EXTREME RICH FENS OF SOUTH PARK, COLORADO: THEIR DISTRIBUTION, IDENTIFICATION, AND NATURAL HERITAGE SIGNIFICANCE

Prepared for:
Park County,
the Colorado Department of Natural Resources,
and the U.S. Environmental Protection Agency

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July 30, 1996

SUMMARY

The extreme rich fens of South Park, Colorado are wetlands with organic soil supported by groundwater with very high nutrient content. These fens provide habitat for two globally rare and eleven state rare plants as well as one globally rare and nine state rare aquatic invertebrates. Two of the major plant communities in these wetlands are restricted to extreme rich fens. These plant communities are found in very few other locations in the world. Given the number of rare plants, animals, and plant communities that occur in these wetlands, extreme rich fens are clearly a natural heritage resource of local, state, and global significance.

This study was initiated with the intent of identifying the locations of all of South Park's extreme rich fens. Locations of twenty-three large and small fens covering a total of approximately 3,625 acres (1,465 hectares) were determined. A map showing these locations is included in this report. During the survey process, over one hundred new records for locations of rare and imperiled plants, animals, and plant communities were added to the Biological and Conservation Database of the Colorado Natural Heritage Program (CNHP). The twenty-three extreme rich fens known from South Park were ranked in terms of their natural heritage significance according to the CNHP's ranking methodology. The seven most biologically significant sites that contain extreme rich fens are profiled in Appendix 1.

Extreme rich fens historically covered approximately 1.4% of the land area in South Park (this is an inclusive estimate that possibly exaggerates their extent. The actual area of extreme rich fens may be less). It appears that nearly 20% of the total extreme rich fen area in South Park has been permanently lost as a result of peat mining. The extreme rich fens lost include two sites that probably were once among the best representatives of these wetland ecosystems. Alterations of hydrology, especially the building of large and small reservoirs has also adversely affected these wetlands. Water ditching and water diversions appear at this point to have had only a small deleterious effect on extreme rich fens, but long-term effects are uncertain. As water becomes a more expensive commodity in Colorado, more water diversions and removal of groundwater could become serious threats to the natural integrity of these wetlands. Heavy grazing has negatively affected extreme rich fens only very locally and mostly at small sites. In almost all cases noted, grazing effects could be reversed by altering grazing levels and timing.

This report is in part designed to serve as a guide to extreme rich fens for field workers unfamiliar with them. The report briefly contrasts extreme rich fens with the more common intermediate and rich fens of the Rocky Mountains. The appendixes present descriptions of the rare plant species as well as two other species that are particularly diagnostic of these wetlands. The three most important plant communities that occur in these fens are also described. Finally, the reader is given a list of diagnostic characteristics, including a list of plants and plant communities, water quality data, and examples of aerial photos that all indicate the presence of extreme rich fens.

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INTRODUCTION

Project Background and Purpose

The extreme rich fens[1] of South Park, Colorado, are wetland ecosystems with very high biological significance. Thirteen vascular plants and one moss associated with these fens are considered rare and imperiled by the Colorado Natural Heritage Program (CNHP 1996). Two of these plants--Porter's feathergrass (*Ptilagrostis mongholica* ssp. *porteri*) and pale blue-eyed grass (*Sisyrinchium pallidum*)--have virtually their entire world population in and near South Park. At least ten aquatic invertebrates--including one globally rare species (*Ochrotrichia susanae*, a caddisfly)--are associated with these wetlands (Durfee and Polonsky 1995). Several of the plant communities found in South Park's extreme rich fens are also globally rare (see Cooper n.d., Major and Bamberg 1967, Fertig and Jones 1992). Scientists believe with a high degree of certainty that South Park's extreme rich fens are completely unlike any other wetlands in Colorado.

The pioneer botanists Elihu Hall, J.P. Harbour, and C.C. Parry first encountered South Park's extreme rich fens during an expedition in the summer of 1862. These early travelers probably didn't realize how unusual these wetlands are. Although our herbariums still contain plant specimens from these travels, extreme rich fens went unrecognized for over 100 years.

In 1990 Dr. David Cooper of Colorado State University wrote a report detailing the results of a wetland inventory he conducted in South Park the previous year (Cooper 1990a). In this report he reported the presence of a wetland system never before described from Colorado, the "extreme rich fen." Extreme rich fens have since generated excitement within the botanical and conservation communities because of their unusual nature and their extraordinary natural heritage value for Colorado and the world.

Having realized the significance of these wetlands, several public and private entities have taken an interest in protecting this unique natural heritage resource. The government of Park County and the South Park Heritage Resource Program are interested in preserving the heritage values of the county in order to maintain the county's unique features and to promote the county as a tourist destination. The U.S. Army Corps of Engineers, the primary regulator of wetlands in Colorado, is interested in the nature and status of these wetlands in order to better process wetland permit applications. The Nature Conservancy, a private conservation organization, has already pursued protection of the best example of South Park's extreme rich fens through the purchase of High Creek Fen, a wetland system approximately 9 miles south of Fairplay.

The primary goal of this project was to identify where extreme rich fens occur, and in doing so to determine their extent and status. A secondary goal of this project and this report is to provide a guide to extreme rich fens for use by future field workers. This study does not elaborate upon the non-fen wetlands in South Park; for information on other wetlands, see Cooper (1990a).

[1] Extreme rich fens are defined later in this introduction.

This report is designed for two types of users: resource managers and field scientists. Both users will find the main report informative. It describes extreme rich fens, their natural heritage significance, and other important aspects of our work. While all the appendixes may also interest both groups of users, we recommend that after reading the main report, resource managers first direct their attention to Appendix 1. This appendix presents what we at the Colorado Natural Heritage Program believe are the seven most biologically significant extreme rich fen sites. Resource managers may also be interested in perusing the plant and plant community descriptions of Appendix 2 in order to better understand the rare and imperiled plants and plant communities that occur in extreme rich fens. However, Appendix 2 was prepared with primarily field scientists in mind. Field scientists should find this section a useful guide to the most important plants of extreme rich fens. Appendix 3 was also prepared for the field scientist. This appendix describes some basic diagnostic features of extreme rich fens that will help with their field identification.

The Study Area

South Park is one of the great intermountain basins in the Southern Rocky Mountains. It lies approximately 80 miles southwest of Denver in west-central Park County (Figure 1). South Park is bounded on the west by the Mosquito Range, on the north and northwest by the southern end of the Park Range, on the east by the Tarryall Mountains and Puma Hills, and on the south by Black and Thirtynine Mile Mountains. Tributaries of Tarryall Creek drain the northern part of the Park and the South Platte River and tributaries drain the remainder of the park (Spahr 1981). South Park extends approximately 22 miles (35 km) from east to west and 45 miles (70 km) from north to south (Cooper n.d.). The extent of South Park is conservatively estimated at about 400 square miles (1000 km^2) (Spahr 1981), while Cooper (1990a) states that the park includes approximately 700 square miles (1800 km^2). Altitudes within the park range from about 10,000 ft. (3050 m) in the north to 8,200 ft. (2500 m) in the south (Cooper n.d.).

Antero Reservoir, the location in the park with the longest history of weather data, receives around 10 inches of precipitation each year, with approximately 40% of this falling as rain in July and August. Average and maximum temperatures are, respectively, 13°F and 31° in January and 58° and 75°F in July (Owenby and Ezell 1992).

South Park has a long and varied geologic history[2]; two large events in this history are particularly important to a thorough understanding of extreme rich fens. The first important event was the frequent inundation of the area by a shallow sea during the late Cambrian (approximately 525 million years ago). Advancing and retreating seas deposited a series of sediments now present as limestone and dolomite in the western part of the Park and on the flanks of the Mosquito Range (Stark et al. 1949). These rocks of oceanic origin contain high levels of calcium, magnesium and other minerals, all of which occur in high levels in extreme rich fens and are very important to the presence of the plants that grow there. Rocks with this mineral content are very unusual at high elevations in Colorado (for example, the mountains on the east side of South Park are composed of granitic rocks).

[2] For an especially clear and comprehensive description of South Park's geologic history see the summary on pages 132-149 in Stark et al. (1949).

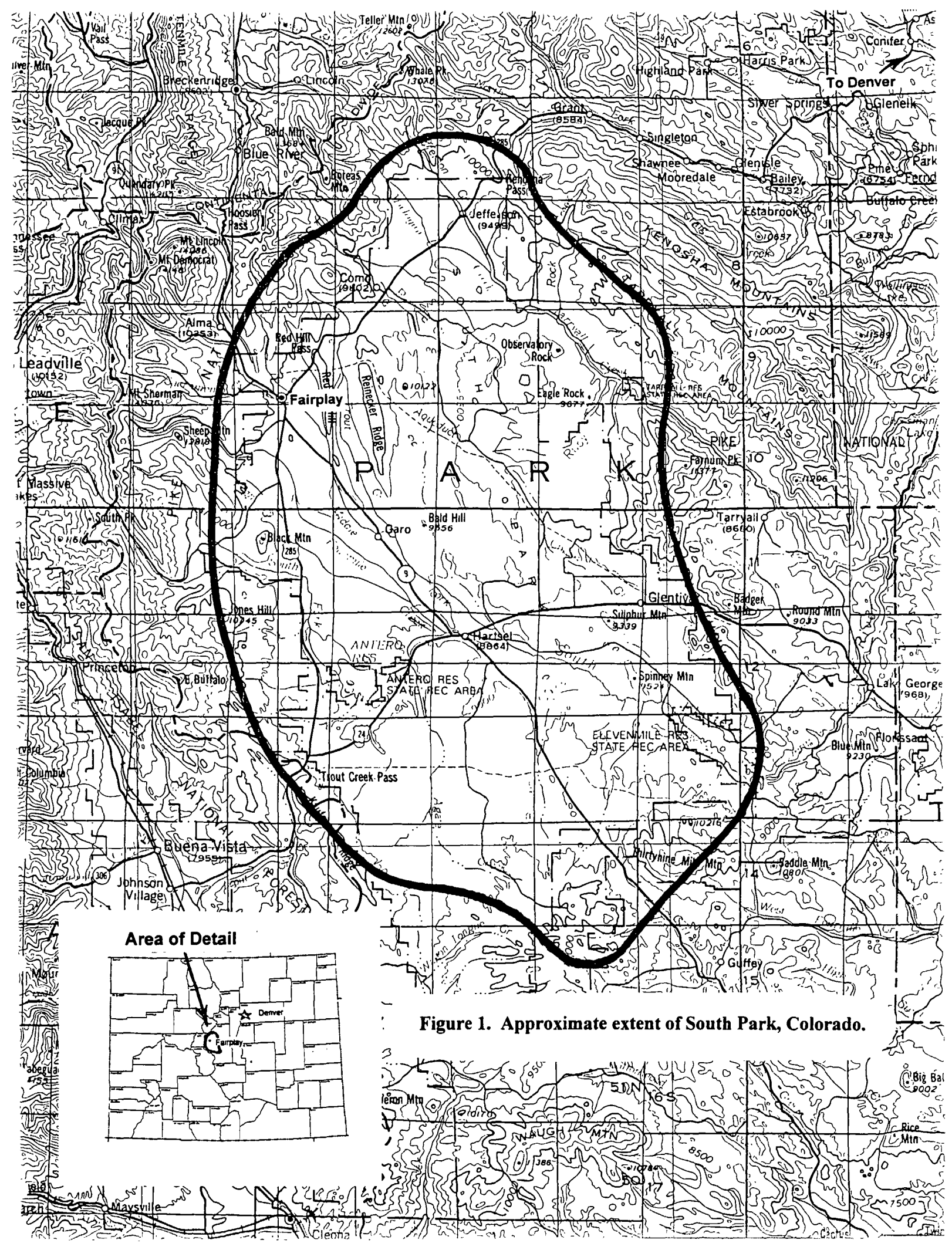

Figure 1. Approximate extent of South Park, Colorado.

The second event, Pleistocene glaciation, occurred much more recently in the history of the park, from 1.6 million to a little as 13,000 years ago. During the Pleistocene, glaciers flowed down to the base of the Mosquito Range, and in some places slightly into the park. Voluminous rivers pouring from these glaciers deposited tremendous amounts of boulders, gravel, and finer sediments throughout the park, with especially thick deposits in the western portion of the park. Through this process of sedimentation, copious amounts of the minerals mentioned above (calcium, magnesium, etc.) were distributed in the park. It is the minerals in these glacial deposits that create the unusual water chemistry of these wetlands.

In addition to the generally cool climate and the unusual geology of the area, one other aspect of South Park is very important with respect to the extreme rich fens: hydrology. Despite low precipitation, extreme rich fens remain saturated to the soil surface most of the growing season. Much of the water that keeps them wet originates as precipitation in the mountains to the west of the park, percolates into the ground (where it dissolves and entrains calcium, magnesium, and other minerals), then re-emerges to the surface at the extreme rich fens. The glacial material that blankets much of South Park, with its large capacity for storing and conducting water, allows this water in many instances to reach far out into the relatively flat portions of the park before discharging to the surface. Once at the surface, South Park's water drains generally southeast until it leaves the park, flowing in the South Platte drainage in the south end of the park, and via Tarryall Creek and its tributary creeks in the north end of the park.

While this report focuses exclusively on extreme rich fens, there are many other types of wetlands that occur in South Park. Cooper (1990a) lists these types as:

1. Rooted aquatics in pools with mud bottoms.
2. Rooted aquatic vegetation of slow streams and ponds.
3. Reed swamps in standing water dominated by cattail, bulrush, and large sedges.
4. Salt marshes and salt flats (mainly near Antero Reservoir).
5. Wet meadow.
6. Mires (i.e., peatlands, including extreme rich fens).
7. Forest and shrublands along floodplains of low elevation streams.
8. Shrublands along streams in the mountains.

See Cooper's report for a description of all these types.

Extreme Rich Fens

Scientists call both fens and bogs "peatlands." Peatlands are wetlands with soils that consist of at least 25% organic matter (i.e., undecomposed leaves, stems, etc.). They form where the rate of plant growth exceeds the rate of litter decomposition. Both saturated soils and cool climates contribute to the conditions necessary for peatland formation.

Fens are peatlands that remain saturated primarily as a result of water percolating up from the ground with some contribution from surface water runoff. All peatlands in Colorado are properly classified as fens. Bogs are peatlands that receive water primarily from rain and snow. Colorado's dry climate precludes the formation of bogs.

Before settlement wetlands covered only 1-2% of Colorado (Jones and Cooper 1993), and fens are a small fraction of total wetlands. Despite their small total area, fens are a relatively common montane feature, found usually between 8,000 and 12,000 feet in elevation, occurring throughout Colorado and the Rocky Mountains (Cooper 1990a). To most of these fens, biologists apply the adjectives "intermediate" or "rich" (Cooper n.d.). These terms do not refer to the number of species in the wetland. They refer instead to the levels of nutrients (calcium, magnesium, etc.) in the water. Intermediate and rich fens are found in river basins, on seepy slopes, and in small, water-filled depressions formed by glaciers. Intermediate and rich fens typically are dominated by beaked sedge (*Carex utriculata*), water sedge (*Carex aquatilis*), and diamondleaf willow (*Salix planifolia*). Their pH tends to be near neutral (7.0) or slightly acidic (less than 7.0). The peat soils in these range from shallow (less than 1 meter) to moderately deep (up to 4 meters).

In contrast to the wide distribution of intermediate and rich fens, extreme rich fens appear restricted to a small area in Colorado, primarily the west and north portions of South Park. Even on a global basis extreme rich fens appear to be quite uncommon. Only three other small locations of extreme rich fens exist in the Western U.S.: in northwestern Montana (Lesica 1986), in California at Convict Creek Basin (see Major and Taylor 1977), and in northwestern Wyoming (Fertig and Jones 1992). They are also known from the eastern foothills of the Rocky Mountains in Canada (Slack et al. 1979, Karlin and Bliss 1984), from northern Ontario (Sjörs 1961), and from Scandinavia (Nordqvist 1965). Only the Wyoming and California sites appear to be floristically similar to the South Park extreme rich fens.

As with the intermediate and rich fens, "extreme rich" in the name of these wetlands refers to the chemical content of the water, not to species richness or community diversity (Cooper n.d.). The levels of calcium, magnesium, and other plant nutrients in the groundwater that feeds this system are very high (see Table 1 (next page) and Table 18 (page 90)). The groundwater picks up these elements as it percolates through the glacial deposits derived from the Mosquito Peaks. As a result of the copious supply of elements in water, the water that feeds South Park's extreme rich fens is very basic (high pH) relative to other montane fens.

Peat accumulates slowly in all southern Rocky Mountain peatlands, but the rate of accumulation in extreme rich fens--as low as 4 inches per thousand years (Cooper 1990b)--is exceedingly slow. This slow rate is in part a result of the dry climate in South Park. Total precipitation in South Park is lower than the montane and subalpine areas where most southern Rocky Mountain peatlands occur. Also, contrary to what might seem intuitive, the extreme nutrient rich nature of these peatlands makes growing conditions for plants generally worse, not better, and this probably lowers plant productivity. Many plants cannot grow well at very high pH levels because certain essential nutrients are locked up in the soil. Since peat accumulation rates result from a combination of saturated conditions and plant productivity, the rate is low in extreme rich fens.

Because peat accumulation rates are so slow, the depth of peat in extreme rich fens tends to be less than that in rich fens. The slow accumulation rates also suggest that extreme rich fens cannot be restored to historic conditions after massive disturbance in any time period relevant to humans.

Table 1. Comparison of rich and extreme rich fens in and near South Park.*

	Rich Fen	Extreme Rich Fen
Peat depth	Moderate: up to 12 ft. (4 m)	Thin: typically less than 5 ft. (1.5 m) in deepest spot, often 3 ft. (1 m) or less
Peat accumulation rate	Moderate: 10-16 in. (25-40 cm) per thousand years	Slow: 4.3 in.(11 cm) per thousand yrs. at High Creek Fen
pH	Around neutral or slightly acidic (6.0-7.6)	Basic (7.4-8.6)
Calcium content of water	Moderate: 1.5-2.5 mg/l	High: 15-95 mg/l
Important plants	Planeleaf willow, Beaked sedge, Water sedge	Hoary willow (state rare), Simple kobresia (typically alpine), Bellardi kobresia (typically alpine)

*Numbers based on Cooper (1990b) and 1995 field work.

The unusual water chemistry of extreme rich fens lends them one of their most important characteristics: they provide habitat for many rare plants, animals, and plant communities. Porter's feathergrass (*Ptilagrostis mongholica* ssp. *porteri*) and pale blue-eyed grass (*Sisyrinchium pallidum*) are both globally rare plants. Porter's feathergrass is known from only 25 locations in the world, all in or near South Park. The most extensive occurrences of this species are in extreme rich fens in northern South Park. Pale blue-eyed grass was recognized as a distinct species only a decade ago. The first description of the species was made from a specimen collected east of Antero Reservoir. Although not rare in South Park, this species is globally restricted to central and northern Colorado and southern Wyoming.

Eleven other vascular plant species and one moss that are very rare in Colorado also occur in South Park's extreme rich fens (see Table 4 in the Results section). Some of these (e.g., Canadian single-spike sedge) are locally common in South Park, but are absent from the rest of Colorado, while others are rare throughout South Park and the rest of the state. Most of these

state rare plant species are not globally imperiled, but are disjunct populations extremely far removed from their usual far-north (boreal) distribution.

It is not surprising that extreme rich fens support rare plant communities in addition to rare plants. Three of these communities are described in Appendix 2 of this report. The dominant plants in two of these communities, simple kobresia (*Kobresia simpliciuscula*) and Bellardi kobresia (*Kobresia myosuroides*), typically occur above treeline. These plant communities occur in very few other places in the world. The third plant community occurs more commonly on a global basis, but is uncommon in Colorado and is a useful indicator of extreme rich fens.

