evaluated.
* Note, abbreviations are spelled out at end of table.

WETLAND NUMBER	FUNCTIONS
1	GD, FS, SA, ST, NRL, NRS, FCD, FCW, HF, FW, PR
2	GD
3	GD, NRL, NRS, PR
4	GD, SA, NRL, HW, PR
5	GD, SA
6	FCD, FCW, HF, HW, AR
7	GD, FS, SA, ST, NRS, FCW, HF, HW
8	NONE
9	FS, NRS, HF, HW
11	GD, NRL, NRS, FCW, HW, PR
12	GD, SA, NRL, NRS, FCD, FCW, HW, PR
13	PR
14	GD
15	GD, SA, ST, NRS, FCD, FCW, HF, HW, AR, PR
16	GD, SA, ST, NRS, FCD, FCW, HF, HW, AR, PR
18	FS, SA, ST, NRS, FCD, FCW, HF, FW, AR, PR
19	HF
20	HW
21	GD, NS, FCW, FCD, HW, PR
22	GD, FCW, HW
23	GD, SA, FCW, HW
24	FCW, FCD, HF, HW, AR, PR
25	SA, FCD
26	NONE
27	GD, NRS, PR
28	GD, NRS
29	GD, SA, ST, NRL, NRS, FCW, HW
30	NRS
31	FS, SA, ST, NRS, FCD, FCW, HF, HW, AR, PR
32	GD, NRS, HW
33	NRS, GD
34	SA, ST, FCW, HW
35	GD, NRS
37	GD, NRS
38	GR, SA, ST, FCD, FCW, HF, HW, PR
39	FS, SA, ST, FCP, FCW, HF, HW, AR, PR
40	GR, GD, FS, NRL, NRS, HF, HW, PR
41	GD, NRL, NRS, FCD, FCW, HF, HW, PR
42	FS, ST, FCW, HF, HW, PR
43	SA, PR
44	FCW, HW, PR
45	GD, FS, FCW, FCD, HF, HW, PR
46	GD, NRS
47	GD, NRS
48	GD, FS, SA, NRL, NRS, FCD, FCW, HF, HW, PR
49	GD, FS, SA, ST, NRL, NRS, FCD, FCW, HF, HW, PR

50	GD, SA, ST, NRL, NRS
51	FS, FCW, HW, PR
52	GD, FS, SA, ST, NRL, NRS, FCD, FCW, HF, HW, AR, PR
53	GD, NRL, NRS, FCD, FCW, HW, PR
54	GR, GD, FS, SA, ST, NRL, NRS, PR
55	GR, GD, NRS, HW, PR

ABBREVIATIONS USED IN TABLE 6.

GR = Ground water recharge
GD = Ground water discharge
FS = Flood storage
SA = Shoreline anchoring
ST = Sediment trapping
NRL = Nutrient retention, long-term
NRS = Nutrient retention, short-term
FCD = Food chain support, downstream
FCW = Food chain support, within basin
HF = Habitat, fish
HW = Habitat, wildlife other than fish
AR = Active recreation
PR = Passive recreation, heritage value

Table 7. Number of high quality functions performed by each wetland.

WETLAND NUMBER	NUMBER OF FUNCTIONS
1	11
2	1
3	4
4	5
5	2
6	5
7	8
8	0
9	4
10	-
11	6
12	8
13	1
14	1
15	10
16	10
18	10
19	1
20	1
21	6
22	3
23	4
24	6
25	2
26	0
27	3
28	2
29	7
30	1
31	10
32	3
33	2
34	4
35	2
37	2
38	8
39	9
40	8
41	8
42	6
43	2
44	3
45	7
46	2
47	2
48	10
49	11
50	5
51	4
52	12
53	7
54	8
55	5

Table 8. Number of wetlands performing each function to a high degree. * denotes that at least approximately 1/2 of the wetlands studied perform this function to a high degree.

WETLAND FUNCTION	NUMBER OF WETLANDS
GROUND WATER RECHARGE	4
GROUND WATER DISCHARGE	33*
FLOOD STORAGE	13
SHORELINE ANCHORING	19
SEDIMENT TRAPPING	16
NUTRIENT RETENTION, LONG-TERM	14
NUTRIENT RETENTION, SHORT-TERM	30*
FOOD-CHAIN SUPPORT, DOWNSTREAM	16
FOOD-CHAIN SUPPORT, WITHIN BASIN	26*
HABITAT, FISH	19
HABITAT, WILDLIFE OTHER THAN FISH	32*
ACTIVE RECREATION	7
PASSIVE RECREATION, HERITAGE VALUE	28*

Table 9. Number of wetlands performing a certain number of high quality functions.

NUMBER OF FUNCTIONS	NUMBER OF WETLANDS
0	2
1-2	16
3-4	10
5-9	17
10+	8

Description of Functions Performed by South Park Wetlands

Functions and values of South Park wetlands are summarized below. A more detailed description of each function and value is in Appendix 1.

GROUND WATER RECHARGE: Ground water recharge is difficult to evaluate without field measurement. In the study area, wetlands that retain standing water for much of the summer and streams for which surface flow diminishes visibly downstream (losing streams) were considered to perform this function at least moderately well. The value of most Rocky Mountain wetlands for performing this function is not known (Cooper et al. 1990).

GROUND WATER DISCHARGE: Portions of more than 1/2 of the wetlands in the study area appear to be supported largely by ground water discharge and therefore occur where this function occurs. Wetlands with significant ground water discharge typically are saturated throughout much of the year and can perform vital water quality functions because their soils are anaerobic and reducing conditions exist. The portions of these wetlands with the strongest and most constant springs have peat soils and are subject to mining activities. These are the fens in South Park, including the extreme rich fens with their unique complement of rare plant species.

FLOOD STORAGE: Approximately 1/4 of the study area wetlands can perform valuable flood storage functions. These wetlands occur in level topographic sites, on densely vegetated floodplains adjacent to streams and in basins with ponds and lakes. This function is most valuable to residents of Hartsel which could be subject to flooding from the South Platte River. Most of the other towns in the study area are in no flood danger.

SHORELINE ANCHORING: Approximately 1/3 of the study area wetlands provide valuable shoreline anchoring, protecting streambanks and pond edges from erosion. Well-developed willow and sedge dominated vegetation in particular provides valuable shoreline stabilization. Many of these areas could be greatly enhanced by the restoration of woody vegetation along streambanks. This functions also provides important fish habitat.

SEDIMENT TRAPPING: About 1/4 of the study area wetlands provide valuable sediment-trapping functions. Most valuable in this regard are wetlands with dense vegetation that are flooded by surface water.

LONG-TERM NUTRIENT RETENTION: Approximately 1/4 of the study area wetlands provide this function. These primarily are wetlands that accumulate peat and sediment and that have been relatively stable, supporting the same or similar types of wetland communities for long periods of time. Fens and willow carrs are the most common wetland types performing this function.

SHORT-TERM NUTRIENT RETENTION: More than 1/2 of the wetlands in the study area provide high quality short-term nutrient retention. These wetlands typically are anaerobic for long periods of time during the growing season and can convert, trap and/or transform nutrients and heavy metals and remove them from the water column. Wetlands that provide long-term nutrient retention also provide short-term nutrient retention.

DOWNSTREAM FOOD CHAIN SUPPORT: Approximately 1/4 of the wetlands in the study area provide valuable food chain support to downstream aquatic ecosystems. This small number is due to the spring-fed nature of many of these wetlands and the intermittent character of most streams fed by these wetlands. Not all of the wetlands are connected to large streams where significant aquatic life occurs. However, most wetlands provide moderate downstream food chain support important to the aquatic life in the South Platte River, Tarryall Creek or Michigan Creek. Wetlands dominated by willow and sedges provide organic matter potentially important to aquatic insects in streams.

WITHIN-BASIN FOOD CHAIN SUPPORT: Approximately 1/2 of the wetlands in the study area provide very valuable food chain support within their basins. These include spring-fed wetlands and beaver ponds. Any wetland that supports significant insect, bird, or mammalian populations would be important in performing this function.

FISH HABITAT: Approximately 1/3 of the wetlands in the study area provide high quality fish habitat. These are the wetlands located along the larger creeks and rivers in South Park. The other study area wetlands do not provide the aquatic habitat necessary to support fish.

WILDLIFE HABITAT: More than 1/2 of the study area wetlands provide high quality wildlife habitat. These include wetlands that are large enough to provide diverse habitat.

ACTIVE RECREATION: Only seven wetlands in the study area provide important active recreation. These are the wetlands where fishing is popular.

PASSIVE RECREATION: High quality passive recreation potential is provided by 28 wetlands in the study area. These are wetlands with a wide diversity of habitat and visual beauty. They also support significant plant populations and may also support other wildlife populations.

Water Chemistry Characteristics of South Park Wetlands

The complete set of water quality data collected during this project is in Appendix 4. Field data on pH, conductance, salinity and temperature were taken at most wetlands and in many instances at several stands within a wetland. Water samples collected in the field were analyzed by atomic absorption spectroscopy to determine Na^+ cation concentrations of the water. Cations of calcium, sodium and magnesium are typically incorporated into the plant cells and are not recycled within the plant as are other nutrients such as nitrogen and phosphorus. This is important because in peatlands plant leaves and roots do not decompose and these cations are lost to the ecosystem. Thus, a continued source of these cations is necessary to support species with very exacting nutrients requirements.

Selected water chemistry characteristics of South Park wetlands are shown in Figures 9 through 12. Water pH shown in Figure 9 indicates that overall, water in the study area is neutral to basic in reaction. Water in the northern portion of the Park is generally in the mid 7's while water in the southern portion of the Park is closer to 8. Some very high pH's occur in the area of Antero Reservoir indicating the locations of salt springs.