Plants and plant communities are not the only rarities that survive in the unusual habitat provided by South Park's extreme rich fens; rare aquatic and semi-aquatic macroinvertebrates also live in these wetlands. In High Creek Fen, South Park's best example of an extreme rich fen, Durfee and Polonsky (1995) collected nine aquatic beetles that have been found nowhere else in Colorado. Five of these beetles had been reported from adjacent states, thus, their documentation in Colorado was not unexpected. However, the discovery of four of the nine beetles at High Creek Fen represents a considerable southern range extension. As with the plants, these occurrences are far removed from the more typical boreal populations of these species. These researchers also collected a caddisfly (*Ochrotrichia susanae*) that is known from only one other location in the world (also in Colorado).

A rare snail, the glass physa (*Physa skinneri*), is also believed to be associated with extreme rich fens. It would not be surprising to find that this same pattern of rarity among invertebrates also extends to terrestrial invertebrates, especially butterflies (Order Lepidoptera).

METHODS

Survey Site Selection and Visits

Site selection was based on the goal of visiting every extreme rich fen location in South Park. Initial information about known locations of extreme rich fens was obtained from Cooper (1990a), which indicated locations of extreme rich fen plant communities, and the Colorado Natural Heritage Program Biological and Conservation Data System (CNHP 1996), which provided locations of rare plants associated with extreme rich fens. A conversation with Cooper (pers. comm.) yielded more information about actual and potential locations. The Colorado Natural Areas Program (J. Coles, pers. comm.) also provided general information on potential fen locations.

With this baseline of information, the locations of sites to be targeted for inventory were refined using U.S. Geological Survey 7.5' orthophotos, U.S. Geological Survey 7.5' topographic maps, and 1:12,000 color IR photographs provided by the U.S. Forest Service and the U.S. Army Corps of Engineers. A low-level flight over the study are in mid-summer information added more information on known and potential locations. Some wetlands not designated as "targeted" inventory sites were visited through invitation by the landowner--in two of three cases these proved to have small extreme rich fens on the site that were too inconspicuous to be perceived on aerial photos.

Thirty-one sites were targeted for inventory. Only one of these sites was on federal land, so field personnel requested permission to access the remaining thirty. For various reasons we did not receive permission to access all or part of the targeted site in eight of the thirty locations. In cases where we were unable to access the property, assessments were made from the nearest accessible location or conclusions were drawn based only on available information.

Extreme Rich Fen Identification

Extreme rich fens were identified based primarily on the presence of plants and plant communities that are strongly correlated with the high pH, high conductivity, and high levels of nutrients in the discharging groundwater (e.g., *Salix candida, Scirpus rollandii, Kobresia simpliciuscula–Scirpus rollandii* plant association, and *Kobresia myosuroides–Thalictrum alpinum* plant association). Although no precise taxonomic definitions of these plant association exist, in almost all cases, the experienced observer recognizes readily the extreme rich fen communities. Diagnostic features that can be used by field personnel less experienced with extreme rich fens are described in Appendix 3.

Mapping

Approximate boundaries of extreme rich fens were sketched on 7.5' USGS during field visits. Fen boundaries were later modified by comparing field notes and sketches to 1:12,000 color IR photos printed at approximately 1:24,000 (the same scale as the topographic maps). As noted earlier, these boundaries are only approximate, because determination of the fen/non-fen

boundary is very difficult with the aerial photos at hand. The boundaries shown should be considered approximate only. A dot map showing general fen locations is included in the results (Figure 2). A 1:100,000 scale map with approximate fen boundaries drawn is included in an envelope on the back cover of this report (Figure 2A). These boundaries should in no way be interpreted as jurisdictional boundaries, nor even wetland boundaries--they are intended only to illustrated approximate boundaries of known extreme rich fens. In addition to approximate fen boundaries in Figure 2A, site boundaries for the seven most significant fen sites are shown on 7.5' USGS topographic maps in Appendix 1. The site boundaries in Appendix 1 show the area believed necessary to protect the extreme rich fen and associated plants and animals. The boundaries do not indicate the extent to the fens.

The total area covered by extreme rich fens was approximated with planimeter measurements of the areas shown on Figure 2A. The area of each site of biological significance was measured with a planimeter directly from the maps included for each site.

Colorado Natural Heritage Program Ranks

Each of the species and plant communities tracked by the Colorado Natural Heritage Program (CNHP) is an element of natural diversity, or simply an element. Each element is assigned a rank that indicates its relative rarity or degree of imperilment on a five-point scale (1 = extremely rare and/or imperiled; 5 = abundant and demonstrably secure; see Table 2 below). These ranks are at the core of the Heritage Program methodology; they permit a standardized approach to assessing conservation priorities. In this report Heritage Program ranks are used in Appendix 1 and Appendix 2.

The primary criterion for ranking elements is the number of occurrences, i.e. the number of known distinct localities. Also of great importance is the number of individuals at each locality or, for highly mobile organisms, the total number of individuals. Other considerations include condition of the occurrences, number of protected occurrences, threats, and historic distribution. However, the emphasis remains on the number of occurrences such that ranks are an index of known biological rarity. These ranks are assigned both in terms of the element's rarity within Colorado (its State or S-rank) and the element's rarity over its entire range (its Global or G-rank). Taken together, these two ranks give an instant picture of the rarity of the element. Although most species protected under state or federal endangered species laws are extremely rare, not all rare species are legally listed as endangered or threatened. Natural Heritage rarity ranks should not be interpreted as legal designations.

Two other Natural Heritage Program ranks apply to the location where an element is found. Element occurrence (EO) ranks indicate the quality, condition, defensibility, and viability of any one location of a particular element. Biodiversity ranks (B-ranks) indicate the relative natural heritage significance of a site where an element occurs. B-ranks are a function of both rarity ranks and element occurrence ranks. Explanations of Heritage Program ranks are given below in Table 2.

Table 2. Colorado Natural Heritage Program Ranks.

Note: These ranks should not be interpreted as legal designations.

Rarity Ranks (applied to an element only)

S1(G1)	Extremely rare: usually 5 or fewer occurrences in the state (world); or simply a few remaining individuals; often especially vulnerable to extirpation.
S2(G2)	Very rare; usually between 5 and 20 occurrences in the state (world); or with many individuals in fewer occurrences; often susceptible to becoming endangered.
S3(G3)	Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.
S4(G4)	Common; usually > 100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.
S5(G5)	Very common; demonstrably secure under present conditions.
S?(G?)	Unranked; some evidence that element may be imperiled, but awaiting formal rarity ranking.
SU(GU)	Status uncertain, often because of low search effort or cryptic nature of the element.
T	Used to indicate the status of a subspecies or variety. These taxa are ranked using the same criteria as for G and S ranks.

Notes: When a question mark follows a numerical rank (e.g., S2?), it indicates uncertainty about the accuracy of this rank. When two numbers appear in a state or global rank (e.g., S2S3), the actual rank of the elements falls between the two numbers. When a 'Q' follows a rank, it indicates uncertainty about the taxonomic status of the element.

Element Occurrence ranks (applies to the site where an element occurs)

A	The occurrence is relatively large, pristine, defensible, and viable.
B	The occurrence is small but in good condition, or large but removed from its natural condition and/or not viable and defensible.
C	The occurrence is small, in poor condition, and possibly of questionable viability.
D	The occurrence does not merit conservation efforts because it is too degraded or not viable

Biodiversity ranks (applies to the site where element(s) occurs)

B1	Outstanding biodiversity significance, for example, the best occurrence of a G1 element.
B2	Very high biodiversity significance, such as the best occurrence of a G2 or G3 element.
B3	High biodiversity significance, such as C-ranked occurrences of G2 or G3 elements, or A-ranked occurrences of G5S1 elements.
B4	Moderate biodiversity significance (not used in this report).
B5	Of general conservation interest (not used in this report).

RESULTS

Locations of Extreme Rich Fens

Most extreme rich fens in South Park are distributed in the western portion of the park, north of Antero Reservoir. The area between the base of the mountains on the west side of the park and a line drawn from Kenosha Pass to Antero Reservoir includes nearly all the extreme rich fens in South Park. This distribution is strongly related to the hydrologic patterns of the area, the proximity to the Mosquito Peaks, and the distribution of glacial till and outwash in the park. Most of the fens are located at the base of the mountains, where the steep slope grades into shallow slope. However, several fens, even large ones (High Creek Fen, Antero Reservoir) occur out in the park, away from the base of these slopes. Small fens are scattered throughout the park, predominantly along creeks. It is likely that many more small fens exist that were not discovered during this study.

The locations of the twenty-three large and small documented extreme rich fens are shown in Figure 2. These same fens are shown in more detail with approximate boundaries in Figure 2A, a 1:100,000 scale map enclosed in an envelope inside the back cover of this report. Extreme rich fens were considered separate when some reasonable discontinuity occurred between them. In some cases (e.g., the Jefferson/Guernsey Creek Site), relatively distinct fens are lumped together into one "site." The twenty-three fens reported here represent an increase over the ten reported by Cooper (1990a). This increase is in part due simply to counting fens as separate when they are near each other (versus calling them a single fen). It is also due to the discovery of several additional small fens and the confirmation of one large fen that Cooper anticipated but was unable to confirm due to a lack of access.

Status and Trends

Several of the major extreme rich fen systems in South Park have been heavily impacted by human activities. In several cases the important habitat has been completely destroyed or irreversibly altered, mainly by extensive peat mining. Using a planimeter to measure the total extreme rich fen area in Figure 2A, we determined these wetlands (including mined an unmined) cover approximately 3,625 acres (1,465 hectares). If we use Spahr's (1981) conservative estimate of the extent of South Park (400 square miles), then the 3,625 acres (1,465 hectares) of extreme rich fens cover 1.4% of the park. By carefully measuring mined areas at each fen site, we determined that nearly 20% of the extreme rich fen area in South Park has been destroyed by peat mining. Currently approximately 2,900 acres (1,175 acres) of extreme rich fen, just over 1% of the area of South Park, remains intact.

It is difficult to obtain an accurate assessment of the total area of extreme rich fen in South Park because with the photos available (1:12,000 scale Color Infra-red) the difference between extreme rich fen and moderate to rich fen is difficult to discern from aerial photos. It is sometime even difficult to differentiate fen and non-fen wetlands. Our estimate may also be in error because we have not included all of the extreme rich fens in South Park. However, during the demarcation of extreme rich fens in Figure 2A, we tended to include areas of uncertainty, so

the areas indicated probably over-estimate the actual area. Also, if any fens were not included on this map, they are probably small and not an important percentage of the total fen area (i.e., we believe all of the large extreme rich fen systems in South Park are represented in Figure 2A).

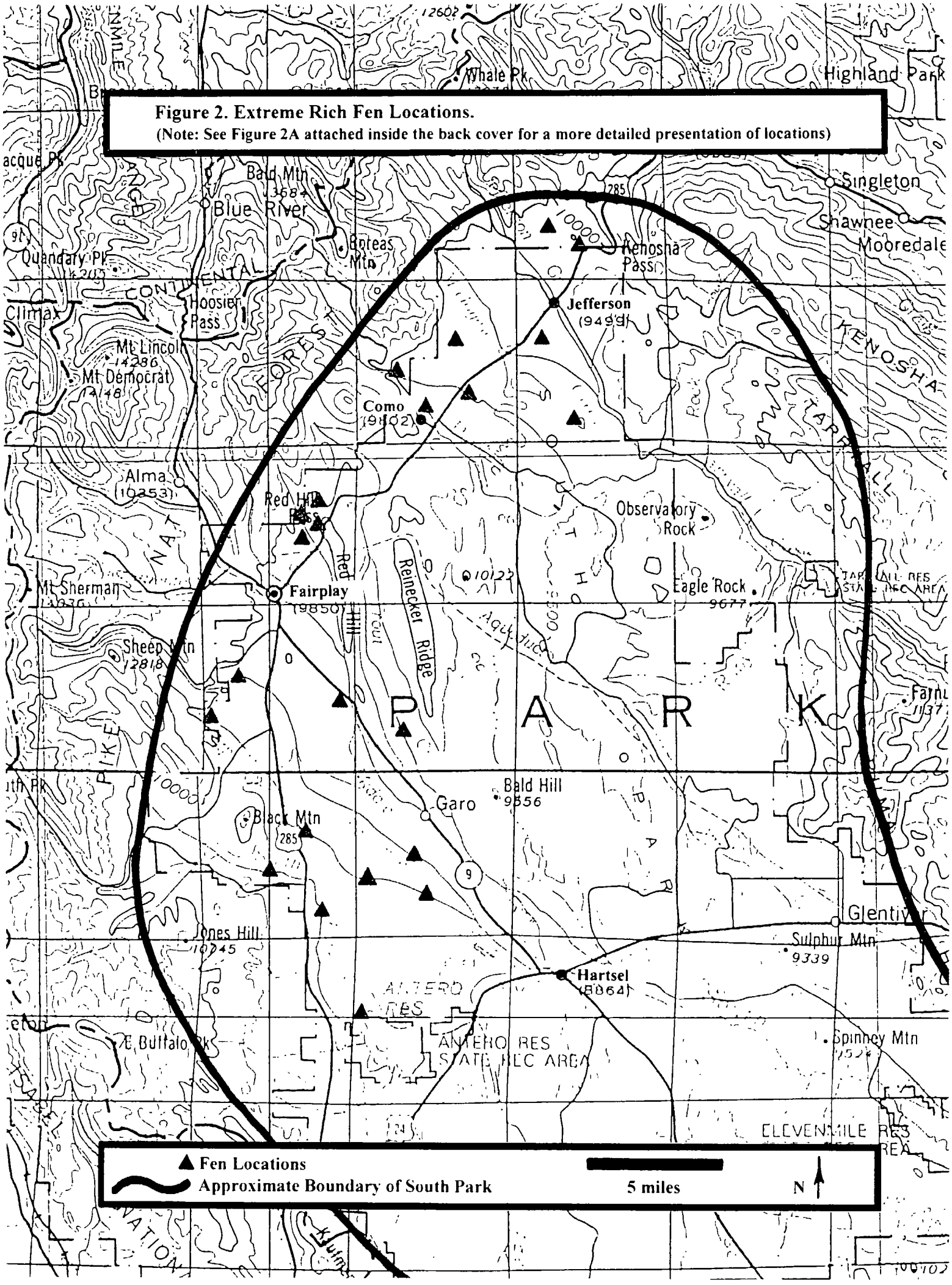
Figure 2. Extreme Rich Fen Locations.
(Note: See Figure 2A attached inside the back cover for a more detailed presentation of locations)
Whale Pk
Highland Park
Bald Mtn
Blue River
Singleton
Shawnee
Mooredale
Quandary Pk
Boreas Mtn
Kenosha Pass
Jefferson
Climax
Hoosier Pass
Mt Lincoln
Mt Democrat
Como
Alma
Red Hill
Observatory Rock
Mt Sherman
Fairplay
Reinecker Ridge
Eagle Rock
Sheep Mtn
Bald Hill
Garo
Black Mtn
Jones Hill
Sulphur Mtn
Hartsel
Antero Res
Antero Res State Rec Area
E Buffalo Pk
Spinney Mtn
Eleven Mile Res
Fen Locations
Approximate Boundary of South Park
5 miles
N

The single greatest impact on fens has resulted from peat mining. It appears that nearly 20% of the total extreme rich fen area in South Park has been destroyed by peat removal.

Building of stock ponds and reservoirs has destroyed extreme rich fens in some areas by inundating the vegetation and radically changing the hydrologic regime. Antero Reservoir, for example, inundated and destroyed an unknown amount of a well-developed extreme rich fen. Another significant percentage of fens has been adversely affected by heavy grazing during the growing season. Occurrences affected by heavy grazing are generally small occurrences near limited water sources such as the lower parts of High Creek and Fourmile Creek. Larger extreme rich fens tend to be less impacted by grazing because of more abundant water supplies. With sufficient water and pasture elsewhere, cattle generally do not heavily utilize the peatlands.

The straightening and diverting of streams and the digging of ditches have also impacted extreme rich fens. In several areas, ditches have been dug directly through a peatland either to drain the peat or to facilitate flow throughout the peatland. The most profound effect of digging a ditch has been simply the direct removal of the vegetation. The effects of changes in the hydrologic regime are less clear. In some areas the peatland vegetation appears to be unaffected by a ditch in close proximity. In terms of total area affected, stream manipulation appears to have had the least impact to date of all threats to these wetlands, but potential future impacts remain.

It appears that no significant amounts of groundwater are pumped in South Park, thus wells have not had a great impact on extreme rich fens. Groundwater removal remains an important long-term threat to these wetlands.

Rare Plants and Plant Communities

Fourteen rare plant species and two important rare plant communities occur in South Park's extreme rich fens. In total, over 100 new occurrence records for these elements were documented during this study. The locations and site information from all of these occurrences have been entered in CNHP's Biological and Conservation Database for use in future planning and tracking efforts. In order to facilitate identification of these rare plants and communities, guides to habit, habitat, and distribution as well as an illustration are included in Appendix 2. This appendix also includes two species and one community that, while not considered rare, serve as diagnostic features of South Park's extreme rich fens.

Two globally rare plants have been documented from South Park's extreme rich fens: Porter's feathergrass and pale blue-eyed grass (Table 3). Two new locations were discovered for Porter's feathergrass and many more records of pale blue-eyed grass. These additions in conjunction with existing data on these species provide further evidence that South Park contains most of the global population of both of these species, and that the wetlands of the area continue to be important to both species. Extreme rich fens are particularly critical to the long-term viability of Porter's feathergrass.

Table 3. Globally rare plants of South Park's extreme rich fens

Common Name	Scientific Name	Heritage Program Rank*
Porter's feathergrass	*Ptilagrostis mongholica* ssp. *porteri*	G2T2S2
Pale blue-eyed brass	*Sisyrinchium pallidum*	G2G3S2S3

*see Table 2 in the Methods section for a description of Heritage Program ranks.

In addition to the globally rare plants, twelve state rare plants have been documented from South Park's extreme rich fens (Table 4). Many new locations were recorded for most of these species. Canadian single-spike sedge, Greenland primrose, pygmy bulrush, hoary willow, and few-flowered ragwort were all frequently found in extreme rich fens and associated wetlands. However, it should be kept in mind that these habitats are the sole locations in Colorado for *all* of these species.

Table 4. State rare plants of South Park's extreme rich fens.

Common Name	Scientific Name	Heritage Program Rank*
Livid sedge	*Carex livida*	G5S1
Canadian single-spike sedge	*Carex scirpoidea*	G5S1
Green sedge	*Carex viridula*	G5?S1
Slender cottongrass	*Eriophorum gracile*	G5S2
Greenland primrose	*Primula egaliksensis*	G4S2
Hoary willow	*Salix candida*	G5S2
Low blueberry willow	*Salix myrtillifolia*	G5S1
Autumn willow	*Salix serissima*	G4S1
Pygmy bulrush	*Scirpus rollandii* (=*Trichophorum pumilum*)	G2G3QS1
Few-flowered ragwort	*Senecio pauciflorus* (=*Packera pauciflora*)	G4G5S1S2
Northern bladderwort	*Utricularia ochroleuca*	G4?S1?
A moss	*Scorpidium scropioides*	G4G5S?

*see Table 2 in the Methods section for a description of Heritage Program ranks.

Two important globally rare plant communities have also been documented from the extreme rich fens (Table 5). There are several more wetland communities in South Park that occur primarily in extreme rich fens (see Cooper n.d.), and some of these may also be globally rare. Only two of these potentially rare communities are highlighted in this report because they epitomize extreme rich fens and are consistently found in these wetlands. At least one, and often both, of these communities occurs in virtually all extreme rich fens. The known locations of these communities have all been entered into CNHP's Biological and Conservation Data System.

Table 5. Important globally rare plant communities of South Park's extreme rich fens.

Common Name	Scientific Name	Heritage Program Rank*
Extreme rich fen	*Kobresia simpliciuscula–Scirpus rollandii* plant association	G2S1
Extreme rich fen	*Kobresia myosuroides–Thalictrum alpinum* plant association	G1S1

*see Table 2 in the Methods section for a description of Heritage Program ranks.

Durfee and Polonsky (1995) demonstrated that extreme rich fens also provide habitat for state and potentially globally rare invertebrates (Table 6). Their work was done only at High Creek Fen. No similar work was performed as a part of this study, but their results are so important for the further understanding of extreme rich fens that they are included here. Based on CNHP records (1996), the state rare glass physa (*Physa skinneri*), is also believed to be associated with extreme rich fens.

Table 6. Rare invertebrates at High Creek Fen.

Common Name	Scientific Name	Heritage Program Rank*
An aquatic beetle	*Agabus bifarius*	G?S1?†
An aquatic beetle	*Rhantus suturellus*	G?S1?
An aquatic beetle	*Hydroporus despectus*	G?S1?
An aquatic beetle	*Hydroporus notabilis*	G?S1?
An aquatic beetle	*Hydroporus paugus*	G?S1?
An aquatic beetle	*Hydroporus tenebrosus*	G?S1?
An aquatic beetle	*Helophorus sempervarians*	G?S1?
An aquatic beetle	*Helophorus angusticollis*	G?S1?
An aquatic beetle	*Haliplus salinarius*	G?S1?
A caddisfly	*Ochrotrichia susanae*	G1?S1?
Glass physa	*Physa skinneri*	G?S2

* see Table 2 in the Methods section for a description of Heritage Program Ranks.

† Since the presence of these species in Colorado was only recently brought to the attention of CNHP, their rank is still uncertain.

DISCUSSION

The Natural Heritage Significance of Extreme Rich Fens

The past several years of research in South Park's extreme rich fens has demonstrated clearly that these wetlands have extraordinarily high natural heritage value. These fens contain 14 rare plants, at least 11 rare invertebrates, and two major rare plant communities. Their value as a unique piece of South Park's and Colorado's natural heritage is undeniable: they are unlike any other wetlands in the state and similar to few others in the western U.S. Their importance extends even to the global scale. Two globally rare plant communities, two globally rare plants, and possibly one or more globally rare invertebrates make these wetlands significant on a national and global basis.

Globally Rare Plants

Two globally rare plants, pale blue-eyed grass (*Sisyrinchium pallidum*) and Porter's feathergrass (*Ptilagrostis mongholica* ssp. *porteri*), have the core of their distributions in South Park. As a result of their distributions, protection of their habitat in South Park is essential to the long-term viability of these species.

Protection of extreme rich fens is particularly important for Porter's feathergrass, because this species occurs only in peatlands. Among wetlands in South Park, it is restricted to extreme rich fens north of Como (i.e., in the north end of the park). Nine occurrences of Porter's feathergrass are known from South Park. Although there are twenty-five known occurrences of this plant (all of them in Colorado), by far the most extensive occurrences are in South Park.

The most significant occurrence of Porter's feathergrass, and the associated *Kobresia myosuroides–Thalictrum alpinum* community, is located at the Fremont's Fen Site. This site may contain more plants than all other occurrences combined (Cooper 1990a). With peat having been removed from several hundred acres of land, we can confidently surmise that many extreme rich fen plants and communities were destroyed, potentially including a significant portion of the global population of Porter's feathergrass.

Pale blue-eyed grass was first described as a distinct species only twelve years ago by Cholewa and Henderson (1984). The original descriptions of this species were made from a collection taken east of Antero Reservoir. Unlike Porter's feathergrass, pale blue-eyed grass is not restricted to extreme rich fens, but it does occur in many of them. While not restricted to extreme rich fens, this species does have a strong affinity for South Park's alkaline wet meadows.

As with Porter's feathergrass, pale blue-eyed grass is restricted to the southern Rocky Mountains. It is found in southern Wyoming and northern Colorado, but the vast majority of its occurrences are in South Park. A tour of South Park's wetlands suggests the species is rather common, but it should be remembered that these occurrences represent the greater part of the **global** distribution.

Pale blue-eyed grass occurrences in South Park may have expanded over the last century as extensive formerly upland areas were heavily irrigated, but more recently irrigation has been taken off many of these upland areas. One of the greatest threats to this species in addition to peat mining is the loss of its wet meadow habitats, especially natural wet meadows, as dewatering of wetlands continues in South Park (Cooper 1990a).

State Rare Plants

South Park's wetlands, especially the extreme rich fens, contain an extraordinary number of state rare plant species. These species are all apparently or demonstrably secure on a global basis (CNHP Ranks of G4 and G5), but several of them are extremely far removed from their core populations. The disjunct nature of the populations in South Park greatly increase the biodiversity significance of these occurrences.

Low blueberry willow (*Salix myrtillifolia*), for example, is known from only two areas in the western United State: South Park and northwest Wyoming. Over 450 miles separate the South Park plants from the plants in Wyoming, which are similarly far removed from the northern core distribution of this species. Cooper (1990a) hypothesizes that the South Park occurrences are relicts from the most recent glacial period when more northern plants dominated the region. Because the Colorado populations are so distant from the next nearest population, there is likely no exchange of genetic material between them. As a result, there is a theoretical possibility that eventually the characteristics of the South Park population and populations elsewhere will diverge and the populations will become distinct species.

Theoretical evolutionary possibilities aside, these disjunct species are a very unusual piece of Colorado's and South Park's natural heritage. They also represent the glacial episodes that dramatically altered Colorado's natural history.

Rare Plant Communities

The rare plant communities found in extreme rich fens serve as powerful indicators of the unique nature of these wetlands. The two extreme rich fen communities and the one alkaline spring community discussed in this report appear as a result of the very high nutrient content of the water, the perennially saturated ground, and the other environmental conditions in the fens. Thus, these communities integrate and manifest the rare biophysical setting of these wetlands. By targeting these rare communities for conservation, we protect known and potential habitat for rare species, even without knowing for certain if rare species occur on the site. For example, protecting High Creek Fen also protected the rare invertebrates in the wetland even before we knew they existed. Habitat is the level on which conservation of these wetlands should occur, and plant communities provide a useful tool for categorizing habitats.

Rare Invertebrates

Durfee and Polonsky (1995) clearly demonstrated the state and potential global importance of extreme rich fens to aquatic macroinvertebrates. Although they studied only High Creek Fen, it

is highly probable that the patterns they uncovered also appear in other extreme rich fens of South Park. It is also quite possible that the pattern of global rarity and extreme population discontinuities also appears among terrestrial invertebrates. More work needs to be done with respect to the distribution of this invertebrates across South Park and terrestrial invertebrates.

Conservation Issues

Despite their significance to the area, the state, and the world, several of South Park's extreme rich fens have been partially or mostly destroyed over the past few decades. The single greatest deleterious impact on these wetlands has been the removal of the organic soil (through peat mining) that provides the foundation for the significant natural heritage elements. Other negative impacts have been caused by the building of small and large reservoirs, heavy cattle grazing, and to some extent alterations of hydrology. The major activities that negatively affect extreme rich fens are listed and discussed below.

1. Peat mining. The direct removal of the organic soil in extreme rich fens continues to be the greatest threat to these peatlands and has had the most deleterious consequences for the fens. Peat is mined to be sold to nurseries and garden supply stores as a soil amendment. Ironically, South Park peat is a very poor quality soil amendment because of its high alkalinity and high mineral content.

Peat mining completely destroys extreme rich fen habitats. Since peat in extreme rich fens accumulates at a rate as slow as 4 inches per 1000 years, their natural recovery in a human time frame is impossible. Additionally, the structure and composition of naturally occurring peat suggest that even very intensive restoration efforts will unlikely be able to reproduce the habitat necessary for the rare plants, animals, and plant communities that exist in these wetlands.

2. Alterations of hydrology. The continuation of the historic hydrologic regime of extreme rich fens is absolutely necessary to their long-term viability. According to Cooper (1990a) 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, at least one site (the west part of Crooked Creek) has had a portion of its peatland dried up by a ditch that cuts across the lower part of the slope. There are also peatlands that do not appear affected even by a ditch bisecting them, although the long-term effects of these ditches is uncertain. Although peatlands seem to be resistant to water diversion upslope from them (for example, High Creek Fen), it is not clear what extent of diversion can occur without negative impacts.

Raising of the water table (i.e., inundation) has had overall a much greater impact than ditches. In some peatlands, most notably the Old Railroad Site on the northwest corner of Antero Reservoir, the inundation of the wetland by the reservoir completely destroyed the extreme rich fen habitat that it covered.

Currently there seems to be little use of groundwater in South Park, but if groundwater use increases in the future as water becomes a more expensive commodity in Colorado, the impact on fens could be profound. Extreme rich fens are almost entirely dependent on groundwater

flow, so changes in water table levels as a result of groundwater pumping could have serious consequences for fen habitats.

3. Grazing. In general grazing has not had a serious impact on extreme rich fens except in very localized cases. In the larger fens grazing has had only minimum impact, mainly because cattle generally refrain from spending large amounts of time in the "boggy" fen habitats. In several small fens, however, where water is not as abundant, cattle have had a profound effect on the extreme rich fen both by trampling and by eating the vegetation, including some of the rare plants. If the native vegetation is still present, effects by cattle can generally be reversed by reducing grazing levels, and by refraining from grazing extreme rich fens during the early and mid summer when the soils are wettest and most susceptible to compaction.

4. Cumulative impacts. Park County has been growing at an extraordinary pace. This development brings roads, water wells, effluent, created ponds, and recreationists. All of these can have small effects on wetlands, including extreme rich fens. Although each small impact may seem insignificant, they can add up to large impacts. As growth continues in the county, the cumulative impacts of development must be carefully considered.

Policy and protection recommendations

The following recommendations are provided as suggested guidelines for protecting extreme rich fens.

1. Disallow the removal of peat from extreme rich fens for any purpose, including sale of the peat, wildlife habitat creation, draining to created upland, or to facilitate throughflow. Peat removal destroys the extreme rich fen habitat for all the associated plants, animals, and plant communities, and given the extremely slow rate of peat accumulation, there exists no reasonable possibility for peatland restoration.
2. Insure that future water projects in South Park do not affect the hydrology of extreme rich fens. Ditching through a peatland or inundation through reservoir construction are obvious, direct potential impacts on extreme rich fens. Indirect potential impacts include surface diversions from above a peatland and removal of groundwater near or above the peatland. Since extreme rich fens appear largely dependent on groundwater flow, upstream diversion may not have a significant effect. This hypothesis is unproved, however, and impact studies should be performed before allowing any major surface diversions that might affect an extreme rich fen. Groundwater flow is not an immediate concern, but has great potential to affect extreme rich fens in the future.
3. Encourage an emphasis on winter grazing in extreme rich fen habitats.
4. Work with landowners to formulate protection plans for the most important sites as shown in Appendix 1. These plans should begin with an emphasis on education regarding the significance of these fens. Thought should also be given to providing landowner incentives, conservation easements, and/or outright purchase for full market value.
5. Develop educational materials and programs to raise awareness about the irreplaceable resources in South Park, including extreme rich fens and other natural heritage elements.
6. Restrict residential development around extreme rich fens (especially upslope). Disallow filling of peatlands for roads, buildings, etc.

Research recommendations

Although past field research has demonstrated the natural heritage significance of South Park's extreme rich fens, this is one of the few aspects of these wetlands about which we can draw confident conclusions. Much remains to be done to learn more about their importance to the county in terms of wetland functions such as water quality maintenance and groundwater discharge and recharge. Extreme rich fens also can serve the broader scientific community as sites for ecological studies that can contribute to a better understanding of wetland and peatland ecosystems in general. The following is a short, incomplete list of projects that would benefit the county and the broader scientific community:

1. Continued water quality studies, especially with respect to the effects of peat mining. Several studies of this sort has provided initial impressions as to the role of extreme rich fens in maintaining water quality, but the picture thus far is not complete.
2. Expanded hydrologic studies to assess the interactions between groundwater and surface water in and around extreme rich fens. These studies will yield insights into the role of

extreme rich fens in the replenishment of surface waters while also indicating how future water projects in the county may affect these wetlands.

3. Studies on the restoration of peatlands after major disturbance. Again, the emphasis should be on peatlands destroyed by peat mining, but should also be extended to ditched and otherwise hydrologically modified sites as well as areas that have been heavily impacted by grazing.
4. Investigations into vegetation/habitat relationships. The very unusual flora of extreme rich fens suggests that there is much to learn about the relationship between the vegetation and its habitat. Why are these plants growing here and nowhere else in Colorado? This information will also assist in the restoration of heavily impacted sites.
5. Additional studies of the aquatic and terrestrial invertebrate species that occur in and are restricted to extreme rich fens.

ACKNOWLEDGMENTS

Our work on this project could not have been nearly as comprehensive if not for the generous guidance and support of Dr. David Cooper. Mary Gentry and Steve Randall of the Park County Government assisted with procuring funding, executing several small tasks along the way, and general encouragement. Mike Gilbert and Tim Carey of the U.S. Army Corps of Engineers, Omaha District, helped facilitate this and other projects in South Park, while providing direction on the purpose and intent of our work. Gene Reetz of the U.S. Environmental Protection Agency provided us with the color infrared aerial photos that greatly facilitated finding extreme rich fens and interpreting our results after the field season. Brad Johnson was always available to mull over ideas and to inspire with his enthusiasm. Janet Coles of the Colorado Natural Areas Program shared information from their Park County inventory of state lands and provided early guidance on locating extreme rich fens.

We appreciate the work of Michael Craig, pilot extraordinaire, and Project LightHawk for their help with an aerial reconnaissance. As always, Dr. William Weber and Tim Hogan at the University of Colorado herbarium provided work space for plant identification and assisted with much of that work.

Illustrations were generously provided by Janet Crawford, Walt Fertig, and Debra Barringer. We also used illustrations through the courtesy of the New York Botanical Garden and the University of Washington Press.

Renée Rondeau and Julie Burt reviewed a draft of this report, although any errors in the final report are the authors.

Finally, we thank the many landowners (too numerous to name here) for their cooperation in allowing us access to their land to conduct the inventory.

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Appendix 1. Sites of Biodiversity Significance

This appendix profiles the seven extreme rich fen sites of highest biodiversity significance. Profiles, which are arranged alphabetically, include size, location, general description, comments on natural heritage significance, and protection and management considerations. The biodiversity rank, as explained in Table 2 (page 10), indicates the biological significance of each site. Table 7 lists all seven sites in order of their significance. All of these sites are biologically significant and therefore merit protection, but any available resources should be directed first toward the B1 sites, then the B2 sites, and finally the B3 sites.

Table 7. Biological significant sites, arranged by Biodiversity Rank (B-Rank).

Site Name	Biodiversity Rank
High Creek Fen	B1 (Outstanding significance)
Fremont's Fen	B1 (Outstanding significance)
Jefferson and Guernsey Creeks	B2 (Very high significance)
Old Railroad	B3 (High significance)
Hollthusen Gulch/Tarryall Creek	B3 (High significance)
Fourmile Creek at Peart	B3 (High significance)
Crooked Creek	B3 (High significance)

The boundaries shown for these sites are preliminary estimates of the area required to protect the natural heritage elements (plants, animals, and plant communities) at the site from direct and indirect impacts. In addition to extreme rich fens, these boundaries include *all* natural heritage elements that are ecologically connected to the site (for example, rare plants that occur beyond the extent of the peatland). It is important to remember that maintaining the biological integrity of these sites alone does not necessarily imply adequate protection of extreme rich fens; it only indicates that the most significant sites are safeguarded. As with all sites ranked by CNHP as having biodiversity significance, these sites alone to not represent a complete conservation program; they represent only the rare and imperiled elements. Other values such as water quality maintenance and wildlife habitat may not be represented in these sites. Also, the sites described in this report address only sites containing extreme rich fens. Other important sites, especially those containing mountain plover breeding habitat, also occur in South Park.

Crooked Creek

Size: ca. 615 acres **Biodiversity Rank:** B3 (High significance)

Location: Directions: This site is located one mile west of Red Hill Pass. The site can be approached by walking from Crooked Creek Road at Crooked Creek, down the hill to the spring/fen. USGS Quadrangle: Como, Park County. Legal Description: T9S R17W sections 10, 11, 14, 15, 22, and 23. Elevation: 9,800 - 10,200 feet.

General Description: This site consists of three parts; only the west part was inventoried in 1995. In the west part of the site, tall willows (mostly *Salix monticola*) characterize the upper edge of the fen, but these grade quickly into the hummock and swale mosaic (mounds of vegetation, the hummocks, rising our of wet, low areas, the swales) that typifies South Park's extreme rich fens. Many elements are present in this Crooked Creek site but in very small occurrences. According to Cooper (1990a), the northeast and southeast this sites contain very well developed occurrences of extreme rich fens.

Natural Heritage Significance: This site contains several state rare plants and a G2S1 plant community. Please see the table below for known element occurrences and rankings of the Crooked Creek Significant Site.

Table 8. Natural Heritage Elements at the Crooked Creek Site.

Element	Common Name	Global Rank	State Rank	EO Rank
Carex livida	Livid sedge	G5	S1	D
Carex scirpoidea	Canadian single-spike sedge	G5	S1?	C
Eriophorum gracile	Slender cottongrass	G5	S2	C
Primula egaliksensis	Greenland primrose	G4	S2	C
Ptilagrostis mongholica ssp. *porteri*	Porter's feathergrass	G2T2	S2	C
Salix candida	Hoary willow	G5	S2	C
Salix myrtillifolia	Low blueberry willow	G5	S1	C
Scirpus rollandii	Pygmy bulrush	G2G3Q	S1	C
Senecio pauciflorus	Few-flowered ragwort	G4G5	S1S2	D
Kobresia simpliciuscula–Scirpus rollandii p.a.	Extreme rich fen plant association	G2	S1	C

EO = element occurrence

Boundary Justification: The site boundaries include the known fens of the area, and for the west portion, an area that has been dried out where the water supply has been cut off by a ditch. The boundary also includes a buffering zone of 500-1000 feet to protect from direct impacts from disturbances such as, vehicle travel and cattle grazing and trampling. The elements on this site require features of water supply that extend beyond the site and may include Crooked Creek and the creek feeding the west side of the site.

Protection and Management Considerations: The west part of the site is owned by the U.S. Forest Service. The other two parts are privately owned. The owner of the abundant water on this site is unknown. Removal of the water would probably result in the destruction of the elements, as has already occurred on the lower end of the central fen site. It is highly important to maintain the hydrological regime, as the success and viability of the extreme rich fens depend on these processes. Several of the identified significant elements probably formerly extended into the now dried fen mentioned above.