Electrical conductance of waters are shown in Figure 10. The lowest numbers are in surface waters, particularly in the northern part of South Park. The highest numbers in the study area are in the Antero Reservoir area where salt springs contain

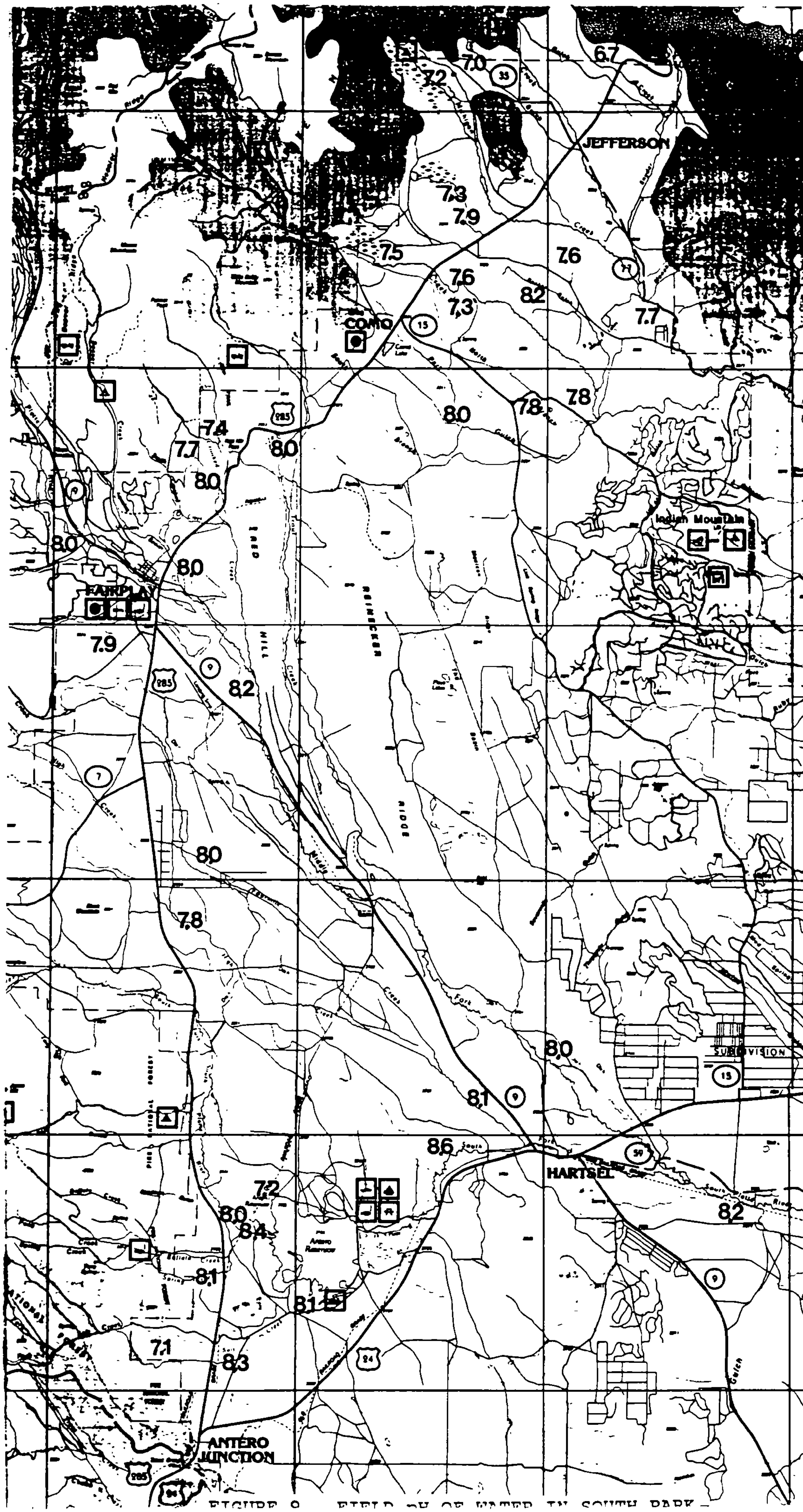


FIGURE 9. — FIELD pH OF WATER IN SOUTH PARK—

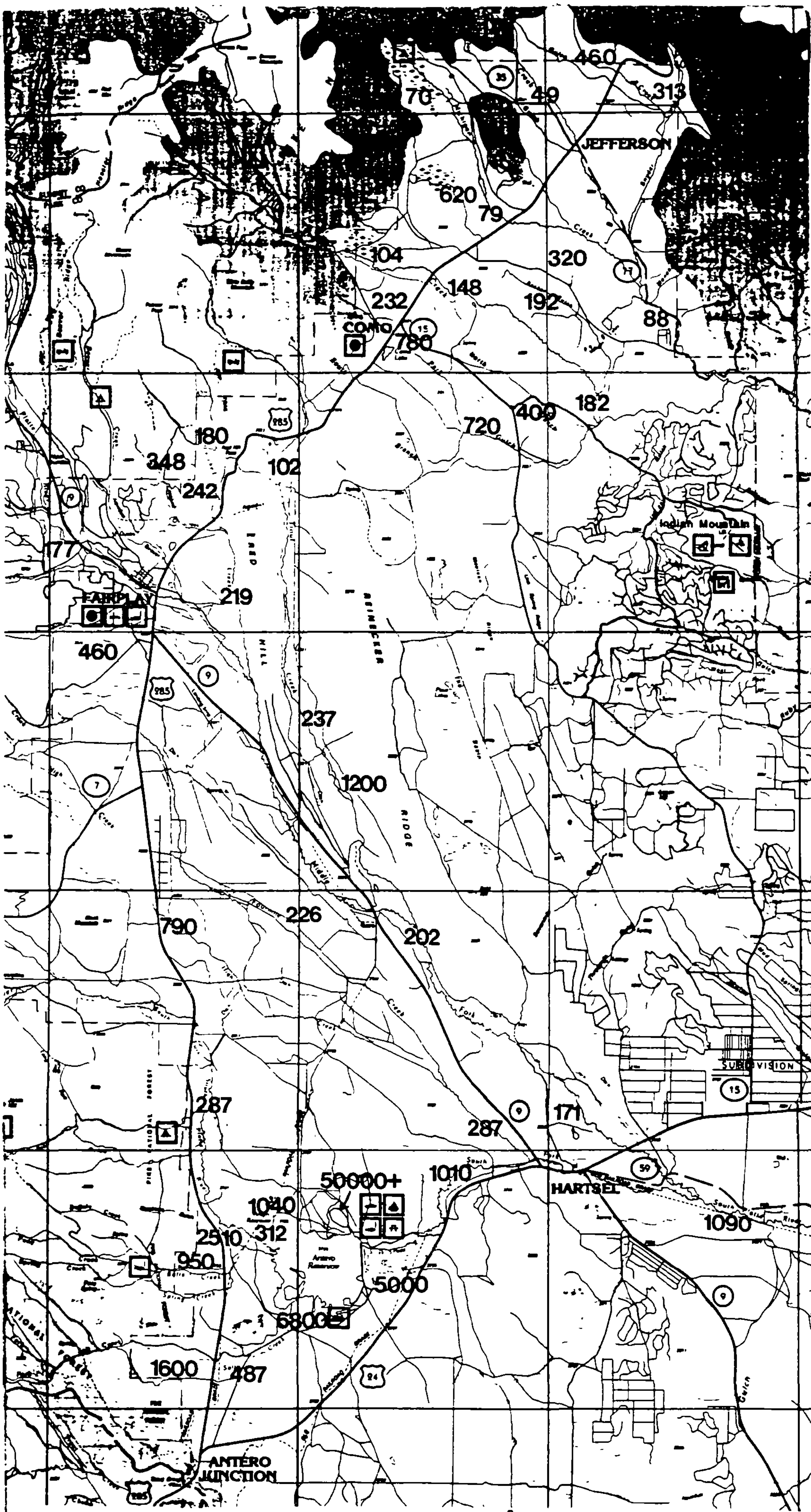


FIGURE 10. FIELD CONDUCTANCE (mmhos/cm²) OF WATER IN SOUTH PARK

high concentrations of dissolved solids.

These salt springs greatly affect the chemistry of surface waters as well. For example, the South Fork of the South Platte River just after it crosses under U.S. 285 has a conductance of 287 mmhos/cm^2. Just before the river reaches Antero Reservoir its conductance reaches 312. Water exiting Antero Reservoir has conductance values greater than 1,000 mmhos/cm^2, and the conductance stays this high all the way to Spinney Reservoir east of Hartsel. By contrast the Middle Fork of the South Platte River is little effected by salt springs. The Middle Fork has a conductance of 177 mmhos/cm^2 just west of Fairplay which rises slightly with the addition of water from Trout Creek, but is 171 mmhos/cm^2 by the time it reaches Hartsel. Michigan Creek maintains low conductance from its headwaters all the way to the eastern part of the Park, while the conductance of Taryall Creek increases somewhat.

Sodium (Na^+ cation) ranges from 6 to 75 mg/l in water from the study area (Figure 11 and Appendix 4). The lowest sodium concentrations are in water from Michigan and Tarryall Creeks. The higest concentrations are from the salt springs in the Antero Reservoir area and in the South Fork of the South Platte River below the Reservoir. Other high concentrations occur at springs throughout South Park. In general the surface waters of creeks had lower concentrations than the concentration of springs. Both forks and the major tributaries of the South Platte River have sodium concentrations in the range of 14-19 mg/l throughout the