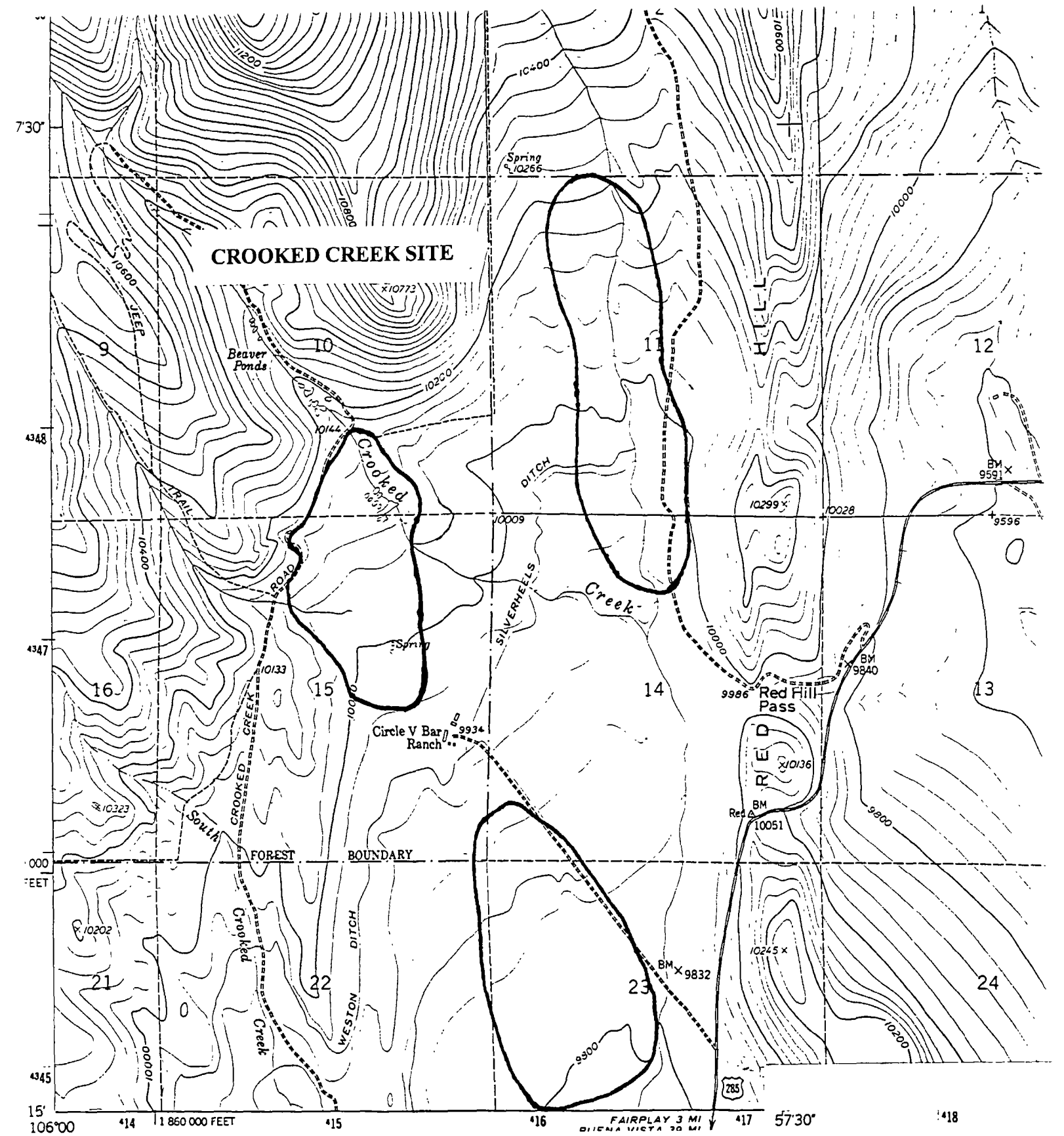


Figure 3. Crooked Creek Site.

LOCATION: Directions: The Crooked Creek site is located one mile west of Red Hill Pass. **Legal Description:** T009S R077W sec. 10, 11, 14, 15, 22, 23. **USGS Quadrangle:** Como, Park County. **Elevation:** 9,800-10,200 feet.

Fourmile Creek at Peart

Size: ca. 450 acres **Biodiversity Rank:** B3 (High significance)

Location: Directions: USGS Quadrangle: Fairplay West, Park County. Legal Description: T10S R77W sec 16:w2; sec 17; sec 18:e2. Elevation: 9,800 feet.

General Description: Fourmile creek emerges from a coniferous forest then spreads out into a large area of beaver ponds and willow stands. To the south of the creek is a large, seepy area where many of the extreme rich fen elements occur. *Primula egaliksensis* is quite common here, as is *Carex scirpoidea.* The mire community with its hummocks of *Kobresia simpliciuscula-Scirpus rollandii* are found in scattered areas to the north of Fourmile Creek, with heavy concentrations along a low-flow drainage.

Natural Heritage Significance: This site encompasses a C-ranked occurrence of a G2S1 community, *Kobresia simpliciuscula-Scirpus rollandii,* and several other state significant elements and several other elements (Table 9).

Table 9. Natural Heritage Elements at the Fourmile Creek at Peart Site.

Element	Common Name	Global Rank	State Rank	EO Rank
Carex scirpoidea	Canadian single-spike sedge	G5	S1?	B
Primula egaliksensis	Greenland primrose	G4	S2	B
Scirpus rollandii	Pygmy bulrush	G2G3Q	S1	C
Senecio pauciflorus	Few-flowered ragwort	G4G5	S1S2	C
Kobresia simpliciuscula–Scirpus rollandii p.a.	Extreme rich fen plant association	G2S1	S1	B
Eleocharis quinqueflora–Triglochin spp. p.a.	Alkaline spring plant association	GU	S1?	B

EO = element occurrence

Boundary Justification: The boundary of Fourmile Creek encompasses the significant elements identified while including important seeps and springs to the north and south of Fourmile Creek as well as contiguous wetlands along the creek. The boundary also includes a small buffer zone that is necessary to prevent direct and many indirect impacts at the site.

Protection and Management Considerations: Most of this site is owned by the state land board. It is moderately to heavily grazed in summer. The elements remain viable, but most occurrences are only of moderate size and negatively impacted by grazing. From spring until mid summer is an important time frame for the significant plant species' success and viability, therefore, grazing in the wetland should be avoided during this time. It is highly important that the hydrological regime remain intact, including the upstream portion of Fourmile creek as well as the seeps and springs north and south of the creek.

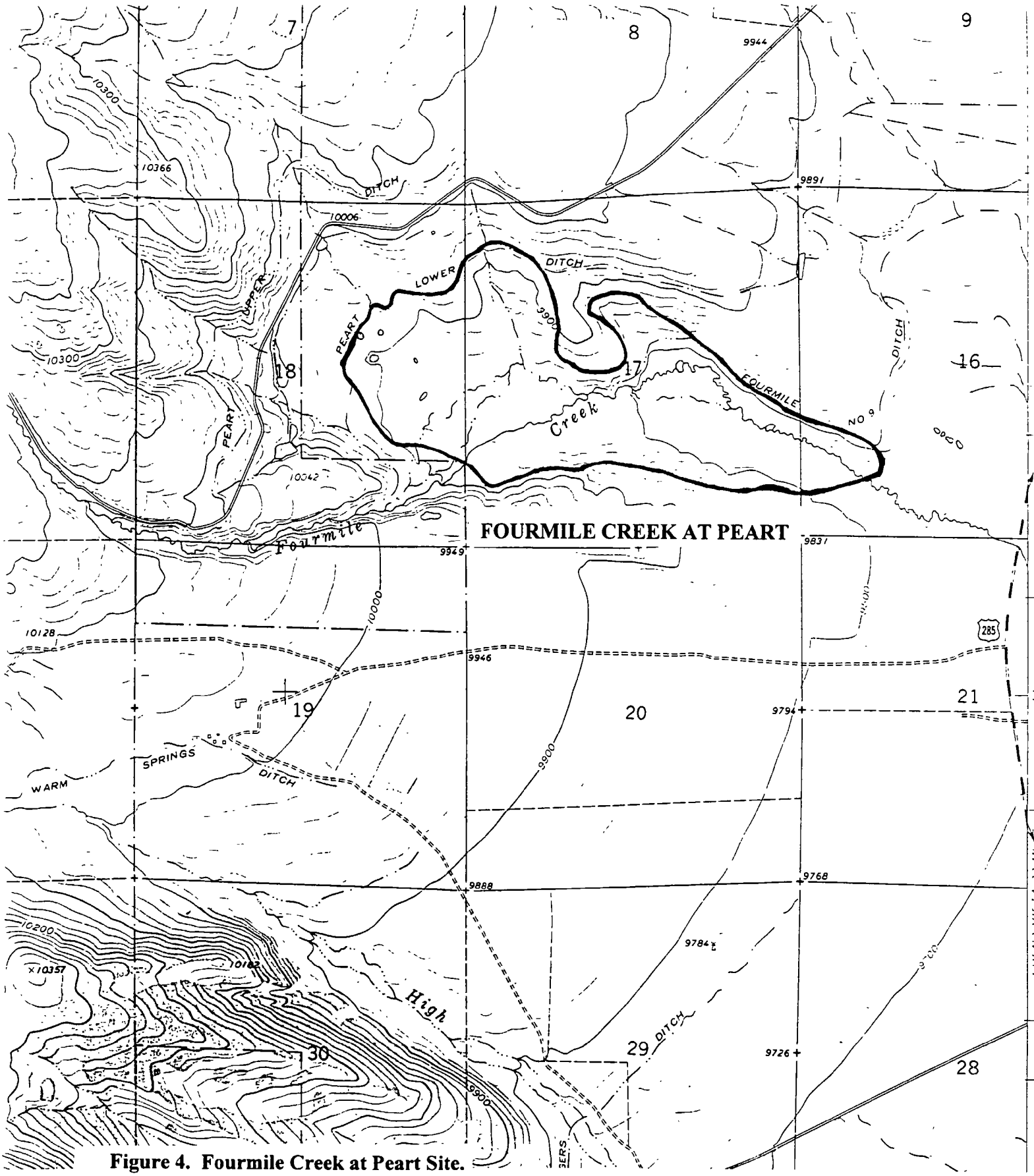


Figure 4. Fourmile Creek at Peart Site.

LOCATION: Directions: The Fourmile Creek at Peart site is located south of Fairplay about one mile to Fourmile Creek Road. **Legal Description:** T010S R077W sec. 16-18. **USGS Quadrangle:** Fairplay West, Park County. **Elevation:** 9,800 feet.

Fremont's Fen

Size: ca. 1075 acres **Biodiversity Rank:** B1 (Outstanding significance)

Location: Directions: This site is located just east of Fremont Knoll and about 1 mile west of Michigan Hill. (About 3 miles north of the town of Como.) USGS Quadrangle: Milligan Lakes and the northeast sliver of Como, Park County. Legal Description: T8S R76W sec 10,11,14, and 15. Elevation: 9,616 feet.

General Description: This site is marked by the elements which occur across an area nearly one mile long and about 1/5th of a mile wide. Large hummocks dominated by the *Kobresia myosuroides–Thalictrum alpinum* plant association cover the entire area. *Ptilagrostis mongholica* ssp. *porteri* occurs sparsely on the eastern end of this community, but toward the west it dominates many hummocks. The western edge of the intact hummock expanse is wetter than the rest and provides habitat for *Scirpus rollandii* and other extreme rich fen plant species.

The elements occur on the south side of what was formerly (before peat mining took place) a very large peatland. It is likely that many other extreme rich fen elements (e.g., *Salix candida*) were once present in abundance. Extant elements are hydrologically above the mined area. They appear to not be adversely affected by the mining.

Natural Heritage Significance: This site is rich with state rare and imperiled plants, and includes the necessary hydrology to support these element systems (Table 10).

Table 10. Natural Heritage Elements at the Fremont's Fen Site.

Element	Common Name	Global Rank	State Rank	EO Rank
Carex scirpoidea	Canadian single-spike sedge	G5	S1?	C
Primula egaliksensis	Greenland primrose	G4	S2	C
Ptilagrostis mongholica ssp. *porteri*	Porter's feathergrass	G2T2	S2	B
Scirpus rollandii	Pygmy bulrush	G2G3Q	S1	C
Senecio pauciflorus	Few-flowered ragwort	G4G5	S1S2	C
Sisyrinchium pallidum	Pale blue-eyed grass	G3	S2	C
Kobresia myosuroides–Thalictrum alpinum p.a.	Extreme rich fen plant association	G1	S1	B

EO = element occurrence

D. Cooper (pers. comm. to J. Sanderson) states that the occurrences of *Ptilagrostis mongholica* ssp. *porteri* and *Kobresia myosuroides–Thalictrum alpinum* are more extensive than revealed in 1995 field surveys. The occurrences may extend into the northwest end of the site which has not been visited by a CNHP scientist.

Boundary Justification: The boundary drawn includes the entire extant and former peatland, encompassing the area of groundwater discharge that creates and supports the fen. The site

boundary includes the mined area for two reasons. First, some activities in the mined area, such as creation of ponds, could affect the elements to the south. Second, the mined area may have restoration potential, perhaps allowing for recolonization of the area by the existing elements. The boundary also includes a buffer to prevent direct impacts and to minimize indirect impacts from areas adjacent to the wetlands.

Protection and Management Considerations: Ownership of the land within the site boundaries is shared by private individuals, the Colorado Division of Wildlife, and the City of Thornton. A peat mining crane remains on the site, but is not active. Cattle graze on at least a portion of the site and do not appear to adversely affect it. It is not known what C.D.O.W. or the City of Thornton plan for their property.

The most immediate threat to this site appears to be the manipulation of water by either the City of Thornton or the C.D.O.W. Ditching or diversion of water in the mined area may adversely affect the elements; these activities in or up-gradient from the hummock area will have a deleterious effect on both the *Kobresia myosuroides–Thalictrum alpinum* plant association and the *Ptilagrostis mongholica* ssp. *porteri*. Groundwater pumping above or near these wetlands would likely negatively affect the extreme rich fen elements, but at present is not a concern.

Management of the area should include planting the mined area with native fen species. Curtailing present water diversion around the elements may increase their viability, although the extant elements appear robust despite these diversions.

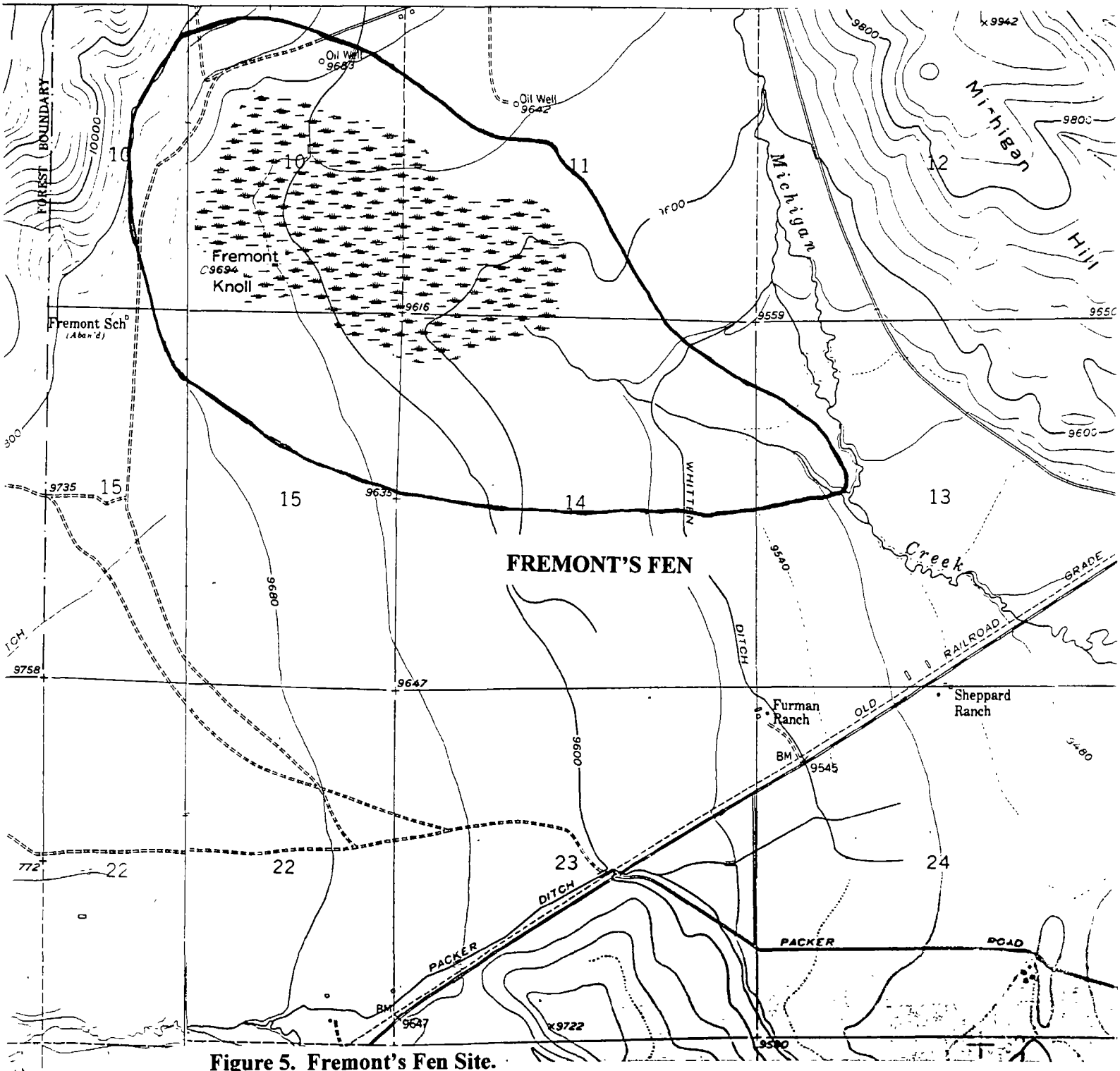


Figure 5. Fremont's Fen Site.

LOCATION: Directions: The Fremont's Fen site is located three miles north of the town of Como. **Legal Description:** T008S R076W sec. 10, 11, 14, 15. **USGS Quadrangle:** Milligan Lakes/Como, Park County. **Elevation:** 9,616 feet.

Jefferson and Guernsey Creeks

Size: ca. 5580 acres **Biodiversity Rank:** B2 (Very highly significance)

Location: Directions: The Jefferson and Guernsey Creeks site is located at the north end of South Park, north of the town of Jefferson, east and west of hwy. 285. USGS Quadrangle: Jefferson and Milligan Lakes, Park County. Legal Description: T7S R75W sec 27-33; T8S R75W sec 3-5; T7S R76W sec 25; T7S R75W sec 30. Elevation: 9,420 - 9,840 feet.

General Description: The most important part of the Jefferson and Guernsey Creeks site is two distinct areas of extreme rich fen (peatland) vegetation that merge into one toward highway 285. Downstream from these peatland areas (to the southeast), an expansive area of wet meadow extends across 285 toward the Steiner Ranch. The western portion of the site is a combination of wet meadow and mesic and upland grasslands. One prominent knoll is included in the site behind the Wahl Ranch, northeast of Jefferson.

One fen is found in a large water discharge zone midway between Deadman Gulch and Guernsey Creek. This area is a hummock/swale complex. Another fen occurs on the creek labeled Deadman Gulch at the point where tall willows give way to lower stature vegetation. This fen is driven by groundwater discharge, but also exhibits influence of surface water draining from the gulch. Vegetation of this peatland grades from what can be called "rich" fen into "extreme rich" fen.

Natural Heritage Significance: The significance of this site is high due to the presence of many high quality element occurrences (Table 11). This site is overall in exceptionally good condition and remains highly viable.

Table 11. Natural Heritage Elements at the Jefferson and Guernsey Creeks Site.

Element	Common Name	Global Rank	State Rank	EO Rank
Astragalus bodinii	Bodin milkvetch	G4	S2	
Carex scirpoidea	Canadian single-spike sedge	G5	S1?	B
Primula egaliksensis	Greenland primrose	G4	S2	A
Ptilagrostis mongholica ssp. *porteri*	Porter's feathergrass	G2T2	S2	A
Salix candida	Hoary willow	G5	S2	A
Salix myrtillifolia	Low blueberry willow	G5	S1	B
Scirpus rollandii	Pygmy bulrush	G2G3Q	S1	A
Senecio pauciflorus	Few-flowered ragwort	G4G5	S1S2	B
Sisyrinchium pallidum	Pale blue-eyed grass	G3	S2	B
Kobresia simpliciuscula–Scirpus rollandii p.a.	Extreme rich fen plant association	G2	S1	A
Physa skinneri	Glass physa	GU	S2	?

EO = element occurrence

Boundary Justification: The boundary drawn encompasses all of the elements associated with an interconnected wetland system that all drains into Guernsey Creek, including both fens and all connected wet meadows to a point downstream beyond which there are no reported elements. It also includes nearly contiguous wetlands in the Jefferson Creek drainage. The boundary includes a buffer to prevent direct impacts and to minimize indirect impacts adjacent to the wetlands. With future inventory the boundary may need to be modified to include wetlands on the southeast and southwest sides of the site.