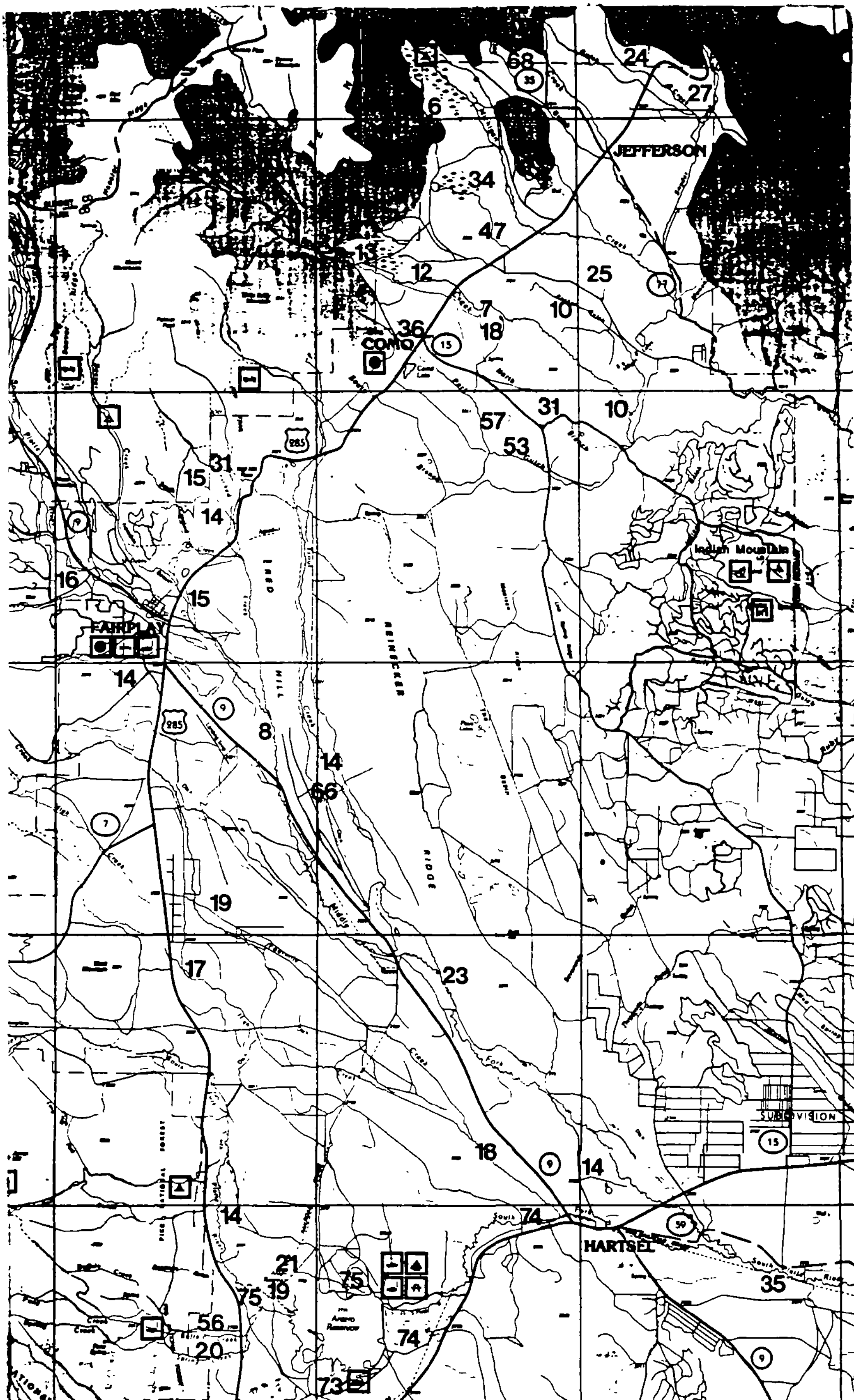
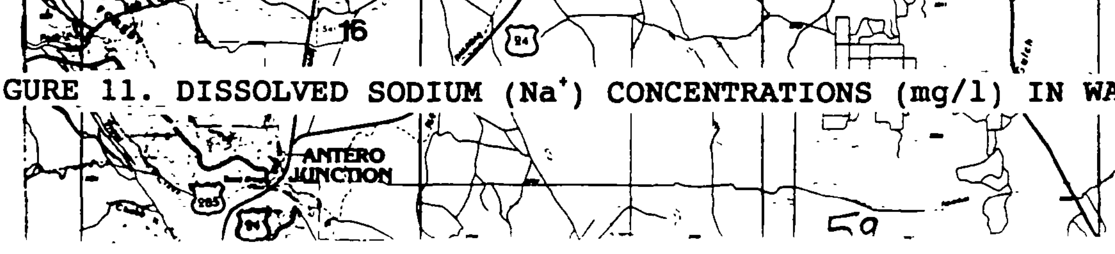


FIGURE 11. DISSOLVED SODIUM (Na^+) CONCENTRATIONS (mg/l) IN WATER.



central portion of the study area. It is only in the area of Antero Reservoir that large sodium inputs occur which radically change the chemistry of the South Fork of the South Platte River. Some dilution of the water occurs when the Middle Fork joins the South Fork near Hartsel. Water collected from the large spring at the Trout Creek Ranch which supports an extreme rich fen complex had a sodium concentration of 66 mg/l, and did not appear to deleteriously affect the vegetation at that site. The sites studied that had sodium concentrations greater than 70 mg/l supported vegetation with very low cover and low species diversity. Sites with sodium concentrations less than 70 mg/l apparently were not deleteriously affected and the floras were more diverse and the vegetation dense in many areas.

Wetlands in South Park are created by surface and ground water that eventually makes its way downstream. These wetlands provide essential filtration and biochemical reduction that removes pollutants from this water. The maintenance of wetlands in South Park, particularly the wetlands that are created by groundwater discharge and those adjacent to streams. These wetlands, particularly streamside riparian wetlands, should also be considered for restorations projects where the means and interest coincide.

Suggestions for Priority Wetlands in South Park

Priority wetlands are suggested here to assist land managers in determining where attention should be focused. I also suggest methods for best management of key wetlands. A priority wetland is one that provides very high quality functions and/or supports unique or significant biological communities. Wetlands where an abundant supply of ground water is being discharged are all priority wetlands and are considered to be key in maintaining the quality of that water. From an agricultural perspective priority wetlands provide exceptional stands of vegetation for livestock and have abundant water available as well. From my experience the most productive stands from a livestock perspective are the extensively irrigated meadows which are not naturally wetlands.

1. Priority wetlands supporting significant biological communities are of two types.

a) Extreme rich fens; 53, 11, 43, 52, 49, 48, 2, 3, 4 and 54. Portions of each wetland identified here is a spring system discharging calcium carbonate rich ground water and supporting extreme rich fens. These are the only well-developed examples of this type of ecosystem in the Southern Rocky Mountains and their distribution is shown in Figure 12.

b) Willow stands along streams are very valuable biologically as passerine bird nesting habitat and for other wildlife species. The most valuable of these streamside wetlands are; 38, 39, 1, 52 and 18.

2. Priority wetlands that are essential for providing water

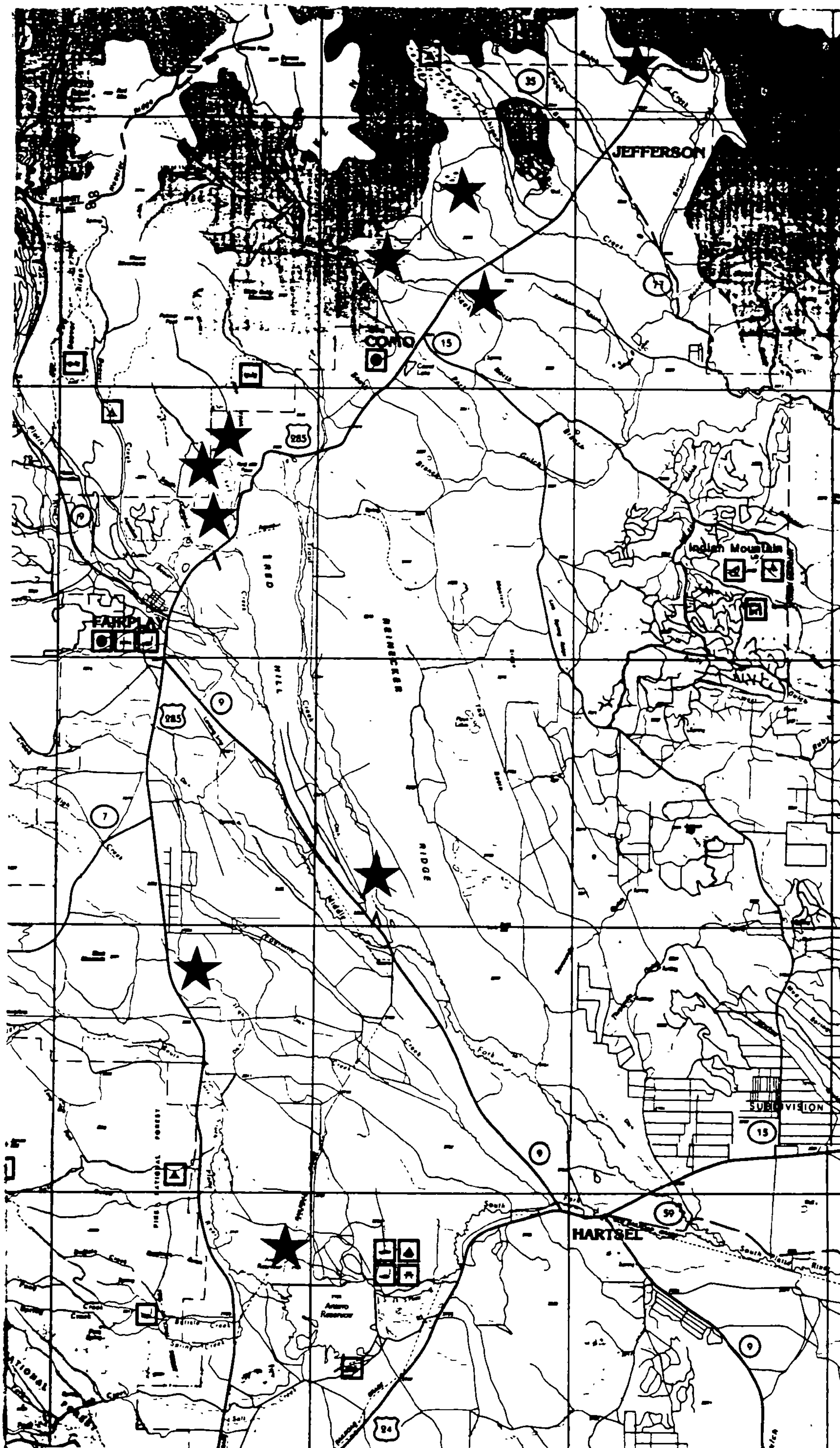
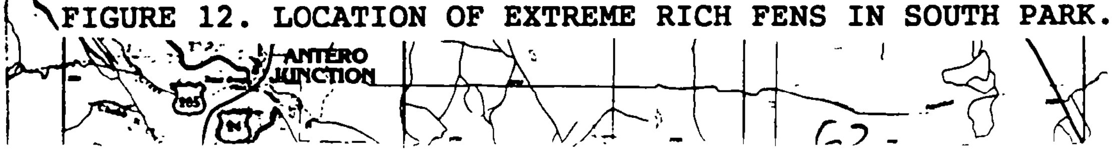


FIGURE 12. LOCATION OF EXTREME RICH FENS IN SOUTH PARK.



quality functions for ground water discharge. Portions of wetlands 1, 41, 49, 52, 50, 54, 2, 4, 29, 35, 32, 47 and 11 occur at large ground water discharge systems. Some ground water is also discharged at many other wetlands, but the sites listed above have very large discharge systems.

Cumulative Impacts to South Park Wetlands

A complete cumulative impacts analysis using the methods described in Gosselink and Lee (1990) is appropriate considering the significance of the wetland resources in South Park, but could not be done during the course of this research. Two major types of wetland impacts have occurred in South Park, and both can be reversed through proper management. The first is the dewatering of streams for the irrigation of drylands. This has reduced the surface water flow in streams and reduced their power to reshape stream banks and store water in the banks. The second impact has been the destruction of streamside and other wetland vegetation due to overgrazing by domestic livestock. In particular the loss of willow dominated stands has been acute. Most likely Jefferson, Michigan, Tarryall and Middle Fork of the South Platte River had willows along their banks and floodplains through South Park.