Protection and Management Considerations: The entire area is used for either cattle grazing or hay production. The most immediate threat to this wetland is the potential mining of peat from the west fen. The single greatest long-term threat is the potential removal of water from the site by Front Range municipalities, as has happened to several other large wetlands in South Park. Ditching of the wetlands or diversion of water from the wetlands may adversely affect the extreme rich fen elements, although surface water diversions to date (for irrigation) appear not to have had a deleterious effect. Groundwater pumping above or near these wetlands would likely negatively affect the fens, but at present is not a concern. Runoff and effluent from residential development around the area poses no short-term threat, but may need to be considered in the future.

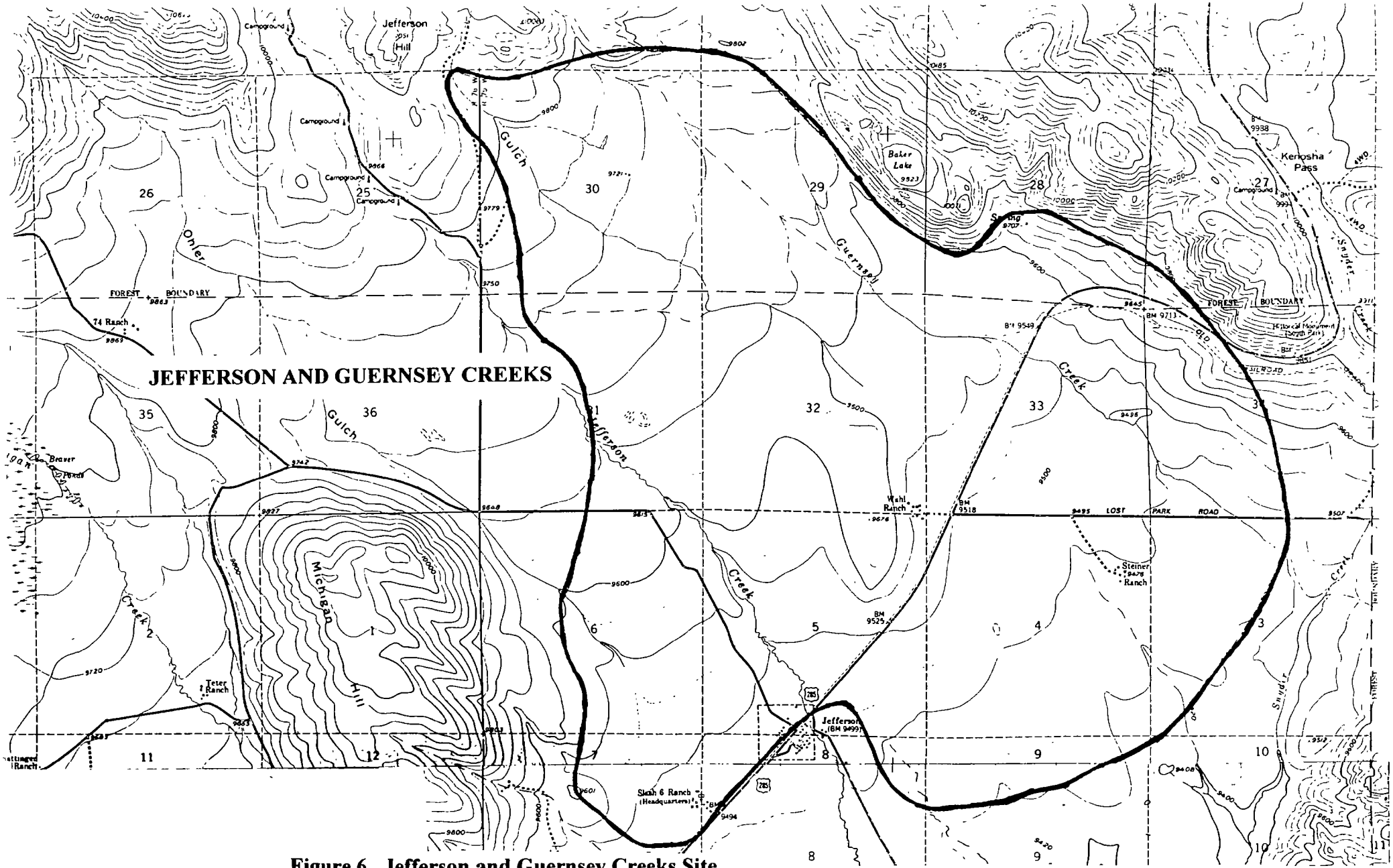


Figure 6. Jefferson and Guernsey Creeks Site.

LOCATION: Directions: The Jefferson and Guernsey Creeks site is located at the north end of South Park, north of Jefferson. **Legal Description:** T007S R075W sec. 19, 20; T008S R075 sec. 3-5; T007S R076W sec. 25. **USGS Quadrangle:** Milligan Lakes/Jefferson, Park County. **Elevation:** 9,420-9,840 feet.

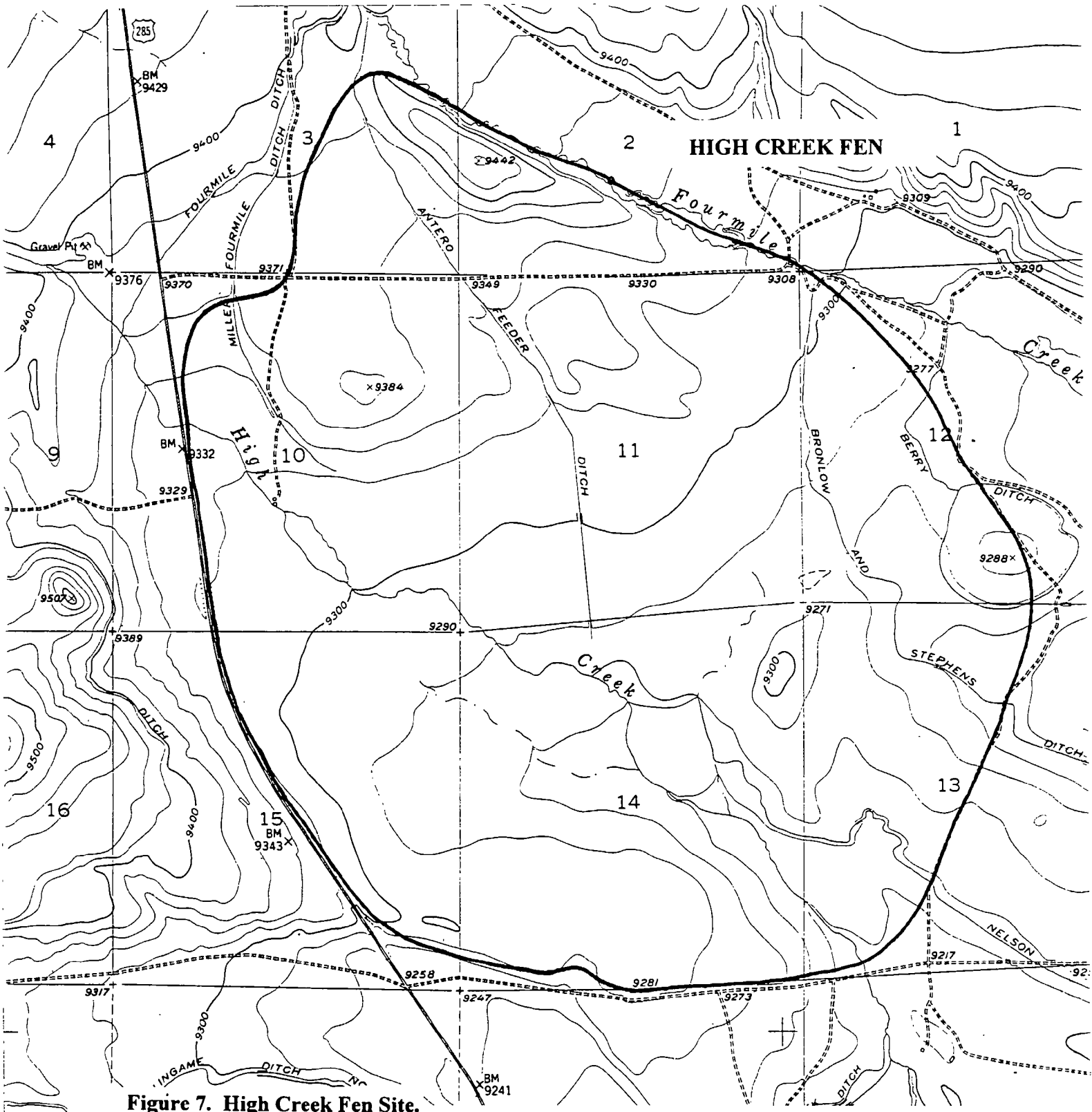


Figure 7. High Creek Fen Site.

LOCATION: Directions: The High Creek Fen is located nine miles south of Fairplay. **USGS Quadrangle:** Garo, Park County. **Legal Description:** T011S R077W sec. 2, 3, 10-15. **Elevation:** 9,000-9,400 feet.

Hollthusen Gulch/Tarryall Creek

Size: ca. 640 acres **Biodiversity Rank:** B3 (High significance)

Location: Directions: This site can be approached by traveling south from Kenosha pass on hwy. 285 to Como and Boreas Pass Road. Approximately 2.5 miles up this road it veers to the left. About 1/3 to 3/4 mile northeast from the point where the road veers is a willow carr and the location of the site. USGS Quadrangle: Como, Park County, Colorado. Legal Description: T8S R76W sec 16 and 17. Elevation: 9,945 feet.

General Description: This site is a large wetland complex of an unusual nature. It appears as a mix of rich fen and extreme rich fen. For example, unlike at other sites, the *Kobresia myosuroides-Thalictrum alpinum* plant association and the *Ptilagrostis mongholica* ssp. *porteri* occur within a matrix of a taller willow community (all other occurrences of these are with low, or no, shrubs). This site also contains a very unusual, large stand of *Salix planifolia/Carex aquatilis* that is in excellent condition. This stand occurs on a moderately steep slope within a mosaic of moss mounds and *Salix candida* with higher cover than almost anywhere else in Colorado. It may deserve recognition as a separate plant association, especially considering the relatively high cover of *Salix candida.*

Natural Heritage Significance: This site is rich with state rare plants and communities (Table 13). It is a large site in good condition. The *Salix planifolia/Carex aquatilis* plant association is an excellent example of this particular element. This element is usually not considered a component of extreme rich fens, but in this case the relatively high cover (ca. 5%) of *Salix candida* illustrates its affinity to extreme rich fens.

Table 13. Natural Heritage Elements at Hollthusen Gulch/Tarryall Creek Site.

Element	Common Name	Global Rank	State Rank	EO Rank
Carex livida	Livid sedge	G5	S1	C
Eriophorum gracile	Slender cottongrass	G5	S2	?
Ptilagrostis mongholica ssp. *porteri*	Porter's feathergrass	G2T2	S2	B
Salix candida	Hoary willow	G5	S2	A
Scirpus rollandii	Pygmy bulrush	G2G3Q	S1	B
Kobresia myosuroides–Thalictrum alpinum p.a.	Extreme rich fen plant association	G1	S1	C
Salix planifolia/ Carex aquatilis p.a.	Planeleaf willow/ Water sedge shrubland	G3?	S2S3	A

EO = element occurrence

Boundary Justification: The boundary includes the entire peatland, the lower stretches of the creeks that feed water into the site, adjacent wetlands to the east and west, and the area extending out to a ditch below the fens. The ditch apparently severs the fen from Tarryall Creek. Tarryall creek was not visited by a CNHP scientist, but it is assumed not to contain peat. Since it is hydrologically below the fen, the creek and the wetlands on the south side of the creek are not included in the site boundary. A buffer of about 500 feet surrounds most of the fens to protect from direct impacts such as cattle activity and vehicular damage.

Protection and Management Considerations: Some water manipulation has occurred on this site and moderate grazing continues, but neither seems to have caused permanent negative impacts on the elements, and some of the element occurrences are still ranked A because of their size or quality. However, grazing and especially water diversion could threaten the elements in the future. The elements look in good condition, but the effect of the current grazing regime is unclear. It is very important to maintain hydrological regimes, as these systems are vital to the viability of the peatland communities.

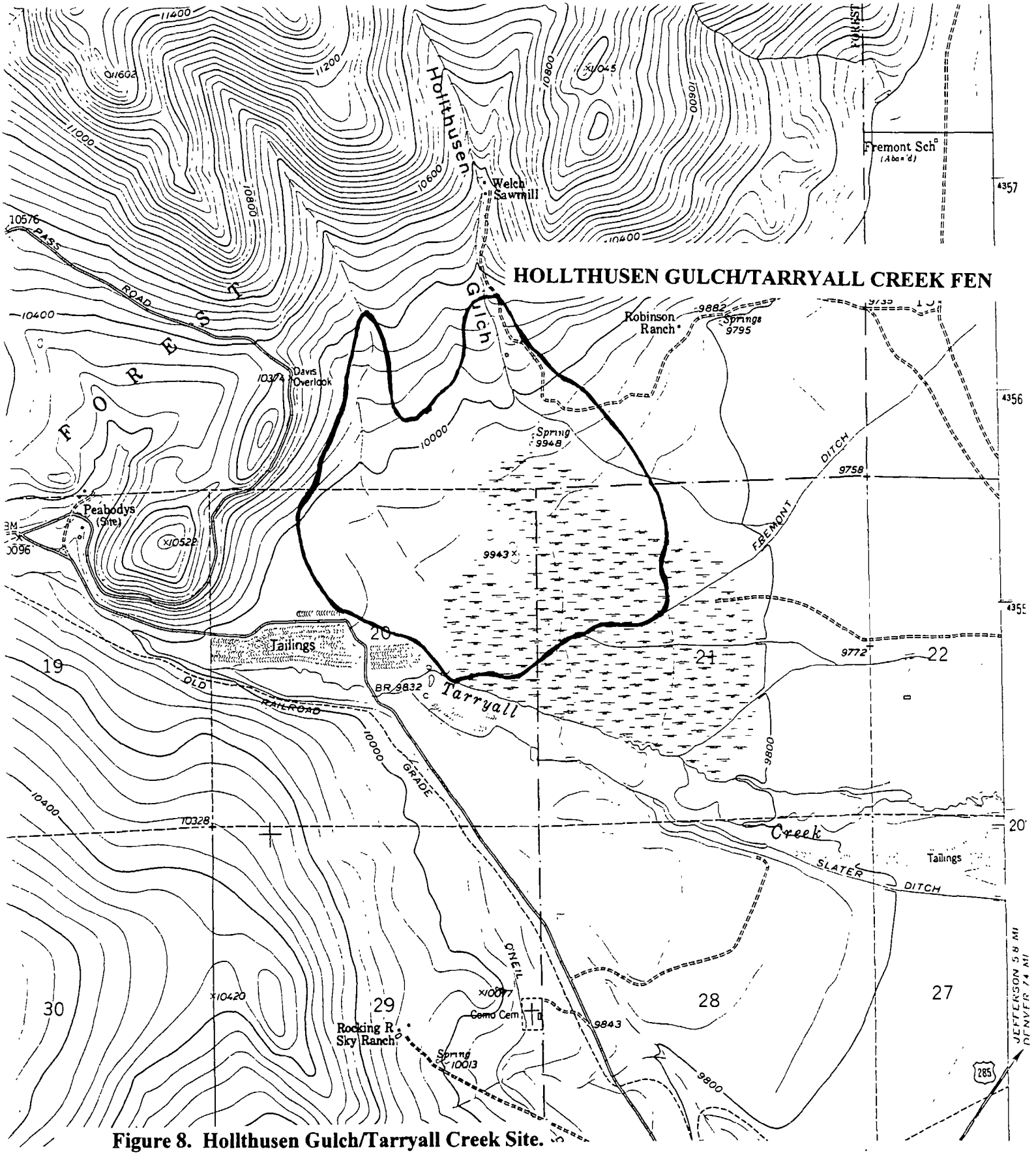


Figure 8. Hollthusen Gulch/Tarryall Creek Site.

LOCATION: Directions: The Hollthusen Gulch/Tarryall Creek Fen site is located near Boreas Pass Road, two and half miles from the Highway 285, junction at Como. **USGS Quadrangle:** Como, Park County. **Legal Description:** T008S R076W sec. 16,17. **Elevation:** 9,945 feet.

Old Railroad

Size: ca. 1240 acres **Biodiversity Rank:** B3 (High significance)

Location: Directions: This site is located northwest of Antero Reservoir. USGS Quadrangle: Garo and Antero Reservoir, Park County. Legal Description: T12S R76W sec 17, sec 18, sec 19; T12S R77W sec 12, sec 13. Elevation: 8,986 feet

General Description: This site encompasses a heavily altered extreme rich fen complex on the northwest corner of Antero Reservoir, east and north of the South Fork of the South Platte River. An old, abandoned railroad grade cuts through the site from the northeast to the southwest, about 1/4 mile from the reservoir. Between the railroad grade and the reservoir is an excellent example of an extreme rich fen. This area contains most of the extreme rich fen rare plant species. In the peat area, hummocks are dominated by the *Kobresia simpliciuscula-Scirpusrollandii* plant associations. *Carex simulata* and other sedges, *Triglochin* spp., and *Eleocharis quinqueflora* dominate the swales. *Carex scirpoidea* and *Senecio pauciflorus* occur mainly on the southern edge of the peat on a light colored soil, with much lower organic content.

West of the railroad grade the extreme rich fen has been destroyed by peat mining. Only scattered extreme rich fen species still occur there.

Natural Heritage Significance: This site contains several state rare elements and globally rare communities (Table 14).

Table 14. Natural Heritage Elements at the Old Railroad Site.

Element	Common Name	Global Rank	State Rank	EO Rank
Carex scirpoidea	Canadian single-spike sedge	G5	S1?	C
Primula egaliksensis	Greenland primrose	G4	S2	C
Salix candida	Hoary willow	G5	S2	C
Salix myrtillifolia	Low blueberry willow	G5	S1	B
Scirpus rollandii	Pygmy bulrush	G2G3Q	S1	C
Senecio pauciflorus	Few-flowered ragwort	G4G5	S1S2	C
Sisyrinchium pallidum	Pale blue-eyed grass	G3	S2	B
Kobresia simpliciuscula–Scirpus rollandii p.a.	Extreme rich fen plant association	G2	S1	C
Kobresia myosuroides–Thalictrum alpinum p.a.	Extreme rich fen plant association	G1	S1	C

EO = element occurrence

Boundary Justification: The site boundary includes the intact peatland, the mined peatland, and the seep area to the west that appears hydrologically connected to the peatland. The encompassed hydrology is vital for the support of the significant elements within the fen. The boundary was drawn to include a buffer of approximately 500 feet to protect from direct impacts such as vehicular travel and heavy grazing.

Protection and Management Considerations: Peat has been removed from half of the fen, and the hydrology has been altered by the railroad grade and upstream diversion. Despite these alterations, the hydrology in the area east of the railroad grade appears sufficiently intact to support the elements. Within the western third of the site is a large seep area, perhaps at the end of a Pleistocene alluvial fan, that may be hydrologically connected to the fen area. Further hydrological alterations at this site should be avoided, and restoration of severely altered hydrology should be considered. Also, Antero Reservoir must not be raised above its current level; the fen abuts the reservoir and any increase in water levels will adversely affect the elements present. Any remaining peat at this site should remain in place.