The picture of many wetlands in South Park is a stream system that carries much less water than in presettlement conditions. These streams also have had their adjacent vegetation greatly modified. Groundwater fed wetlands have received additional irrigation water in many areas and are mowed annually for hay production and grazed by cattle at least seasonally. In addition, there are large irrigated areas that once were uplands. It is possible that the total acreage of wetlands in South Park has been significantly increased by irrigation practices. However, it should be kept in mind that to irrigate dry lands streams have been dewatered. Thus, some of the most valuable wetlands in the region (streamside riparian wetlands) have been sacrificed to create what are most likely the least valuable wetland communities, the wire rush (Juncus arcticus) meadows.

The functions that have suffered the most are streambank stabilization, wildlife habitat, fish habitat, short-term nutrient retention and downstream food chain support. The other important wetland functions that still occur in South Park are supported largely by the unaltered groundwater flow systems.

Opportunities for Restoration of South Park Wetlands

Opportunities for wetland restoration in South Park exist in many areas. I have lumped the opportunities under three general categories; stream bank restoration, livestock management in peatlands, and filling drainage ditches.

A large unknown in trying to piece together the presettlement vegetation of South Park is what was the effect of bison on these wetlands. It is well known that South Park supported large herds of bison, at least seasonally. They may have formed wallows in certain wetlands and fed seasonally in other wetlands. While my perspective of presettlement South Park wetlands does include herds of large mammals it does not include nearly constant use of most wetlands by large mammals. Bison feeding systems include nearly constant movement and utilization of blue grama grass. Thus, impact to any particular area is somewhat limited. Long-term grazing by confined livestock appears to have a very different impact on wetlands.

Stream Bank Restoration

Many of the streams in South Park had willow lined banks and floodplains that extended from the western mountain front across South Park through the Tarryall Mountains to the Great Plains. Jefferson Creek, Michigan Creek, Tarryall Creek, Middle Fork of the South Platte River and possibly Four Mile Creek all have willow stands along portions of their floodplains. A few streams still support willow-dominated vegetation. These range from stands in very good condition, such as those at the headwaters of Michigan Creek, to those that are severely degraded such as Tarryall Creek east of U.S. 285.

These communities dominated by mountain willow (Salix monticola) were found along streambanks and extended back from the streams for hundreds of feet in many instances. Some idea of how extensive the willow vegetation could have been is seen along the Middle Fork of the South Platte River east of Colorado 9, east of Garo, at wetland number 18. The willow stands here are extensive, even though they have been severely degraded. By contrast the River has no willows along its course west of the highway in this area.

Willows have long life spans, probably hundreds of years and have not just died out naturally. They have either been cut out by mechanical means or trampled by livestock. These woody plants are vital for stabilizing streambanks and providing the structural integrity for holding banks vertical and for allowing the formation of undercut banks. Willow leaves are an important food for aquatic insects in winters and the food chain must have been greatly enhanced. The willows also must have supported large populations of migratory songbirds and other wildlife.

Restoration would entail limiting livestock use along portions of the streams and planting dormant willow stem cuttings both along the banks and in areas with high water tables farther from the banks. This method could initiate willow populations, but it should be understood that the development of mature willow communities would take decades. However, if restoration is not initiated, it will never happen.

Livestock Management in Peatlands

Peatlands occur where groundwater is being discharged and saturates soils for the entire growing season. These sites are constantly wet and the growth forms of plants lead to the formation of hummocks. The hydrologic regime in most peatlands is intact because it is not possible for ditches and other water collecting devices to dry up groundwater. However, cattle were found wallowing in the wettest portions of these ecosystems and have destroyed many of the hummock complexes and potholed the landscape. The extreme rich fens at wetland numbers 11 and 43 would especially benefit from the removal of cattle grazing. At wetland 43 less than 10 acres would need management, while at wetland 11 approximately 50 to 100 acres would need management. It would also be advisable to limit cattle grazing along streams with badly degraded banks.

Filling of Ditches in Wetlands

In attempting to salvage water from wetlands, some wetlands in South Park were ditched. These ditches run from valley side to valley side and bring water to a central point, usually a stream or another ditch. Two wetlands were found this summer that had been ditched; number 47 in Park Gulch and 35 at the head of Packer Gulch. The extensive ditch systems should be filled to restore the hydrologic regime of these wetlands.

The Effects of Drying up Land in South Park

South Park water rights have been and are being purchased by municipalities on the eastern slope of the Front Range and transfered from agricultural to municipal use. Agricultural use in South Park includes the application of water, via ditch systems, to previously dry uplands with the goal being hay production. This land use pattern removed water from streams reducing the volume of surface water in streams. The effect was reduced riparian wetlands and increased marsh type wetlands in South Park, a pattern that occurs throughout the West.

In most instances the irrigated areas have developed complex biological communities supporting dozens of plant species, including two of the rare species known from South Park; *Primula egaliksensis* and *Sisyrinchium pallidum*. These haylands are usually dominated by arctic rush, *Juncus arcticus*, or the sedge, *Carex simulata*. Hairgrass, *Deschampsia cespitosa*, can dominate some of these wetlands as well. In many respects these communities resemble natural wetlands, except in their hydrologic regime which can be easily altered.

Removal of water from the uplands has and will result in the loss of irrigated wetlands in some portions of South Park. At the same time this activity could increase the amount of water in streams and effect the restoration of the natural hydrologic regime of these waterways. Cessation of irrigation will result in the death of most wetland plant species living in the irrigated lands and the subsequent invasion of upland species.

Although the wetland plants die the soil retains the grey colors and mottled appearance that was created by the reducing soil regime of the wetland. These soil morphologic characteristics will be retained for many decades.

From observations made during the past two summers, I know that the first colonizers are weedy plant species such as fringed sage, Artemisia frigida and plantain Plantago eriopoda. This pattern of invasion can be seen in the area around Jefferson, on the Trout Creek Ranch, on Walt Coil's ranch near Fairplay or along Four Mile Creek east of U.S. 285.

The colonization of dried up hayland by the native plant species that dominate the grasslands in South Park is extremely slow. The native grasses include blue grama Bouteloua gracilis, western wheat, Pascopyrum smithii, and the sedge, Carex stenophylla ssp. eleocharis. These species are long-lived but apparently are very slow to recolonize disturbed sites from seeds.

Several suggestions are presented here with regard to the management of water and waterways in South Park. First, water purchased for downstream use should be required to flow in its natural manner down rivers and through wetlands as the water has for thousands of years. No ditching of wetlands should be allowed. Second, the conversion of land from irrigated agriculture to dryland should include the full price of land restoration. This must include both riparian restoration and upland restoration. Efforts must be made to enhance the germination and growth of native populations of the dominant native plant species. There can be no doubt that Park County is the loser if water purchasers merely remove water from irrigation without addressing the large-scale and long-term impacts of land conversion.

If water is purchased and allowed to flow through wetlands and down streams in the natural hydrologic regime, and if ditches are not created, and if the dried land including streambanks is restored, then the conversion could possibly, in many respects bring the hydrologic regime of streams and the floristic composition of many ecosystems back to pre-settlement conditions. This would provide less water to wet meadows, but more to streams and riparian vegetation.

This additional water could have both negative and positive effects on riparian zones. Areas with degraded vegetation along banks could suffer erosion, while those with healthy vegetation will be greatly enhanced by the additional water.

It should also be considered that one of the most spectacular displays of wildflowers in Colorado occurs in South Park each summer. The bistorts, louseworts, gentians, and myriad other species occur in profusion in the irrigated meadows throughout the region. In many respects Park County should sell itself as the "wildflower capital of Colorado."

It is in the best interest of Park County to require water developers to pay the full price of land reclamation. This would ultimately include restoring land contours, filling ditches and restoring the native upland vegetation. The big question is, how do you restore the native grassland vegetation? Reclamation success in short-grass prairie areas has been poor or indecisive throughout the western U.S. Thus, there are no well tested and effective means of establishing the species desired.

Due to South Park's high elevation and severe weather, the commercially available native plant species, which originate at low elevations, will not be suitable. Seeds of blue grama grass can be purchased but they are from low elevation populations that would not survive in South Park. It will most likely be necessary to collect seeds of the most important grasses in South Park for reclamation purposes.

The land will then have to be prepared, by disking or ripping to create a seed bed for germination. Because blue grama is a warm season grass which germinates and grows in the warmest part of the summer (July and August), it may be necessary to provide supplemental irrigation during July to promote germination and growth in a dry year.

It is suggested that this type of reclamation can be performed for approximately $500 to $600 per acre. There will be additional cost for native seed collection. Since blue grama grass seeds are very small, every pound of seed will go a long way and can be applied at a rate of approximately 5 pounds per acre. This is, of course, considering that the seed is viable and the material collected is clean of chaff and other seeds.

Park County should consider a pilot project that would attempt restoration of a small irrigated parcel where the irrigation will be removed. This parcel must retain water rights for at least one to two years so that the site could be irrigated in mid-summer if necessary.

One wetland, number 26, apparently was created entirely by irrigation and has now been dried up. I mention this wetland because approximately 2 inches of organic matter occurs in the low lying portions of the site. It indicates that in cases of extreme irrigation up to 2 inches of organic soil could accumulate in approximately 120 years. It indicates that peat deposits of more than a few inches have been created by naturally occurring hydrologic regimes and represent a much longer span of time than the longest possible period of irrigation, which is 125 years.

Peatlands in South Park almost always occur where ground water is being discharged from the earth. Thus, the hydrologic regime is long-standing and constant. This type of hydrologic regime cannot easily be modified or dried up. For example, the ditches constructed in the ground water discharge portions of wetlands 47 and 35 have not dried up the peat accumulating areas but adjacent downstream wetlands have been dried up.

CONCLUSION

South Park contains a large area of wetlands, most of which are supported by ground water flow systems and streams. However, a large acreage of wetlands have also been created and are supported entirely by irrigation. The natural wetlands provide important water quality improvement, wildlife habitat, livestock forage, fishery habitat, and stream baseflow that benefits all residents of Park County. It is in the best interest of the County to manage these wetlands so that they continue to provide these functions. Priority wetlands have been identified in this report and show where, what this author considers to be, the most valuable wetlands in South Park occur. These priority wetlands should especially be considered for special management programs.

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APPENDIX 1 : DESCRIPTION OF WETLAND FUNCTIONS

This appendix describes each function listed in this report, how each was evaluated in the field, how the ranking system for each function was applied. The functions and the performance indicators are derived from "A Method For Wetland Functional Analysis: Volumes I and II" by Paul Adamus and L. Stockwell, published by the Federal Highway Administration (Adamus and Stockwell 1983). A recently revised and updated version was published by the U.S. Army Corps of Engineers in draft form as the Wetland Evaluation Technique (WET) (Adamus et al. 1987). This latter document has been utilized only slightly because it appeared when the Telluride Region Study was already in progress.