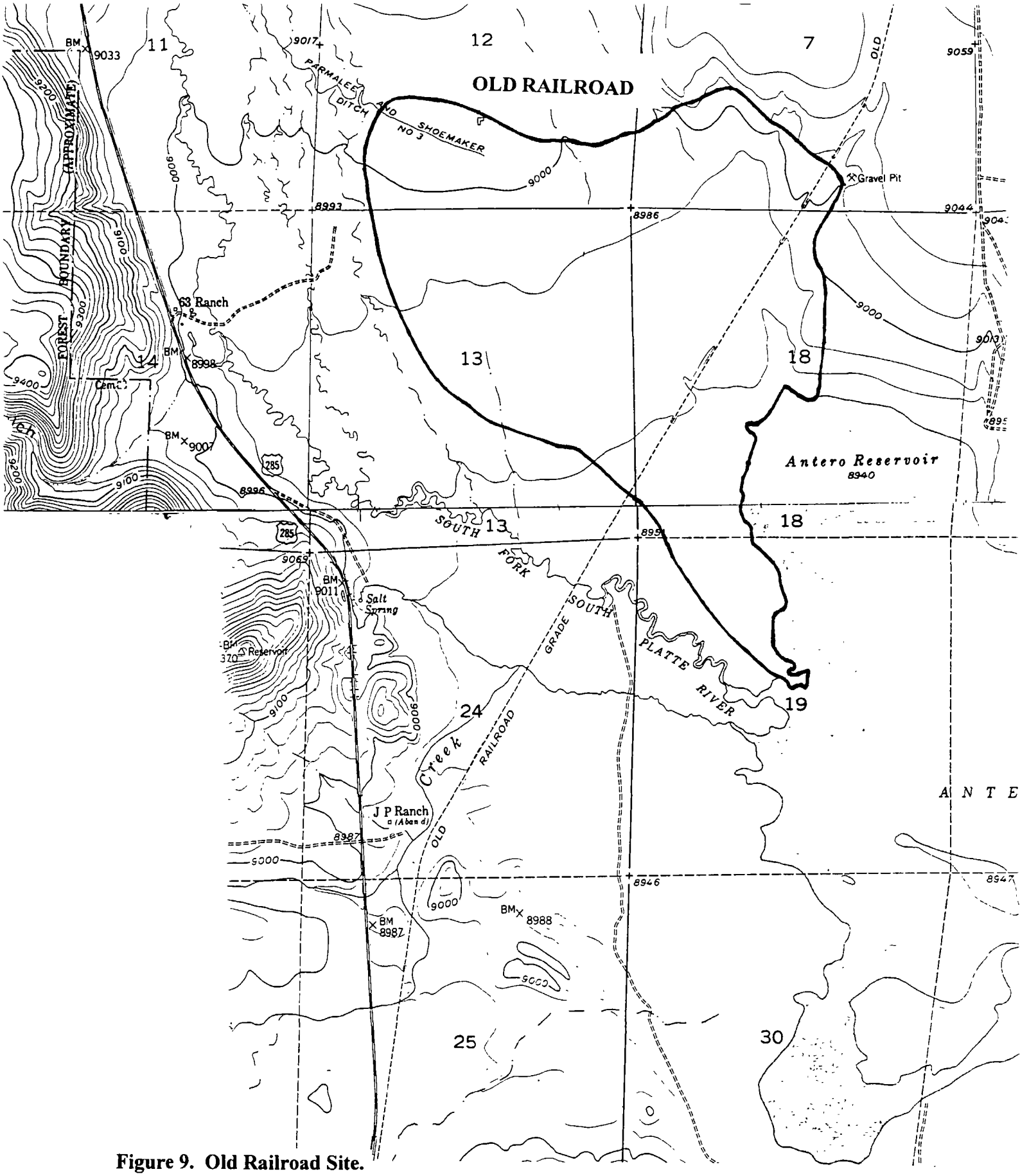


Figure 9. Old Railroad Site.

LOCATION: Directions: The Old Railroad site is located northwest of Antero Reservoir, from Fairplay take 9 SE to Hartsel, then 24 SW toward Buena Vista to the Antero Reservoir. **USGS Quadrangle:** Garo, Park County. **Legal Description:** T012S R076W sec. 7, 18, 19; T012S R077W sec. 12, 13. **Elevation:** 8,986 feet.

Appendix 2. Important Extreme Rich Fen Plants and Plant Communities

This appendix contains descriptions of the rare and diagnostic plants and plant communities that we hope will facilitate future work in extreme rich fens. The appendix is organized into four sections:

1) Globally rare plants.
2) State rare plants.
3) Diagnostic plants that are not rare.
4) Important extreme rich fen plant communities.

The descriptions are ordered alphabetically within section.

Globally Rare Plants

***Ptilagrostis mongholica* (Turcz. *ex* Trin.) ssp. *porteri* (Rydb.) Barkworth**
Porter's feathergrass **CNHP Rank: G2T2S2**

Legal Status: Listed as sensitive by the U.S. Forest Service, Forest Service Manual, 2760.5.

Synonyms:; *Stipa porteri* Rydb. Weber and Wittmann (1992) consider this taxon as a distinct species, *Ptilagrostis porteri.*

Description: This grass arises from dense tufts with stems standing 20-35 cm tall. The leaves are 2-12 cm long and can be flat to round or threadlike. This bunchy appearance combined with the very thin leaves and the distinctive habitat facilitates identification of this plant even when not flowering or from the previous year's plants. When the plant is flowering, it displays a white feathery appearance. The flowering heads or spikes are composed of small seed like flowers each topped with an awn. The awn is like a tiny feather, hence the common name, feathergrass (Weber 1990; Hitchcock 1971). When in flower, the feathery awns greatly facilitate identification.

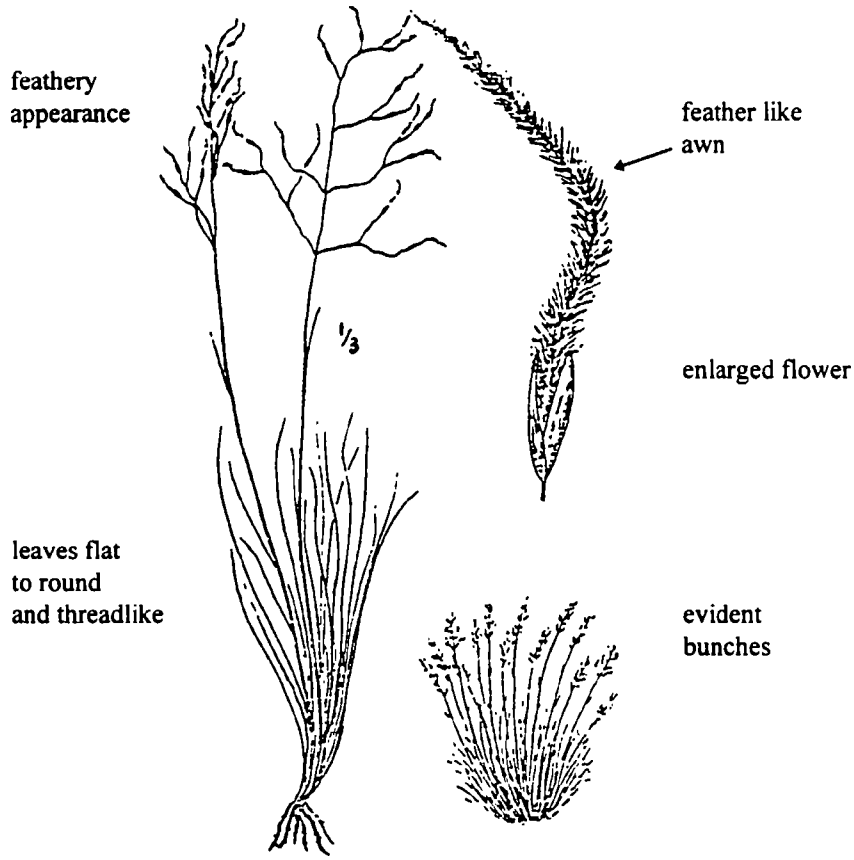
Flowering/Fruiting Period: July through August.

Habitat/Distribution: *Ptilagrostis mongholica* ssp. *porteri* grows on peat hummocks that elevate it above the water table in extreme rich fens. In South Park it is almost always associated with *Kobresia myosuroides* and/or *Kobresia simpliciuscula* and *Thalictrum alpinum.*

As noted above, the most extensive occurrences of *Ptilagrostis mongholica* ssp. *porteri* occur in the northern portion of South Park. Occurrences are also known from Geneva Park northwest of Grant, East Lost Park in the Tarryall Mountains and several of the creek draining east form the Mosquito Range (Cooper 1990a, CNHP 1996).

Similar or Related Species: The bunched growth form, the seeds with long awns, and the single seed per floret could create confusion between *Ptilagrostis mongholica* ssp. *porteri* and some members from the genus, *Stipa.* However, no species of *Stipa* grow in the distinctly hummocky, calcareous fen habitat of *Ptilagrostis mongholica* ssp. *porteri.* Additionally, this species has a small, feather-like awns that distinguish it from *Stipa.*

Figure 10. ***Ptilagrostis mongholica*** **(Turcz. ex Trin.) ssp.** ***porteri*** **(Rydb.) Barkworth (Porter's feathergrass)**



Ill. by Janet Wingate

***Sisyrinchium pallidum* Cholowa & D. Henderson**
Pale blue-eyed grass **CNHP Rank: G2G3S2S3**

Legal Status: Formerly listed as a Category 2 candidate for listing under the Endangered Species Act (U.S. Fish and Wildlife Service 1993). Recently the U.S. Fish and Wildlife Service eliminated the Category 2 status, and this species is no longer a candidate for listing (USFWS 1996).

Description: This superficially grass-like plant stands less than 30 cm, can be bunched, and has spreading, fibrous roots. It has small flowers with six very pale blue petals. A bract that appears to be a continuation of the stem rises above the flower for up to 4 cm. See Cholewa and Henderson (1984) for a complete description of this and closely related species.

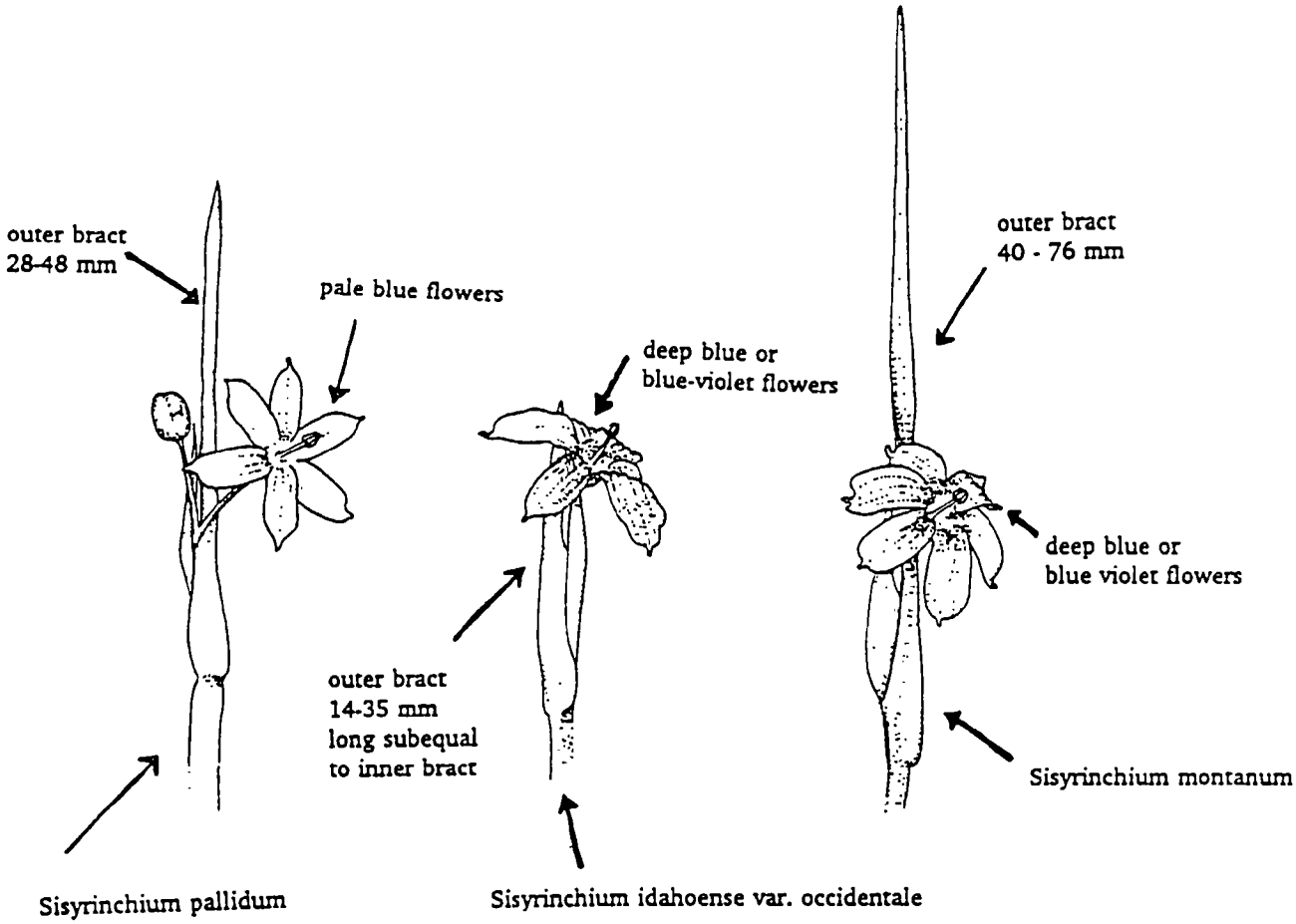
Flowering/Fruiting Period: Flowering in July and fruiting in late July through August.

Habitat/Distribution: This species is widely distributed in South Park, occurring in wet, poorly drained meadows and peatlands. Some of the current habitat for this species may be wet meadow created by decades-old irrigation projects, and in many cases it is impossible to determine the natural wetlands from those which have been created totally by irrigation (Cooper 1990a). Jennings (1991) reported that at the north end of South Park it is associated with *Primula egaliksensis* but during this study it was also found in abundance in areas where *Primula egaliksensis* is absent. West and northwest of Antero Reservoir it was occasionally seen where *Senecio pauciflorus* was also very abundant.

The global range of *Sisyrinchium pallidum* includes only southern Wyoming, and northern and central Colorado. The center of its distribution seems to be in South Park (Jennings 1991), where it appears common.

Similar or Related Species: Other *Sisyrinchium* species are very similar to this one (see the following figure). The very pale blue flowers when examined fresh are the most certain key to distinguishing this species from *Sisyrinchium montanum,* the other common blue-eyed grass in South Park. Jennings (1991) believes the very wet meadow or bog habitat will help to insure the identity of *Sisyrinchium pallidum.* Cholowa and Henderson (1984) state that no other species of *Sisyrinchium* in the Rockies occurs in such a wet meadow and is associated with as many different forb species. However, in South Park *S. pallidum* and *S. montanum* may occur in the same wetland system (e.g., at High Creek Fen, as noted by Cooper 1990a).

Figure 11. ***Sisyrinchium pallidum*** **(Cholowa & D. Henderson) (Pale blue-eyed grass)**



Ill. by Carolyn Crawford; captions from Jennings 1990

State Rare Plants

Carex livida (Wahl.) Willd.
Livid sedge **CNHP Rank: G5S1**

Legal Status: Listed as sensitive by the U.S. Forest Service, Forest Service Manual, 2670.5.

Description: This grass-like perennial is rhizomatous (having horizontal roots) and has sheathing leaves for the lower 1/3 of the plant. The leaves are characterized by a whitish- or bluish-green color. The leaves are narrow and channeled. The plant may have two to four spikes or flowering heads. The spikes are made up of several male (having anthers) or female (having stigmas) flowers. The terminal (upper most) spike has all anthers and the lateral spikes have all stigmas (with careful observation, these parts will be seen protruding from behind the floral scale). Each flower in the spike is subtended by a scale, which on the female flowers, is oval and has a broad green midrib stripe and brown marginal stripes with papery, translucent margins (Weber 1990; Fertig and Jones 1992).

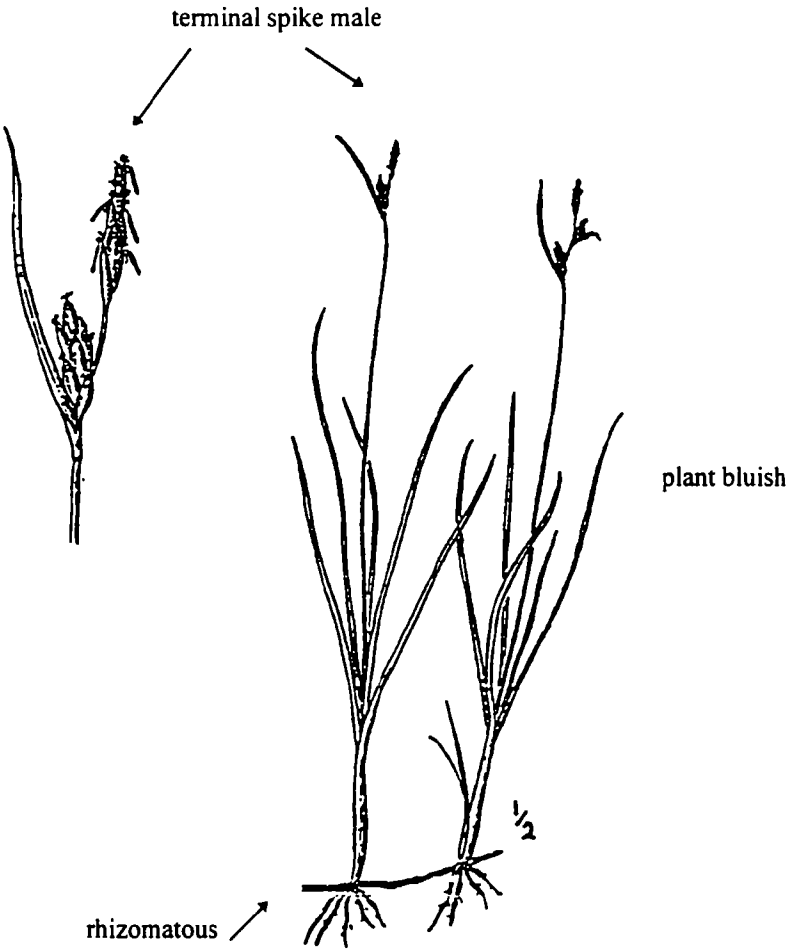
Flowering/Fruiting Period: June through August.

Habitat/Distribution: In Colorado, *Carex livida* is found only in peatlands, and is known only from extreme rich fens in South Park. It occurs on saturated ground among other sedges, typically not on hummocks, though it may grow on the sides or at the base of hummocks.

Carex livida is circumpolar in distribution, found from southern Alaska to Newfoundland in North America (Hermann 1970). Only five occurrences of this species are known in Colorado; three of these occur in South Park. Disjunct populations also occur in Wyoming (Fertig and Jones 1992).

Similar or Related Species: The whitish- or bluish-green foliage may cause this species to be confused with some other *Carex* species. *Carex aquatilis,* for instance, can be distinguished by the stalked flowering heads or spikes; the spikes of *Carex livida* are directly attached to the stem. *Carex limosa* is also similar but can be distinguished by the drooping or nodding spikes; *Carex livida* has erect spikes. *Carex buxbaumii* is another similar species differing in the upper most spike exhibiting stigmas at the very top; *Carex livida* will exhibit anthers at the very top.

Figure 12. ***Carex livida*** **(Wahl.) Willd. (Livid sedge)**



Ill. by Janet Wingate

Carex scirpoidea **Michx.**
Canadian single-spike sedge **CNHP Rank: G5S1**

Legal Status: No federal legal status.

Synonyms: *Carex scirpiformis* Mackenzie; *Carex stenochlaena* (Holm) Mackenzie; *Carex athabascensis* F.J. Herm (Kartesz 1994).

Description: *Carex scirpoidea* is a grass-like plant with stems standing 1-4 dm tall, which can be grouped or grow singly from short, stout rhizomes (horizontal roots). The leaves are long, flat, 1-4 mm wide, and clustered near the base. The wide-spreading nature of the leaves make them diagnostic even without a flowering stalk. The stem will be topped with a single, cylindrical, flowering head or spike. Spikes are unisexual (having only anthers or only stigmas). Usually, a single plant will have only male spikes or female spikes, but not both. The spike is made up of several flowers each subtended by a scale. The scales are blackish with pale, to translucent margins and a lighter stripe down the middle. The scales of the female flowers are hairy (Cronquist 1994; Fertig and Jones 1992).