Ground Water Recharge. This function involves the movement of surface water or precipitation into the ground water flow system. This is a very difficult function to estimate without actual flow measurements. Physical characteristics of a wetland that appear to be good indicators that ground water recharge is occurring are: porous underlying strata, low sediment trapping efficiency, natural damming of a waterway at a wetland location, dense vegetation in a basin, constriction of an outlet, surface water inflow that exceeds surface water outflow, location of a wetland high a basin, and irregular wetland shape with a high ratio wetland edge to wetland area. A dam site on alluvium would most likely perform this function and would be given a high rating. A moving stream in alluvium would likely have a moderate chance of performing this function. A fast moving stream on clay substrate (relatively impermeable) would probably not perform this function or perform it very slightly and would thus get a low ranking.

Ground Water Discharge. This function involves the movement of ground water into surface water (e.g., springs). It is very difficult to estimate whether or not this function is operating unless it is actually seen or measured. Factors that offer an indication that this function may be performed include: unconstricted outlet, low placement in the watershed (low hydrologic head), lithological diversity (different bedrock types, some of which may be waterbearing), a dam upstream (which would be recharging the ground water just upstream), and lack of silt in a basin. Many wetlands occur due to ground water discharge, and numerous springs are identified in this study (as summarized in Table 1).

Flood Storage. Flood storage is the process by which peak flows (from runoff, surface flow, ground water interflow and discharge and precipitation) enter a wetland basin and are delayed in their downslope journey. This function includes flood desynchronization, a process that involves simultaneous storage of peak flows in numerous basins within a watershed and subsequent gradual release in a non-simultaneous, staggered manner. Wetlands known to perform this function typically exhibit some of the following characteristics: occurrence in a large watershed and are along an order 1 or 2 (very small) stream, significant increase in the size of the wetland during flood times, presence of a large and deep basin, low gradient, unsaturated sediments (not permanently saturated), high above-ground and/or below-ground storage, no outlet, and dense vegetation. A wetland that would most likely perform this function to a high degree would occupy a large and broad, low gradient basin (such as wetland numbers 40 and 9) or a small basin that has a dam on it (for example the numerous impoundments in the study area). Wetlands that most likely would not perform this function would be channelized reaches of streams.

Shoreline Anchoring. Shoreline anchoring is the stabilization of soil at the water's edge or in shallow water by plant species with fibrous roots, and it may include long-term accretion of sediment and/or peat. Wetlands that perform this function occur along open water (lakes and streams). Rating this function assumes that vegetation density, vegetation type, and wetland width are important predictors. Wetlands dominated by woody vegetation located along streams in which the stream bottom is largely covered by fibrous roots surely provide this function to a high degree (for example the many wet riparian ecosystems). Wetlands that would not perform this function are those that do not have open water.

Sediment Trapping. Sediment trapping is the process by which inorganic particulate matter of any size is retained and deposited within a wetland or its basin. This function may be performed on a short-term (years to decades) or long-term (decades to millenia) basis. Wetlands that perform this function typically have the following characteristics: no outlet, surface water input that exceeds surface water output, dense vegetation, and gently sloping wetland edges. They also have deposits of mud or organics which indicate deposition. Wetlands that perform this function to a high degree tend to occur behind dams (such as the numerous impoundments in the study area), or in detention ponds in urban areas (some urban wetlands would perform this function).

Nutrient Retention and Removal. Nutrient retention is the storing of nutrients within the substrate and vegetation of wetlands. Nutrient removal is the purging of nitrogen nutrients by conversion to gas (denitrification) while nutrient retention may involve trapping of runoff-borne nutrients in wetlands before they are carried downstream or to underlying aquifers. Nutrient storage in wetlands may be long-term (greater than 5 years) or short-term (30 days to 5 years). The nutrients most critical for retention in aquatic ecosystems and removal are nitrogen and phosphorus compounds, although others may also be important.

Wetlands that perform long-term nutrient retention or removal function typically exhibit the following characteristics: high sediment-trapping function, organic matter accumulation, no outlet, permanent or semi-permanent flooding (which creates reducing soil conditions that support active populations of denitrification bacteria and also minimizes the oxidation of organics that facilitates peat accumulation). A wetland with long-term nutrient retention functions would support highly productive vegetation and permanently saturated, highly organic soils (for example, the numerous spring and wet riparian ecosystem wetlands). Other examples would maintain high sediment retention because many nutrients enter the wetlands adsorbed to sediments (for example, impoundments). Many wetlands located in urban and industrial areas would perform this function.

Wetlands that perform this function short-term typically have the following characteristics: high net biological productivity, sediment retention, non-acid soils, and/or location in watersheds that highly developed with urban, industrial, and/or agricultural land uses (often with eroding soils and/or fertilizers). An example of a wetland that performs this function over the short-term is one with extremely productive vegetation and permanently saturated soils. Most densely vegetated cattail (Typha) stands would meet this criterion (for example, many urban wetlands). A wetland that would not perform this function would have very sparse vegetation, little sediment retention, and a steep slope that would keep sediment moving.

Food Chain Support. Food chain support is the direct or indirect use of nutrients, in any form, by animals inhabiting aquatic environments. Food chain support may occur within a wetland basin or downstream. Wetlands that perform downstream food chain support typically have the following characteristics; an outlet, non-acidic waters, non-sandy substrate, non-permanent flooding, dense and diverse vegetation with high sustained productivity, non-stagnant water, severe scouring, non-hypersaline water, good flushing flows, and vegetation overhanging the water. Examples of wetlands within the study area that would provide high quality downstream food chain support include the numerous wet riparian ecosystems having woody bank vegetation and herbaceous channel and bank vegetation. Wetlands that perform within-basin food chain support typically display the following characteristics: non-stagnant water, highly productive vegetation, irregular shape with no outlet, good mixing of water, and areas that are not entirely shallow and warm in the summer. A wetland that would have high within-basin food chain support value would have high diversity of plants and animals.

Habitat. Habitat includes those physical and chemical factors that affect the metabolism, attachment, and predator avoidance capabilities of adult or larval forms of fish, as well as food and cover needs of wildlife species in the place where they reside. These factors determine the suitability of a given site for an animal species. For this study, habitat was evaluated for fish and for wildlife (birds and mammals) separately. Wetland physical and chemical characteristics that are good for one species are not necessarily good for others, thus few indicators of good habitat exist for animals in general.

Wetlands that provide good fish habitat typically have the following characteristics: some open water that is not shallow, acidic, turbid or flashy; no barriers to migration; no oxygen stagnations; no artificial fluctuations; no oligotrophic profiles; and cool water temperatures with some shade. Few wetlands provide any fish habitat in the study area, but those that do include ones along the perennially flowing San Miguel River. Wetlands without open water do not provide the fish habitat function.

Wetlands that provide good wildlife habitat typically have some of the following characteristics; good edge ratio, islands, high plant diversity, some (but not excessive) alkalinity, relatively large and sinuous and irregular basin shape, gentle gradient, absence of artificial water-level fluctuations, not moss dominated, pH in excess of 6.0, some open water, distance from urban or deep water, channels, farms, and other human influences, and abundant food sources. The wet riparian and spring ecosystems are good examples of the types of wetland that provide high quality wildlife habitat and support a diverse and productive vegetation community, and are undisturbed and isolated from human activities.

Active Recreation. Active recreation involves water-dependent activities that can occur either in an incidental or obligatory manner in wetlands. These include swimming, boating, canoeing, kayaking, and sailing. Because hunting is not always water-dependant, it is not considered. Wetlands that provide this function typically have the following characteristics: direct evidence of actual use for a certain activity, convenient public access, relative lack of vegetation, some sand, little debris, slow standing water, channels and boat launch facilities, permanently flooded basin, no algal blooms, and lack of weeds. A wetland that would provide these characteristics in the study area would typically be a reservoir, although certain streams large enough to support boating also could support this function (though none occur in the study area). However, most wetlands in the study area however, do not support this function to a high degree because little standing or flowing water of significant magnitude exists to support these activities, and limited public access exists.

Passive Recreation and Heritage Value. This function includes use of wetlands for aesthetic enjoyment, nature study, picnicking, education, scientific research, open space, preservation of rare species, maintenance of the gene pool, protection of archaeologically or geologically unique features, maintenance of historic sites, and numerous other activities. Wetlands that perform this function typically display the following characteristics: rare plants, landscape diversity, unity of landscape elements, natural areas, and freedom from eyesores. Most spring and intact wet riparian ecosystems provide this function. Few wetlands in the study area (such as impoundments) provide this function to a high degree at present.

APPENDIX 2. HIERARCHICAL CLASSIFICATION OF WETLANDS IN SOUTH PARK

ROOTED AQUATICS IN MUD BOTTOMED POOLS

1. **Class** Utricularia vulgaris. This class includes the vegetation of mud bottomed pools in rich and extreme rich fens. This class was previously described by Cooper and Cottrell (1990, 1991).

1. **Order** Utricularia vulgaris. This order is similar to the class described above.

1. **Alliance** Utricularia vulgaris. This order is similar to the class described above.

1. **Association** Utricularia vulgaris (Stands 190, 58, 238, 190). Table x. This association occurs in mud-bottomed spring pools at a number of extreme rich fens in South Park, such as the fens at High Creek, Trout Creek and Antero Reservoir NW. Water pH in this association at High Creek was 7.79 with conductance of 2,050.

ROOTED AQUATICS IN SLOW STREAMS AND PONDS

2. **Class** Potamogeton pectinatus. This class includes the rooted aquatic vegetation that occurs in slow moving streams and ponds throughout Colorado. The plants for the most part are completely submerged. Diagnostic species include; Potamogeton pectinatus, P. gracilis, Ceratophyllum demersum, Elodea canadensis, Myriophyllum spicatum, Batrachium aquatilis, Zanichellia palustris and others.

2. **Order** Potamogeton pectinatus Same as the class

2. **Alliance** Potamogeton pectinatus

2. **Association** Potamogeton pectinatus (stands 89, 136, 182, 191, 72. This association is very common, occurring in most slow streams and ponds. The elongated leaves and stems of the lead species are diagnostic in the field.

3. **Association** Sparganium angustifolium = 65

4. **Association** Ceratophyllum demersum (stands 82,86,120) This association is most common at low elevations in Colorado, but also occurs in

5. **Association** Hippuris vulgaris = 92

REED SWAMPS

3. **Class** Schoenoplectus lacustris - Sagittaria cuneata. This class was previously described by Cooper and Cottrell (1990, 1991) and includes the vegetation of deepwater marshes and shallow water marshes in Colorado. Diagnostic species include; Typha latifolia, Schoenoplectus lacustris, Schoenoplectus maritimum and others.

3. **Order** Schoenoplectus lacustris - Sagittaria cuneata. Same as the class.

Tall reed swamps

3. **Alliance** Schoenoplectus lacustris - Sagittaria cuneata.

6. **Association** Schoenoplectus lacustris ssp. creber (stands 93,36,101,111,194). This association occurs in standing water around ponds in South Park. The stands are near

monocultures of bulrush and the water can be up to 18 inches deep.

7. **Association** Eleocharis palustris (stands 14,62,67,110,144,179,193,199,224,245,262,241,70,99,143). Stands dominated by Eleocharis palustris are common on the edges of ponds in South Park. They almost always occur in seasonally standing water which can be in oxbow or other seasonally flooded ponds along streams, but the water is much shallower than that in which association number 6 occurs in.

8. **Association** Beckmannia szygachne (stand 149). Stands dominated by sloughgrass are common in the western U.S. It many times is the only species present or it may occur with Alopecurus aequalis and other species.

Large sedge swamps

4. **Alliance** Carex utriculata. This alliance was previously described by Cooper and Cottrell (1990, 1991) and includes the large sedge vegetation of shallow water in the mountains.

9. **Association** Carex utriculata (stands 3,11,33,40,64,73,96,112,123,124,142,160,180,257). Stands dominated by beaked sedge are common in the Rocky Mountains. They occur in peaty and mineral soils, usually where shallow standing water is present early in the growing season. Carex utriculata is intolerant of high salinity and apparently will be replaced by bulrushes (Schoenoplectus lacustris ssp. creber) is greater than 2-3 parts per thousand in the water source.

Brackish water reed beds

5. **Alliance** Bobloschoenus maritimus. This alliance includes the reed beds of brackish water in the western U.S. Usually some standing water is present early in the summer.

10. **Association** Bolboschoenus (Scirpus) maritimus (stands 60,79,101). This association occurs on the edge of alkaline lakes and on salt flats where seasonally standing water occurs. Alkali bulrush is always the dominant species. Soil and water salinity may be as high as 13.2 parts per thousand with a conductance of 13,000 umhos/cm^2. This species occupies the most brackish water of any emergent plant in the study area. It is replaced in less alkaline sites by Eleocharis palustris, Scirpus lacustris ssp. creber and others.

INLAND SALT MARSHES AND FLATS

4. **Class** Puccinellia airoides - Triglochin maritimum. This class is established to include the vegetation of salt flats and salt marshes where there is little standing water. The combination of high salt content and high water tables limits the flora to halophytes (salt plants) that are hydrophytes (water plants). Diagnostic species include; Puccinellia airoides, Triglochin maritimum, Amphiscirpus nevadensis, Hordeum jubatum, Sporobolus airoides and Distichlis stricta.

4. **Order** Puccinellia airoides - Triglochin maritimum. Same as the class.

Saltmarsh swards

6. **Alliance** Triglochin maritimum. This alliance includes the grass and grass-like plant dominated vegetation of salt marshes. The plant cover is never 100%, production is low, and much bare ground is exposed. The plants are usually moderately short. Diagnostic species include; Distichlis stricta, Puccinellia airoides, Sporobolus airoides, Amphiscirpus nevadensis and Hordeum jubatum.

11. **Association** Distichlis stricta (stand 45). This association includes the salt grass dominated vegetation of salt flats throughout South Park. The stands are seasonally dry and not all stands would be jurisdictional wetland.

12. **Association** Puccinellia airoides (Stands 59, 81, 183,225). Stands of this association occur in seasonally standing water on salt flats around Antero Reservoir and Como Lake.

13. **Association** Sporobolus airoides (Stands 30,107, 225,183). This association occurs on seasonally dry salt flats that never have standing water. The water table may be close to the soil surface creating seasonally saturated conditions. The plants occur in dense tussocks.

14. **Association** Amphiscirpus nevadensis (Stands 87,102). Stands of this association were found only on the salt flats near Antero Reservoir. They have seasonal standing water and can tolerate very high salt concentrations. At wetland number 23 the water in stand x had a conductance of 26,700 umhos/cm^2 and salinity of 26 parts per thousand. No other perennial wetland plant in the study area can tolerate salt concentrations this high. The stands have very low species diversity.

15. **Association** Hordeum jubatum (Stand 223). The one stand of this association sampled was on the shores of Como Lake. The stand is seasonally or periodically inundated and experiences periodic drought when the lake dries up. Hordeum jubatum dominates the stand.

16. **Association** Pascopyrum smithii (Stands 103,118). Stands dominated by Pascopyrum smithii occur where a seasonally high water table and high salinity occurs. This is probably the least wet of all the wetland community types in the study area.

17. **Association** Triglochin maritimum (Stands 109,106, 116,239,44,51,55,78,105,106,109,116,189,237). Triglochin maritimum dominates several different types of habitats in South Park. It is abundant in salt marsh situations, but also at calcareous springs in extreme rich fens. The species is very salt tolerant and is not eliminated until the water has a salinity of greater than 30 parts per thousand, and conductance of greater than 18,500 umhos/cm^2.

18. **Association** Glaux maritimum (Stands 25,27,46, 48,83,85). This association is very common on seasonally wet flats along the South Fork of the South Platte River east of Antero Reservoir and in the vicinity of Antero Reservoir. The water table is usually high but standing water is rarely present.

Mud flats dominated by annuals

7. **Alliance** Suaeda depressa. This alliance includes the vegetation dominated by annual plants that occupy seasonally flooded salt flats. Diagnostic taxa include; Suaeda depressa, Salicornia europa and others. The seasonally deep water and/or very high salinity limits the species that can occur here.

19. **Association** Suaeda calceoliformis (Stands 47,197). Stands dominated by Suaeda are common around Antero Reservoir on seasonally wet flats. It is unclear why this species may be dominant in certain situations and why the next species and association dominant in another.

20. **Association** Salicornia europa (Stands 61,80). Stands dominated by Salicornia are extremely obvious and abundant on the salt flats around Antero Reservoir. The plants turn red in late summer and color the landscape. The stands are usually monocultures and occur on bare mud or dried and cracked mud. The plants can survive on some of the most alkaline sites in South Park. One stand at wetland number 20, located southeast of Antero had water with salinity of greater than 40 parts per thousand and conductance greater than 50,000 $mmhos/cm^2$. These are the upper limits of measurement by my field instruments.

MEADOWS

5. **Class** Juncus arcticus-Deschampsia cespitosa

5. **Order** Juncus arcticus-Deschampsia cespitosa

8. **Alliance** Juncus arcticus-Poa pratensis

21. **Association** Deschampsia cespitosa (Stands 98,146, 167,175,207). This association includes stands completely dominated by the tussock-forming Deschampsia. It occurs at extensive spring systems, such as at wetland number 32. It can also occur in the wettest portion of the meadow complexes created by irrigation.

22. **Association** Juncus arcticus (Stands 10,21,26,37,38, 39,41,53,57,63,264,71,77,88,95,100,104,108,113,114,117,119,122,12 5129,132,140,148,154,178,185,155,159,172,186,192,196,204,205,208, 212,214,219,232,233,249,250,251,256,259,260). This is by far the most common association of South Park wetland. It is always dominated by Juncus and usually has a large number of plant species associated with it, including Carex simulata, Pedicularis crenulata, Gentianopsis thermalis, .. These stands may be either natural or man-induced by irrigation. The natural stands occur where there is a high water table with only very shallow surface flooding in spring. The man-induced stands were created on natural grasslands. When irrigation is ceased most of the plants die quickly and are colonized by fringed sage (Artemisia frigida).

23. **Association** Muhlenbergia richardsonis (Stands 42,49,68,75,126,158,184). This grass-dominated association occurs on the margins of stands dominated by Juncus arcticus and never has standing water. Seasonally high water tables can occur, but the stands are dry for long periods of time during the summer. This association may also develop following the

cessation of irrigation in wet meadows. The production is very low because the leading plant species, Muhlenbergia richardsonis, is a very slender and short grass.

9. **Alliance** Pentaphylloides floribunda. This alliance is established to include the shrub dominated meadow stands in the order Juncus arcticus-Deschampsia cespitosa. The leading shrub in this alliance is Pentaphylloides floribunda, however Salix brachycarpa can also be abundant or dominant. there is usually an understory of Juncus or Poa pratensis.

24. **Association** Salix brachycarpa (Stand 152). This association is provisionally described from only one stand, located on the dryer edge of a willow carr dominated by Salix monticola. The stand is hummocky and Salix brachycarpa dominates the tops of the hummocks.

25. **Association** Pentaphylloides floribunda - Juncus arcticus (Stands 7,56,69,114,127,134,145,150,163,200). This shrub dominated association occurs on the margins of wet meadows. It usually has an understory dominated by Juncus arcticus.

10. **Alliance** Carex nebraskensis. This alliance is characterized by the dominance of the sedges Carex nebraskensis and C. lanuginosa which occur at springs and in consistently wet meadows.

26. **Association** Carex nebraskensis = (Stands 32,121). Two stands dominated by Carex nebraskensis were sampled during the summer of 1990. Both occur at low elevation near Antero Reservoir and Hartsel and occur at springs.

27. **Association** Carex lanuginosa = (Stands 28,66). This association is dominated by Carex lanuginosa and occurs at springs and seasonally flooded sites along creeks. The stands have low floristic diversity.

MIRES (FENS OR PEATLANDS)

6. **Class** Carex aquatilis - Pedicularis groenlandica. This class includes all peatlands in the Rocky Mountain region. These sites occur at high elevation (above 8,000 feet), usually have saturated soils for most of the summer, and usually occur where ground water is being discharged. Diagnostic species include; Carex aquatilis, Kobresia simpliciuscula, Trichophorum pumilum, Eriophorum caurinum, Drepanocladus aduncus, Scorpidium scorpioides, Tomenthypnum nitens, Pedicularis groenlandicum, Thalictrum alpinum and Triglochin palustre.

Rich fens

6. **Order** Carex aquatilis - Pedicularis groenlandica. This order includes the rich fens, those with circumneutral pH, low concentrations of dissolved calcium in the water and dominated by sedges or willows. These ecosystems occur at ground water discharge locations and are usually saturated for the entire growing season. Diagnostic species include; Carex aquatilis, Carex simulata, Pedicularis groenlandica, Eleocharis quinqueflora, Salix planifolia, Salix wolfii, Drepanocladus aduncus and others.

11. **Alliance** Carex aquatilis - Pedicularis groenlandica. This alliance includes the sedge dominated rich fens. Diagnostic species are; Carex aquatilis, Carex simulata, Pedicularis groenlandica, Eleocharis quinqueflora, Drepanocladus aduncus and others.