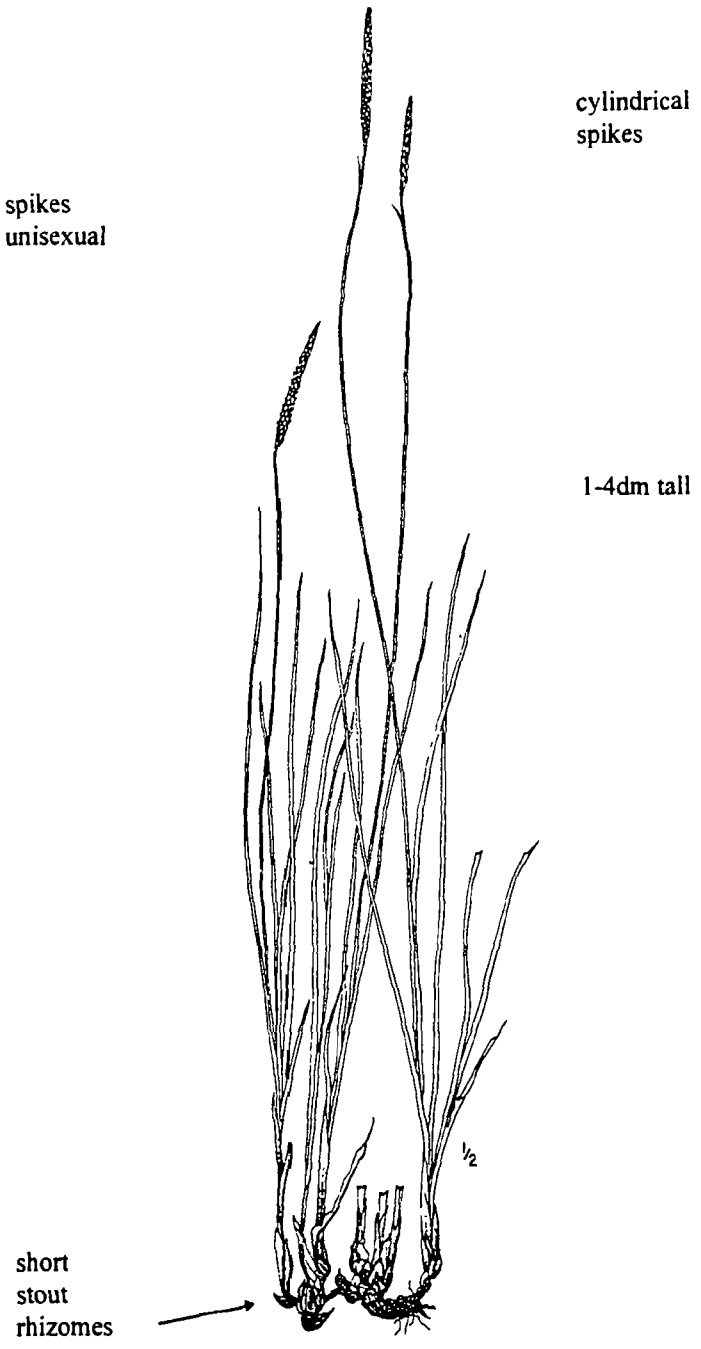
Flowering/Fruiting Period: June through August.

Habitat/Distribution: In South Park, *Carex scirpoidea* generally grows in wet meadows on a light mineral soil that may be high in organic matter but is not, strictly speaking, a peat soil. These meadows frequently occur adjacent to the peaty extreme rich fen habitats, but they also occur in areas that are not associated with the peat-restricted extreme rich fen communities. In these meadows, *Carex scirpoidea* frequently grows with *Senecio pauciflorus*.

The species is found from Greenland to Alaska, south to New York and Michigan, south to Colorado, Utah, and Arizona, and in Nevada and California (Cronquist 1994). In South Park occurrences of this species are concentrated in the more highly alkaline areas south of Fairplay. The largest known occurrence of this species in Colorado is located in a blue spruce (*Picea pungens*) forest on a shallow, seepy soil near the middle fork of the South Platte River. No appreciable peatlands are contiguous with this occurrence.

Similar or Related Species: This species is similar to *Carex hallii (=C. parryana)* except that its floral scales have a green stripe down the midrib. *Carex scirpoidea* resembles *Carex scirpoidea* ssp. *pseudoscirpoidea* in general overall growth habit and appearance. The latter may be more leafy, and upon closer observation will have a short leaf like bract subtending the floral spike; this character is not present in *C. scirpoidea* (Hermann 1970). The subspecies *pseudoscirpoidea* has not been reported from South Park.

Figure 13. ***Carex scirpoidea*** **Michx. (Canadian single-spike sedge)**



Ill. from Cronquist et al. 1977

Carex viridula **Michx.**
Green sedge **CNHP Rank: G5?S1**

Legal Status: No federal legal status.

Synonyms: *Carex oederi* var. *viridula* (Mich.) Kukenth (Hermann 1970).

Description: This grass-like plant grows in clumps or bunches from fine, fibrous roots. The stems stand 6-30 cm tall with the leaves often exceeding them. They are stiff and often brown at the base. Brown, dried leaves of the previous year's growth will be present at the base of the plant. The flowering heads or spikes are unisexual, having either all male flowers (those producing anthers) or all female flowers (those producing stigmas). The spikes are directly attached to the stem (not stalked) with female spikes (several) below the male spike (one) at the very top of the stem. The female spikes have conspicuous fruits that spread almost at right angles from the stem. The scales subtending the female flowers are reddish except for the three green veins and the thin translucent margins (Hermann 1970). This species has a distinctive yellow-green color that sets it apart from other sedges in South Park.

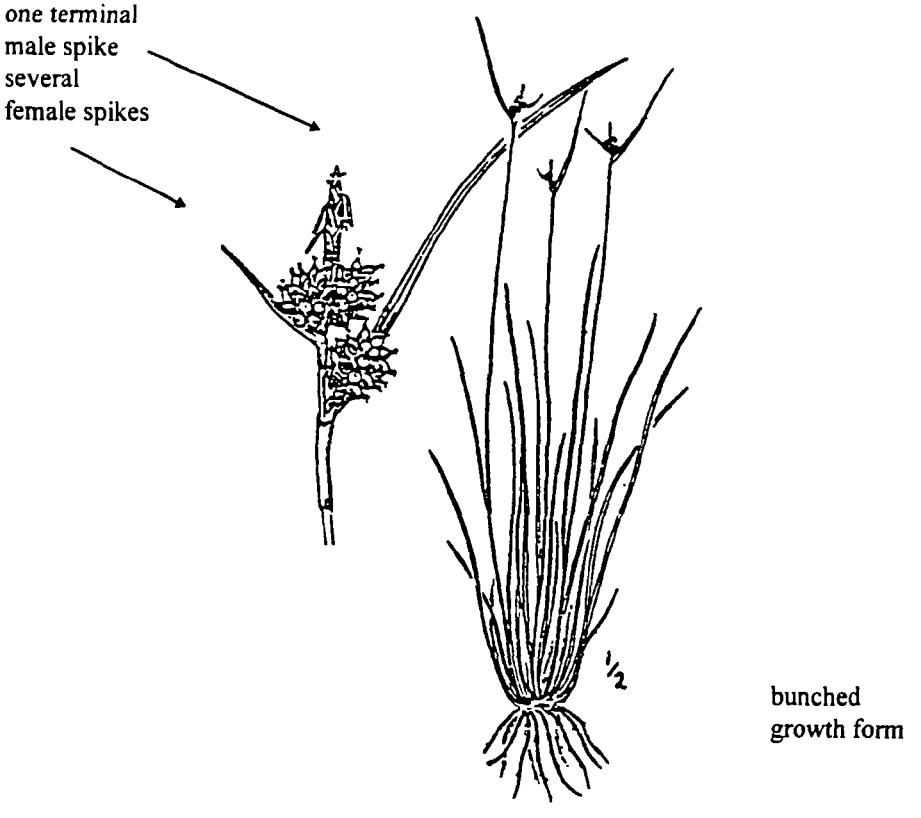
Flowering/Fruiting Period: Approximately June through August.

Habitat/Distribution: In Colorado, *Carex viridula* is found only in peatlands, and is known only from extreme rich fens in South Park. It occurs on saturated ground among other sedges, typically not on hummocks, though it may grow on the sides or at the base of hummocks.

Carex viridula is reported from Newfoundland to Alaska, southward to New Jersey, Indiana, Colorado, and California (Hermann 1970). Only two occurrences are known from South Park, with a total of six in Colorado.

Similar or Related Species: *Carex atherodes* is similar, except the long soft hairs on the leaf sheaths (where the leaf is wrapped around the stem); *Carex viridula* does not have any hairs on the leaf sheaths. *Carex atherodes* will be topped with 2-6 male spikes; *Carex viridula* will be topped with only one. Habitat and distribution in Colorado differ somewhat, so the confusion of the two species may not prove to be a problem (Weber 1990).

Figure 14. ***Carex viridula*** **Michx. (Green sedge)**



Ill. by Janet Wingate

Eriophorum gracile **W.D.J. Koch**
Slender cottongrass **CNHP Rank: G5S2**

Legal Status: No federal legal status.

Description: *Eriophorum gracile* is a grass-like plant with single stems arising from rhizomes (horizontal roots). The stems have edges and stand 2-6 dm tall. There are few to several leaves from the base of the plant that are deep green or brownish to red at the tips and often withered by flowering time. The flowering heads are more conspicuous than grasses as they appear cottony as the common name suggests (Larson 1993).

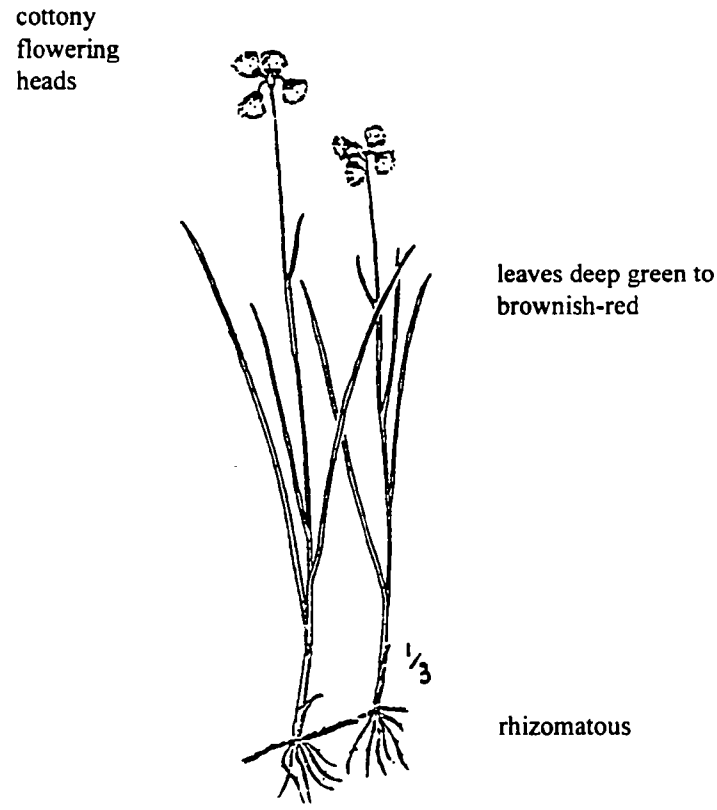
Flowering/Fruiting Period: June through September.

Habitat/Distribution: This species occurs in fens and boggy meadows (Larson 1993). In South Park and throughout Colorado it generally grows on at least a thin layer of peat in a fen, but it is not restricted to extreme rich fens.

Eriophorum gracile is circumboreal, south in North America to Pennsylvania, Indiana, Iowa, Colorado, Idaho and California (Larson 1993). There are thirteen occurrences known in Colorado, only five of which occur in or near South Park.

Similar or Related Species: *Eriophorum angustifolium* is very similar to *Eriophorum gracile* and also occurs in several of South Park's extreme rich fens. *E. gracile* has leaves that are 3 mm or less wide, while those of *E. angustifolium* are 3-6 mm wide (Weber 1976). Also, *E. gracile* tends to form uniform stands that appear reddish due to its red leaf tips (Weber 1990).

Figure 15. ***Eriophorum gracile*** **W.D.J. Koch (Slender cottongrass)**



Ill. by Janet Wingate

***Primula egaliksensis* Wormsk. ex Hornem.**
Greenland primrose **CNHP Rank: G4S2**

Legal Status: Listed as sensitive by the U.S. Forest Service, Forest Service Manual, 2670.5.

Synonyms: *Primula groenlandica* (Warming) W.W. Sm. & G. Forrest (Kartesz 1994).

Description: *Primula egaliksensis* is a small flowering forb, standing about 3-20 cm tall. Its leaves are all at the base of the plant with its flowers topping a naked, purplish stem. The leaves are thin and oval to spatula shaped, and green on both surfaces. The flowers are lilac to rarely white, tube-shaped with five spreading lobes. They are arranged in an umbel (each flower on a stalk, radiating from a central point) subtended by a pair of very small bract like leaves (Weber 1990; Hultén 1968).

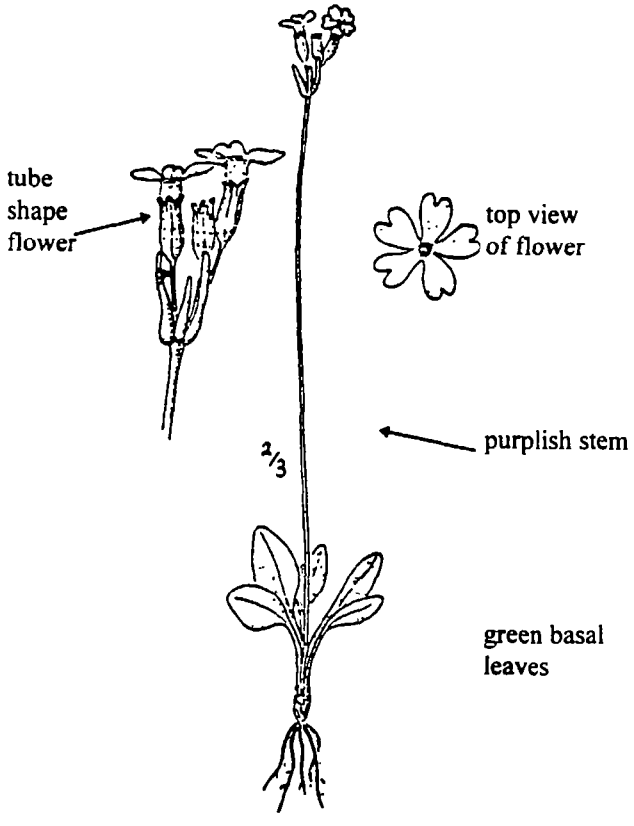
Flowering/Fruiting Period: Mainly June through July. Plants become much less conspicuous after they have finished flowering.

Habitat/Distribution: This species is found in wet meadows and along streams (Hultén 1990). In South Park it occurs in alkaline wet meadow and peatlands from the north end of the park to Antero Reservoir (Cooper 1990a). *Primula egaliksensis* is almost always associated with hummocks.

Primula egaliksensis is found throughout Alaska and the Yukon, eastward to Labrador and Greenland and south to British Columbia (Welsh 1974). Disjunct populations are known from Wyoming and Colorado (Kelso 1991). *Primula egaliksensis* is not rare in South Park, but it is the only place in Colorado that this species is known to occur.

Similar or Related Species: *Primula incana* is similar to *Primula egaliksensis* except that *P. incana* has a mealy or grainy substance on the under side of its leaves and on the upper flowering stalk (Weber 1990). Once the field worker is familiar with this species, the generally shiny, purplish upper stem and the size and color of the flowers allow *Primula egaliksensis* to be usually easily differentiated from *Primula incana.* In fruit *Primula egaliksensis* may be confused with *Parnassia parviflora*, which is very common throughout South Park, but the latter is characterized by leafy stems and broad, oval-shaped fruit.

Figure 16. ***Primula egaliksensis*** **Wormsk. ex Hornem. (Greenland primrose)**



Ill. by Janet Wingate

***Salix candida* Fluegge *ex* Willd.**
Hoary willow **CNHP Rank: G5S2**

Legal Status: No federal legal status.

Synonyms: *Salix candidula* Nieuwl; *Salix candida* var. *denudata* Anderss.; *Salix candida* var. *tomentosa* Anderss. (Kartesz 1994)

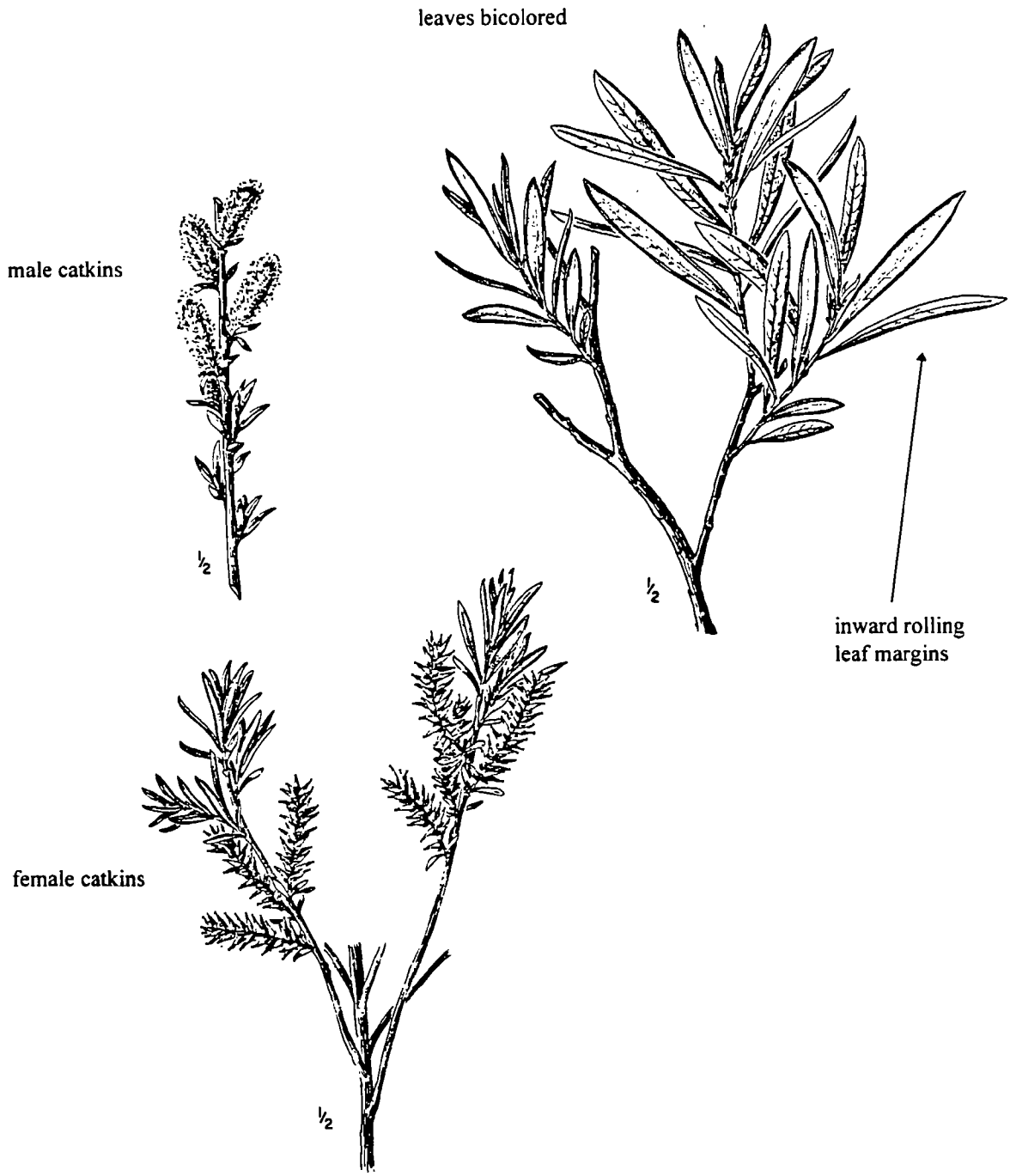
Description: This low growing shrub stands only 5-12 dm tall. It is freely branching with light brown branches, and newer twigs appearing white from dense hair. The distinctive bicolored leaf is helpful in recognizing this species. The upper leaf surface is green with small spots of woolly hair and appears almost leathery, while the under side is densely clothed in white, woolly hair. Leaves are elliptic to narrower, coming to a point at each end; the leaf tips range from very acute to rather obtuse (blunt). The margins of the leaves are rolled inward. The flowering heads or catkins are directly attached to the stem (not stalked) and have brown scales (Carter 1988; Fertig and Jones 1992).