28. **Association** Carex aquatilis (Stands 2,9,15,19,23, 29,38,90,74,97,128,133,141,156,161,164,166,173,169,170,176,181,18 7,195,202,206,209,215,218,221,229,242,248,254,255). Stands assigned to this association are common in South Park occurring at ground water discharge locations. Most likely three different associations are combined here, one with an understory of the moss Scorpidium scorpioides at the most nutrient rich sites, one with an understory of Drepanocladus aduncus at rich sites, and one without a moss understory at sites with more intermittent water sources. Soils in these sites are saturated all summer and productivity is high. Species diversity may be low due to the long periods of saturation. This association may actually include several associations. For example, some stands have a complete carpet of mosses, particularly Drepanocladus aduncus and Scorpidium scorpioides. Other stands have a near monoculture of Carex aquatilis while others have a number of other species.

29. **Association** Carex simulata (Stands 22,35,13,18, 6,43,91,147,157,174,177,198,203,235,239,240,258). Stands of this association are widespread and abundant in South Park, dominating large wetlands where there is seasonal flooding or irrigation. The floristic diversity is usually low. This is an important hay producing association, one used heavily by agriculturists.

30. **Association** Eleocharis quinqueflora = (Stands 241,247). This association occurs at slowly flowing springs and is uncommon in the study area. Good stands occur at the High Creek fen. Eleocharis quinqueflora dominates throughout and may form a near monoculture.

12. **Alliance** Salix planifolia - Carex aquatilis. This alliance includes the willow dominated fens that have peat soils. The stands usually occur on the edges of valleys and where mineral rich ground water occurs.

31. **Association** Salix planifolia-Carex aquatilis (Stands 1,8,17,24,227,231). Stands of this association occur at seeps and springs, usually at high elevations in the study area. Salix planifolia and Salix wolfii are usually present. The understory is dominated by Carex aquatilis.

32. **Association** Salix planifolia-Calamagrostis canadensis (Stand 213). Only one stand of this association was found in South Park, but this association is widespread in Colorado. It occurs on the driest sites that support peat soils.

Extreme Rich Fens

7. **Order** Kobresia simpliciuscula - Trichophorum pumilum. This new order is described from stands surveyed all over the western and northern side of South Park. The water feeding these stands has dissolved calcium concentrations exceeding 20 mg/l. Free carbonates are usually seen on the soil surface and covering hummocks. Marl may be present in pools. The water source is

always ground water and the stands may occur in a matrix of drier vegetation. Character species include Kobresia simpliciuscula, Trichophorum pumilum, Carex scirpoidea, Salix myrtillifolia, and Salix candida.

13. **Alliance** Kobresia simpliciuscula - Trichophorum pumilum. This alliance includes the extreme rich fens as described for the order of this same name.

34. **Association** Kobresia simpliciuscula - Trichophorum pumilum (Stands 12,16,50,188,211,216,222,230,236,252). This association includes the tops of peat hummocks in extreme rich fens in South Park. The hummocks are usually within 12 to 16 inches of the summer water table and are thoroughly watered by capillary rise through the peat. It appears that Kobresia simpliciuscula is the hummock forming plant and creates the habitat that Trichophorum pumilum occurs on.

35. **Association** Kobresia myosuroides (Stands 52,135, 153,168,201,210,217,228,244,253). This association occurs on peat hummocks in extreme rich fens. The hummocks are drier than those of the previous association, usually occurring more than 16 inches above the summer water table. Ptilagrostis porteri frequently occurs on the hummocks with Kobresia myosuroides.

36. **Association** Carex scirpoidea (Stands 234,243). This association was found only at the High Creek Fen (wetlands number 53). It occurs where the soil is permanently saturated, but not flooded. The stands may be extensive.

37. **Association** Juncus alpinus (Stands 245,246). This association was found only at the High Creek Fen (wetland number 53). It occurred in shallow pools and depressions in stands of the last association. Only a few species occur in these stands.

38. **Association** Triglochin maritimum - Salix candida. This association occurs at High Creek fen (wetland Number 53) and the Antero Reservoir Fen (wetland 11). It occurs in the flow path of water discharged from springs.

FORESTS AND SHRUBLANDS ON LOW ELEVATION FLOODPLAINS

7. **Class** Populus deltoides - Clematis liqusticifolia

14. **Alliance** Salix exigua - Poa pratensis. This alliance includes the willow stands on low elevation floodplains.

39. **Association** Salix exigua - Poa pratensis (Stands 137,34). This association is dominated by sandbar willow (Salix exigua) and occurs on the floodplains of the larger rivers at low elevation.

SHRUBLANDS ALONG STREAMS AND SPRINGS IN THE MOUNTAINS

8. **Class** Salix monticola - Calamagrostis canadensis

8. **Order** Salix monticola - Calamagrostis canadensis

14. **Alliance** Salix monticola - Calamagrostis canadensis

40. **Association** Salix monticola - Calamagrostis canadensis (Stands 4,5,20,70,76,151,162,165,171,215,220,226). Stands of this association occur on the floodplain of streams throughout the Southern Rocky Mountains at high elevations. The shrubs are usually tall (greater than 2 meters) and dense stands

may form. Canada reed grass (*Calamagrostis canadensis*) occurs on hummocks within these stands and can be abundant.

41. **Association** *Salix monticola* - *Carex aquatilis* (Stand 130). One stand of this association was found in a wetter site than the last association occurs in.

APPENDIX 3. WETLAND FLORA OF SOUTH PARK

VASCULAR PLANT SPECIES
(difficult species identified by W.A.Weber, November 1990)

Scientific name	Common Name
Achillea lanulosa	yarrow
Aconitum columbianum	monkshood
Agrostis gigantea	redtop
Agoseris glauca	agoseris
Allium geyeri	geyer onion
Alopecurus alpinus	
Alopecurus aequalis	
Alumaster pauciflorus	aster
Alyssum sp.	alyssum
Amphiscirpus nevadensis	bulrush
Anemone sp.	windflower
Anaphalis margaritacea	
Antennaria microphyllus	small leaf pussytoes
Arabis hirsuta	arabis
Argentina anserina	potentilla
Artemisia frigida	fringed sage
Aster lanceolatus ssp. hesperius	aster
Aster occidentalis	aster
Astragalus leptophyllus	vetch
Astragalus sparsiflorus	vetch
Atriplex argentea	atriplex
Batrachium circinatum ssp. subrigidum	water buttercup
Beckmannia syzigachne	beckmannia
Betula fontinalis	river birch
Betula glandulosa	bog birch
Bistorta bistortoides	bistort
Bistorta vivipara	bistort
Boechera fendleri	mustard
Bolboschoenus (Scirpus) maritimum ssp. paludosus	alkali bulrush
Bromopsis canadesis	brome grass
Calamagrostis canadensis	canada reed grass
Calamagrostis stricta	reed grass
Campanula parryi	parry's harebell
Cardamine cordifolia	cardamine
Carex aquatilis	water sedge
Carex aurea	golden sedge
Carex capillaris	sedge
Carex dioica ssp. gynocrates	sedge
Carex disperma	sedge
Carex festivella	sedge
Carex hasseyi	sedge
Carex interior	sedge
Carex lanuginosa	sedge
Carex microglochin	sedge
Carex microptera	sedge
Carex nebraskensis	nebraska sedge
Carex norvegica ssp. norvegica	sedge
Carex parryi	parry sedge
Carex praegracilis	sedge
Carex saxatilis ssp. laxa	sedge
Carex scirpoidea	sedge
Carex simulata	sedge
Carex utriculata	beaked sedge
Castilleja sulphurea	paintbrush
Catabrosa aquatica	grass

Ceratophyllum demersum	pond hornwort
Chamerion angustifolium	fireweed
Chondrophylla aquatica	gentian
Chondrosum (Bouteloua) gracilis	blue grama grass
Cirsium arvense	canada thistle
Cirsium coloradensis	colorado thistle
Clementsia rhodantha	queens crown
Conioselinum scopulorum	umbel
Critesion (Hordeum) brachyantherum	barley
Critesion (Hordeum) jubatum	foxtail barley
Delphinium barbeyi	larkspur
Deschampsia cespitosa	hairgrass
Descurania incana	mustard
Distichlis stricta	salt grass
Dodecatheon pulchellum	shooting star
Eleocharis palustris	spike rush
Eleocharis quinqueflora	spike rush
Elymus (Agropyron) trachycaulus	thick spike wheatgrass
Epilobium leptophyllum	willow herb
Equisetum arvense	horsetail
Equisetum variegatum	scouring rush
Erigeron flagellaris	trailing daisy
Erigeron glabellus	daisy
Erigeron lonchophyllus	daisy
Erigeron peregrinus	daisy
Eriophorum angustifolium	cottongrass
Eriophorum caurianum	cottongrass
Erysimum capitatum	wall flower
Erysimum cheiranthoides ssp. altum	wall flower
Festuca arizonica	arizona fescue grass
Fragaria sp.	strawberry
Galium boreale	bedstraw
Galium trifidum	bedstraw
Gentiana affinis	gentian
Gentianopsis thermalis	fringed gentian
Gentianella stricta	gentian
Gentianella amarella	gentian
Geranium fremontii	geranium
Geum macrophyllum	large leaf avens
Glaux maritima	sea milkwort
Glyceria striata	manna grass
Hackelia floribunda	stickseed
Hectonia sceleratus	blister buttercup
Halerpestes cymbalaria ssp. saximontana	alkali buttercup
Heracleum sphondylium	cow parsnip
Hippuris vulgaris	mares tail
Hirculus prorepens	saxifrage
Iris missouriensis	iris
Iva axillaris	iva
Juncus albescens	rush
Juncus alpinus	rush
Juncus arcticus ssp. ater	wire or black grass
Juncus castaneus	rush
Juncus longistylus	rush
Juncus saximontanus	rush
Kobresia myosuroides	elk sedge
Kobresia simpliciuscula	elk sedge
Koeleria macrantha	june grass
Lepidium ramosissimum	lepidium
Limnorchis hyperborea	bog orchid
Linum lewisii	flax
Lomatogonium rotatum	white gentian

Lonicera involucrata	twin berry
Luzula parviflora	luzula
Macranthera sp.	aster
Maianthemum stellata	solomon seal
Mentha arvensis	mint
Mertensia ciliata	blue bell
Mimulus glaberatus	monkey flower
Muhlenbergia montana	mountain muhly
Muhlenbergia richardsonis	richardsons muhly
Myriophyllum sibiricum	water milfoil
Oligosporus dracunculus var. glaucus	aster
Orthocarpus luteus	owl clover
Oxytropis deflexa var. sericea	vetch
Oxytropis deflexa var. foliolosa	vetch
Oxytropis lambertii	loco weed
Packera pauciflora	packera
Packera paupercula	packera
Packera pseudaurea ssp. flavula	packera
Parnassia parviflora	grass of parnassis
Pascopyrum smithii	western wheat grass
Pedicularis crenulata	crenate lousewort
Pedicularis groenlandica	elephantella
Pedicularis scopulorum	rocky mountain lousewort
Pentaphylloides floribunda	shrubby cinquefoil
Persicaria amphibia	smartweed
Petasites sagittata	petasites
Phleum pratense	timothy grass
Picea engelmannii	engelmann spruce
Plantago eriopoda	plantain
Pneumonanthe affinis	gentian
Pneumonanthe parryi	gentian
Poa compressa	canada bluegrass
Poa juncifolia	alkali bluegrass
Poa pratensis	kentucky bluegrass
Polemonium caeruleum	jacobs letter
Populus balsamifera	balsam poplar
Potamogeton pusillus	pondweed
Potamogeton pectinatus	pondweed
Potentilla gracilis	potentilla
Potentilla hippiana	potentilla
Potentilla plattensis	potentilla
Potentilla subjuga	potentilla
Primula egaliksensis	greenland primrose
Primula incana	birds eye primrose
Psilochenia runcinata	hawksbeard
Psychrophila leptosepala	marsh marigold
Ptilagrostis porteri	porters feathergrass
Puccinellia airoides	alkali grass
Pyrrocoma clementis	sunflower
Ranunculus cardiophyllus	buttercup
Ranunculus eschscholtzii	escholtzii buttercup
Ranunculus gmelinii var. hookeri	buttercup
Ranunculus hyperboreus ssp. intertertus	buttercup
Ranunculus pedatifidus	birds foot buttercup
Ranunculus reptans	creeping buttercup
Rhinanthus minor ssp. borealis	rattle
Ribes inerme	current
Rudbeckia hirta	black eyed susan
Rumex aquaticus ssp. occidentalis	dock
Rumex triangulivalvis	dock
Salicornia europa ssp. rubra	glasswirt
Salix bebbiana	bebb willow

Salix brachycarpa	willow
Salix candida	hoary willow
Salix drummondiana	drummond willow
Salix exigua	sandbar willow
Salix lasiandra spp. caudata	tailed willow
Salix monticola	mountain willow
Salix myrtillifolia	myrtle leaf willow
Salix planifolia	plane leaf willow
Salix wolfii	wolf willow
Schoenoplectus pungens	three-square
Schoenoplectus lacustris ssp. creber	soft stem bulrush
Senecio crocatus	senecio
Senecio integerrimus	senecio
Sisyrinchium montanum	blue eyed grass
Sisyrinchium pallidum	blue eyed grass
Sparganium angustifolium	burreed
Spartina gracilis	alkali cordgrass
Spiranthes romanzoffiana	romanzoff lady treses
Sporobolus airoides	alkali sacaton
Stellaria crassipes	chickweed
Stellaria longipes	chickweed
Suaeda calceoliformis	chickweed
Swertia perennis	star gentian
Taraxacum officionale	dandylion
Thalictrum alpinum	alpine meadow rue
Thalictrum sparsiflorum	meadow rue
Thlaspi arvense	candy tuft
Thermopsis montana	mountain golden banner
Trichophorum pumilum	little bulrush
Trifolium hybridum	hybrid clover
Trifolium pratense	pasture clover
Trifolium repens	white clover
Triglochin concinna	arrow root
Triglochin maritimum	arrow root
Triglochin palustre	arrow root
Unamia alba	daisy
Utricularia ochroleuca	bladder wort
Utricularia vulgaris	bladder wort
Valeriana edule	valerian
Viola adunca	blue violet
Viola sororia	violet
Zizia aptera	zizia
Zygadenus elegens	death camus
222 species	

* All vascular plant nomenclature follows Weber, W.A. 1990. Colorado Flora: Eastern Slope, University Press of Colorado, Boulder, CO 396p.

<u>MOSSES</u>

(identified by W. A. Weber, April 1991)

Amblystegium serpens (Hedw.) Bruch & Schimp.
Aulacomnuim palustre
Campyliadelphus stellatus
Climacium dendroides
Cratoneuron filicinum (Hedw.) Spruce
Drepanocladus aduncus (Hedw.) Warnst. (several varieties)
Plagiomnium ellipticum (Brid.) Koponen
Pohlia nutans (Hedw.) Brid.
Scorpidium scorpioides (Hedw.) Limpr.

Scorpidium turgescens (T. Jens.) Loeske
Tomenthyphum nitens
Warnstorfia exannulata (Bruch & Schimp.) Loeske

* All moss nomenclature follow

APPENDIX 4. WATER CHEMISTRY DATA FOR SOUTH PARK WETLANDS

Wetland numbers are the same as appear on the data sheets and wetland maps. Water pH, temperature, conductance and salinity were measured in the field. Na was determined using atomic absorption in the laboratory and is expressed in mg/l. Some wetlands have water data for more than one stand. In many cases the dominant plant species for the wetland stand sampled is abbreviated next to the wetland number.

WETLAND #	pH	WATER TEMP	COND	SALINITY PPT	Na^{++}	
1a	6.99	15	60	0	6.6	14.1
1b	7.2	13.9	71	0	5.5	
2	7.35	8	180		30.9	
3	8		242		13.5	
3b (Carsim)	7.65	171				
4 (Car aqu-moss)	7.65		348		14.6	
4a (Car aqu)	7.8		348			
4b (Sal pla)	7.90	302				
5	8.05	16	102		13.0	
6	8.17		1,090		70.6	34.5
7	7.96	171		.5		
7a (Car aqu)	7.6	307			14.2	
7b (Sci lac)		530		.5		
8	8.13	287		.5	17.8	
9	8.65	30	1,010	1.0	73.9	b=68.9
10			1,200	1.2		
11	7.22		1,040		20.8	
11a (Sal can)	7.88		670		10.4	
12			2,130	2		
13a (Puc air)			6,500	5.9	74.3	
13b (pond)			50,000+	40+	74.6	
13c (Sal eur)			18,700	7.8	75.1	
13d (Ele pal)		4,080	3.9			
13e (Sci mar)			13,800	13.2		
14	7.96		226	.2	18.7	43.7
15a	8.06		287	.2	14.5	41.0
15b	7.08		436	.5		
16	8.01		1,090	1.9	66.2	
17a	8.28		530	.3	12.8	
17b	7.65		605	.7	19.8	
18a (seeps)	7.73	16.5	302	.5	9.5	
18b (river)	7.7	16.5	202	.5	22.8	
19	8.09	15	6800	6.1	73.3	
20a (Jun arc)	6.96		5000	6.5		
20b (Ele pal)			4000	4.2	74.0	
20c (Cer dem)			1700	1.5		
20d (Sal eur)	8.73	50,000+	40+			
21	8.1		1680	1.7	20.2	
22a	8.26		950	156.3		
22b	7.34		7010	6.5		
23a (spring)	7.97	10	2510	2.3	75.0	74.6=a
23b (Amp nev)		26,700	26			
23c (Tri mar)			10,000	9.2		
23d (Tri mar eliminated at)			18,500	30		
24a (river)	8.42		312	.5	19.2	
24b (Sci lac)		2,700	2.7			
24c (Car utr)			1,650	1.5		
27a (Jun A.smi)		23	5100	4.8	69.1	
27b (Jun C.sim)	8.28	25	2000	1.9	31.7	
27c (creek)	8.56	28	487	.5	16.0	
28 (Car utr)	7.1	19	1600	1.5	50.8	
29 (creek)	8.03	17	235	.2	14.9	

31a (Car aqu)	7.9	7	150	0	24.3	
31b (creek)	7.99	14.5	177	.2	16.1	
32 (creek)	8.25	14	219	.1	8.8	
33a (creek)	7.95	16	338	.1	13.9	
33b (Car sim)	7.62	19	429	.2	15.9	69.8
34a (creek)	7.85	9	460	.3	16.5	
34b (4 mile cr)	7.95	14	187	.5		
37 (creek)	8.2	13	192	0	10.4	
38 (creek)	7.35	14	49	0	8.2	
39	7.7	12	88	0		
40a (spring)	7.04	21	181	.1		
40b (Sal mon)		23	69	0	67.8	
41a (Car aqu)	7.29	11	320	0	24.7	
41b (Car sim)	7.65	11.5	400	0	16.8	
42a (Lrg lk)		12.3	163	0	14.6	
42b (Lk S)		10.4	333	.2	36.2	
42c (sm lk)		13.2	260	.1	9.4	
43a (creek)	8.73	16.5	237	0	14.4	
43b (Kob sim)	8.13	18.2	1220	1.0	66.3	
44 (pond)	8.6	17	220	0	14.1	
45a (Sua cal)	9.61	18	2500	2.7	76.1	
45b (creek)	8.15	12.5	182	0	10.0	
45c (Kob myo)	7.83	10	625	.6	27.1	
45d (Car aqu)	8.11	12.4	570	.5	27.0	
46 (seep)	7.87	11.5	400	.2	30.8	
47a (creek)	8.45	21.3	980	1.0	52.9	
47b (Car aqu)	7.97	16	720	.7	56.6	
48a (creek)	8.5	16	148	0	6.8	
48b (spring)	7.22	20.2	399	0	18.4	
48c (Car aqu)	7.28	6	148	0	19.4	
48d (Kob sim)	7.6	16	162	0	19.1	
49a (creek)	8.1	16	79	.1	46.6	
49b (Car utr)	7.9	23	530	.3	24.8	
49c (Car aqu)	7.27	19	620	.4	34.2	
50a (creek)	7.99	19	780	.4	36.4	
50b (Kob sim)	7.07	17.5	327	0	20.2	
50c (Car aq-mo)	7.12	17.5	232	0		
52a (creek)	7.76	8.5	112	0	12.4	
52b (Sal pl)	7.46	10	104	.1		
52c (Kob sim)	6.2	13.5	142	0	12.8	
52d (Sal pl)	6.94	13.5	93	0	24.5	
53a (Jun arc)	7.16	22	620	.2	17.9	
53c (Car sci)	7.39	23	795	.4	27.1	21.5
53d (Car sim)	7.77	22	790	.4	15.4	
53e (Kob sim)	8.53	26	510	.1		
53f (Tri mar)	7.43	23	510	.2	17.3	
53g (Utr vul)	7.79	10	2050	1.2	17.6	
53h (Tri mar)	7.12	10	397	.1	14.2	
54a (Car sim)	6.73	12	242	.1	21.7	
54b (Car Drep)		19	459	.1	24.0	
55a (spring)	6.1	9	313	.1	26.5	
55b (Spring)	7.2	24	780	.4	39.5	