Flowering/Fruiting Period: June through July.

Habitat/Distribution: *Salix candida* is found in cold bogs and marshy areas (Carter 1988). It occurs from Labrador to Alaska and south to the Great Lakes states, South Dakota, Colorado, and Idaho (Hitchcock and Cronquist 1964). In Colorado, the thirteen known occurrences of this species are all reported from South Park (Carter 1988; CNHP 1996) and in nearby Guanella Pass. In South Park, this species occurs on the calcium rich fens dominated by sedges, spikerushes, and willows.

Similar or Related Species: *Salix drummondiana* has bicolored leaves like *Salix candida*, but is a taller shrub with silvery hairs, not white woolly hair. Also, *Salix drummondiana* does not grow in the hummocky extreme rich fens. *Salix brachycarpa*, which is very common in extreme rich fens, is a low-growing species with gray hairy leaves, but it lacks the dense woolly hair on the under surface of the leaf.

Figure 17. ***Salix candida*** **Fluegge ex Willd (Hoary willow)**



Ill. from Hitchcock et al. 1964

Salix myrtillifolia **Anderss.**
Low blueberry willow **CNHP Rank: G5S1**

Legal Status: Listed as sensitive by the U.S. Forest Service, Forest Service Manual 2670.5.

Description: *Salix myrtillifolia* is a very low growing shrub, reaching only 30 cm high. It has a trailing habit, rooting along the stem. Branches are green to reddish brown. Leaves are green on both surfaces, 3-7 cm long, elliptic to oval in shape, with a blunt leaf tip. The leaf margins are serrulate or finely toothed. The flowering heads or catkins have evident, black scales (Weber 1990; Fertig and Jones 1992).

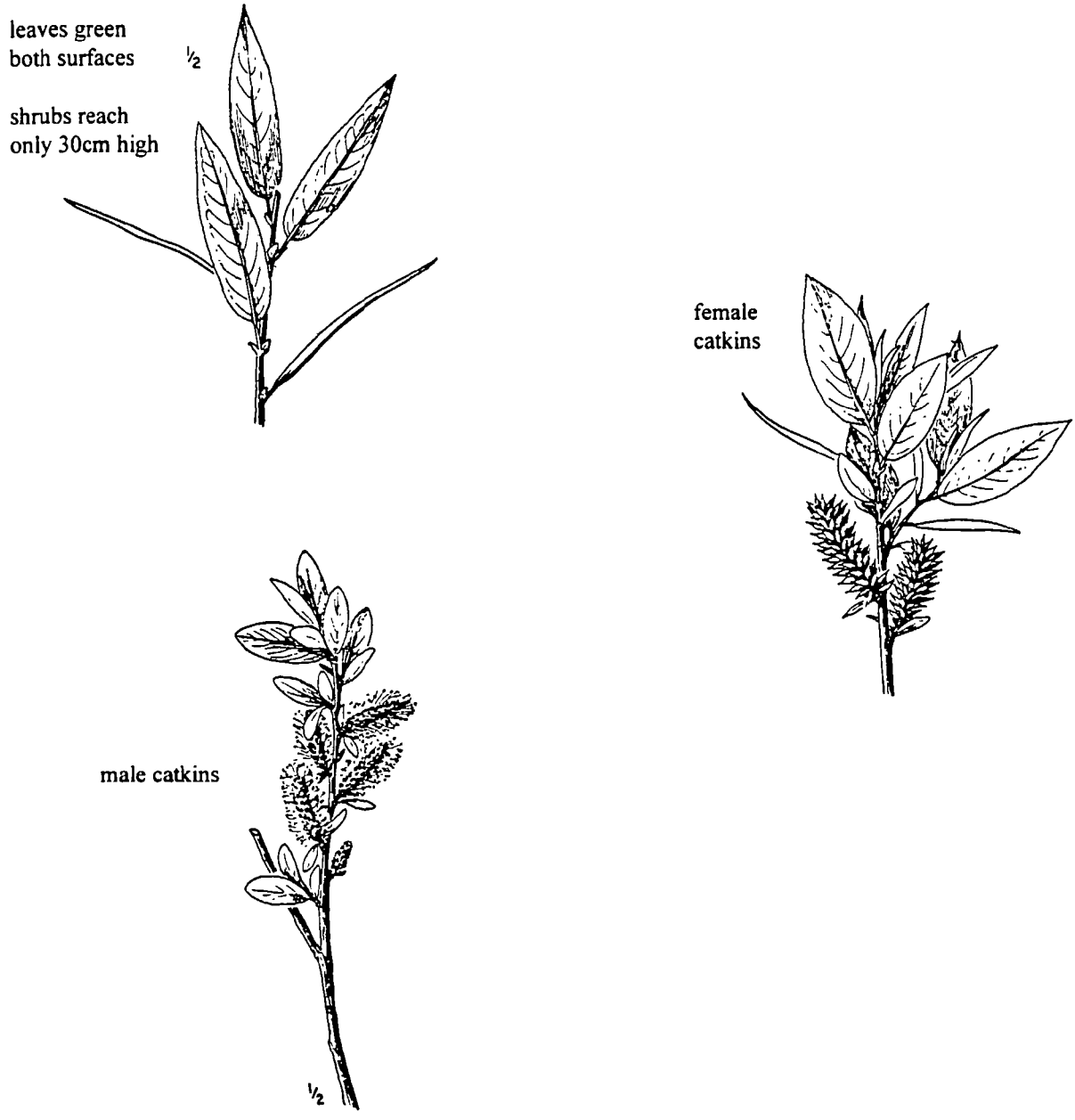
Flowering/Fruiting Period: June through July.

Habitat/Distribution: *Salix myrtillifolia* occurs only in extreme rich fens with strong, constant springs and very calcareous groundwater. In all cases *Salix candida* and generally *Salix brachycarpa* are found nearby.

Salix myrtillifolia normally occurs from Alaska to Newfoundland south to Alberta and Manitoba. In South Park it is common at the High Creek Fen Site and at the Old Railroad Site, and occurs in small numbers in very few other locations. In Colorado, South Park is the only location this species has been reported from (Weber 1990; CNHP 1996). The South Park populations are extremely far removed from the usual northern distribution of this species. They were formerly thought to be the only locations in the western United States (Cooper 1991). The next nearest population to the South Park population is over 450 miles away at the Swamp Lake Botanical Area in Wyoming (Fertig and Jones 1992).

Similar or Related Species: *Salix boothii* is similar and was once considered the same species. It differs from *Salix myrtillifolia* in that it is taller and has some fine hair on the leaves. *Salix wolfii* is another low growing species that is similar to *Salix myrtillifolia*, but differs also in having hair on the leaves (Fertig and Jones 1992). Neither of these potentially confusing species grow in extreme rich fens.

Figure 18. ***Salix myrtillifolia*** **Anderss. (Low blueberry willow)**



Ill. from Hitchcock et al. 1964

***Salix serissima* (Bailey) Fern**
Autumn willow **CNHP Rank: G4S1**

Legal Status: Listed as sensitive by the U.S. Forest Service, Forest Service Manual, 2670.5.

Synonyms: *Salix arguta* var. *pallescens* Anderss.; *Salix arguta* Anderss. var. *alpigena* Anderss.; *Salix lucida* Muhl. var. *serissima* Bailey (Kartesz 1994).

Description: This shrub stands 2-4m (6-12 feet) tall. Young twigs are shiny and hairless. Its leaves are elliptical, very acute at the tip, bright green above, and pale beneath (sometimes whitish) where the brown veins can be easily seen. The flowering heads or catkins have yellowish bracts; capsules (the tiny vase-shaped fruits of the female catkin) are olive-brown and open in late summer or autumn (Weber 1990; Hultén 1968).

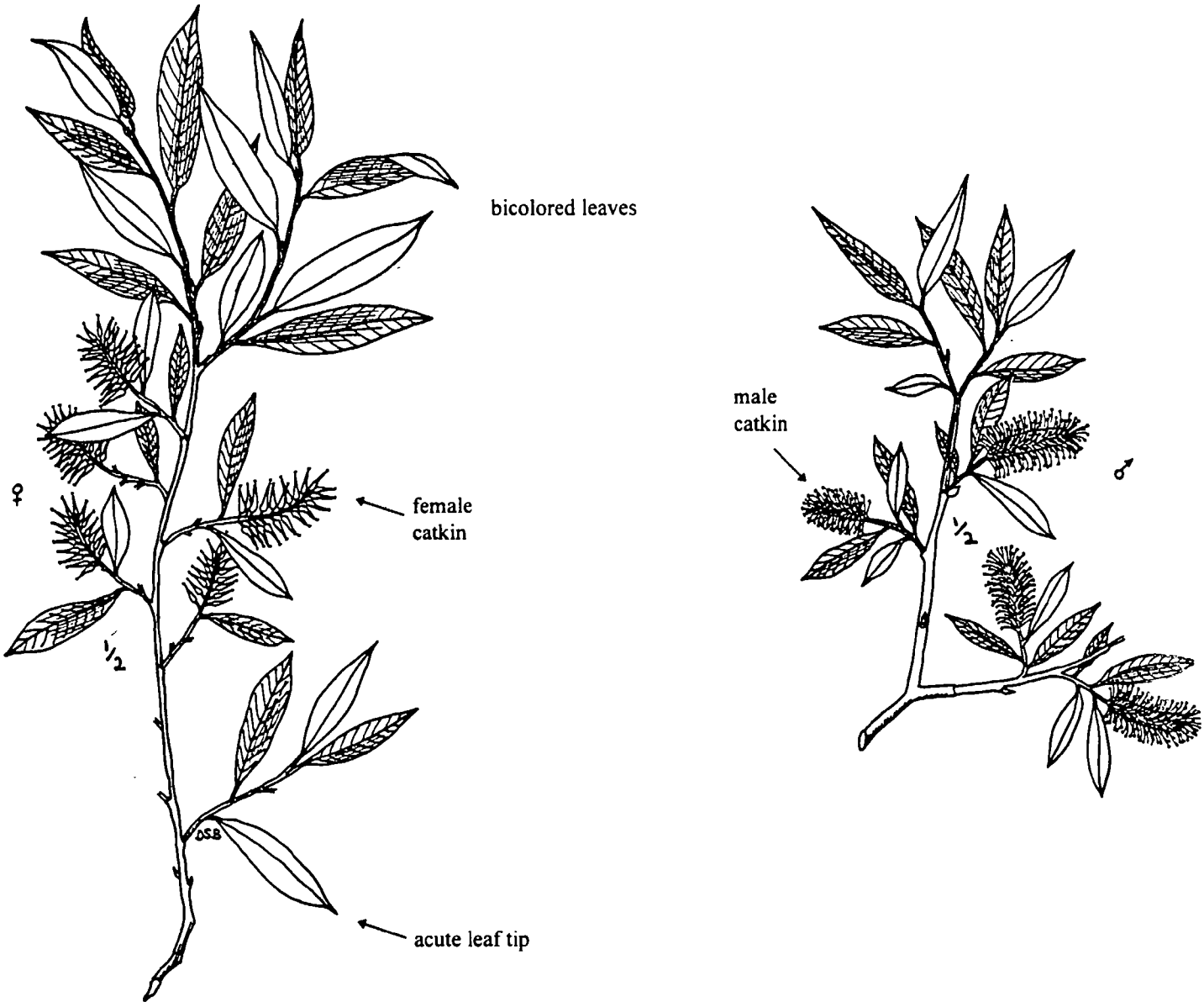
Flowering/Fruiting Period: July through September.

Habitat/Distribution: This species occurs in bogs, marshes and wet meadows (Weber 1990; Hultén 1968). In South Park *Salix serissima* is apparently restricted to extreme rich fens.

In general, *Salix serissima* is found from British Columbia to Newfoundland, south into some areas of the United States (Dorn 1977). It occurs in local, disjunct sites in Montana, South Dakota, and Colorado. There are eight confirmed occurrences of this species in Colorado, three in South Park. It appears to be more common in the north end of the park, but is also found at High Creek Fen.

Similar or Related Species: Glandular leaf tips may cause *Salix serissima* to be confused with *Salix myrtillifolia*. The former is somewhat whitish or pale beneath (Dorn 1977), while the latter is distinctly yellowish green. Also, *Salix serissima* can be taller than *Salix myrtillifolia*, but not necessarily in extreme rich fens. The late-summer flowering and fruiting of *Salix serissima* sets it apart from all other Colorado willows (i.e., if you find a willow in flower or fruit in the spring or early summer, it is *not* this species).

Figure 19. ***Salix serissima*** **(Bailey) Fern (Autumn willow)**



Ill. by Debra Barringer

Scirpus rollandii **Vahl**
Pygmy bulrush **CNHP Rank: G2G3QS1**

Legal Status: Listed as sensitive by the U.S. Forest Service, Forest Service Manual 2760.5.

Synonyms: *Scirpus pumilus* Vahl; *Baeothryon pumilum auct. non* (Vahl) A. & D. Love; *Trichophorum pumilum* (Vahl) Schinz & Thellung (Kartesz 1994)

Description: This very inconspicuous grass-like, tufted perennial has slender rhizomes (creeping horizontal roots), short leaf blades about 0.5 to 1 mm long, and stems standing only 5-10 cm tall. The stems are round with one flowering head at the apex. This flowering head or spikelet is oval and consists of three to five flowers that contain an achene (dry fruit or seed) within. The tiny achenes are lens shaped and in some cases will be subtended by brick red bristles. Other field characters to look for are dead, persistent brown leaves and stems at the base of the plant (Fertig and Jones 1992; Fertig 1994).

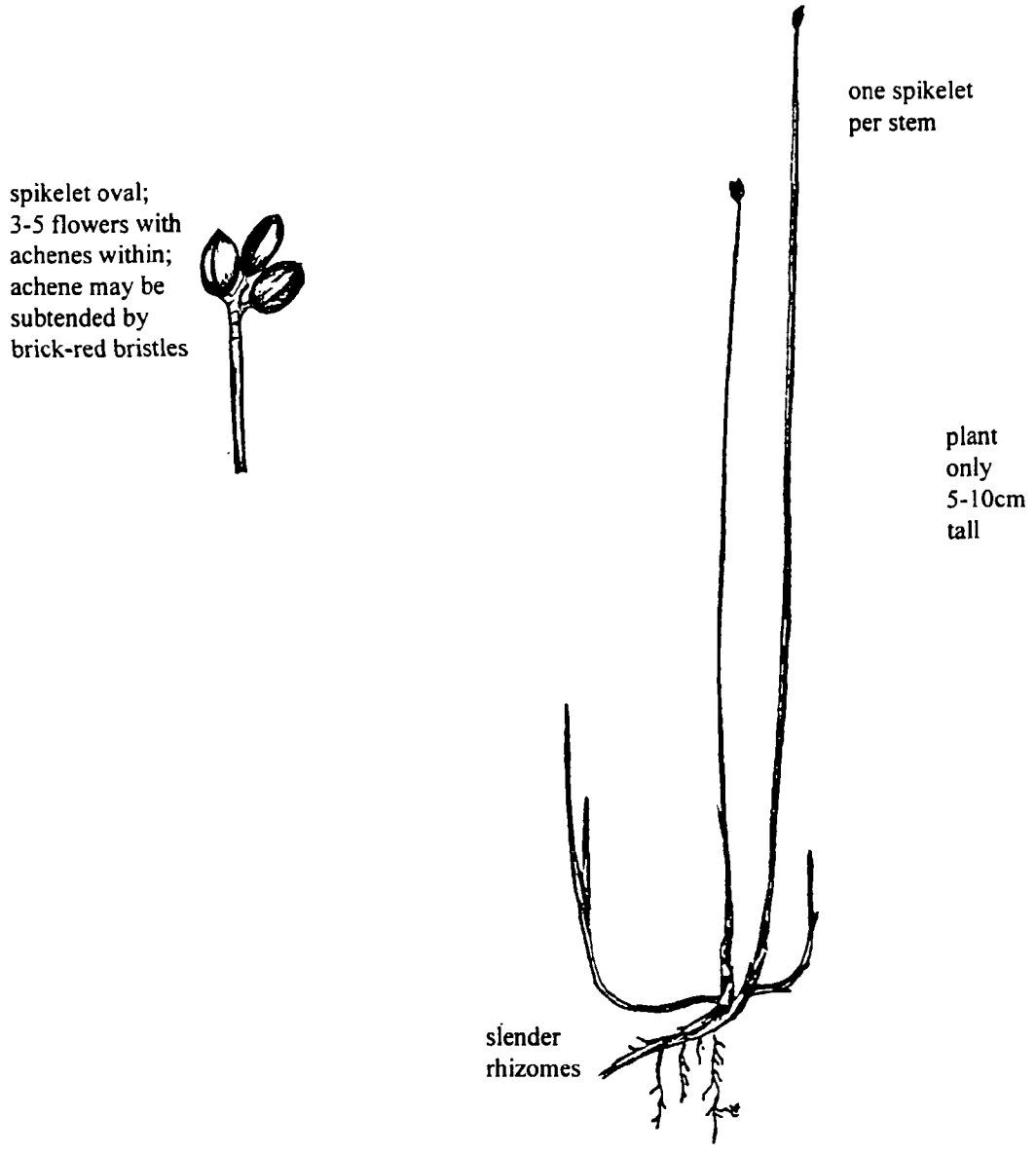
Flowering/Fruiting Period: Flowering in June or July. Fruiting from July through August.

Habitat/Distribution: In South Park, *Scirpus rollandii* grows exclusively on hummocks in extreme rich fens. It is almost always associated with simple kobresia (*Kobresia simpliciuscula)* (Cooper 1990a).

It is a circumboreal species with disjunct populations in Colorado, Wyoming, Montana, and California (Hitchcock and Cronquist 1973; Fertig and Jones 1992). Within Colorado all known occurrences of this species are found in and around South Park. The most extensive population of this species is found at the Jefferson/Guernsey Creek Site. Cooper (1990a) noted that the densities of this plant at the Old Railroad Site (the northwest corner of Antero Reservoir) is particularly dense, but not as extensive.

Similar or Related Species: *Scirpus rollandii* may be confused with low growing spikerushes (*Eleocharis* sp.). Spikerushes do not have any leaves attached directly to the stems, where *Scirpus rollandii* will have leaves attached to the stem (this may require careful observation). The shape of the leaf is also distinctive with an awl like appearance. Also, the inflorescence of *Scirpus rollandii* tends to be slightly inclined, while those of the spikerushes are upright. Since *Scirpus rollandii* occurs on hummocks in extreme rich fens, the only spikerush with which it could be confused is *Eleocharis quinqueflora.*

Figure 20. ***Scirpus rollandii*** **Vahl (Pigmy bulrush)**



Ill. by Walt Fertig

Senecio pauciflorus **Pursh**
Few-flowered ragwort **CNHP Rank: G4G5S1S2**

Legal Status: No federal legal status.

Synonyms: *Packera pauciflora* (Pursh) A. & D. Love; *Senecio discoideus* (Hook.) Britt. (Kartesz 1994)

Description: This composite (having many, usually tiny, flowers within a head, as in a sunflower or dandelion) stands 1-4 dm tall. *Senecio pauciflorus* has a cluster of leaves at the base, with a stem rising from these, topped with the flowering heads. The orange flowers are few (2-6), small, and positioned at the top of the stem. Its leaves at the base of the plant differ from the leaves attached to the stem. The basal leaves are round to elliptic, have toothed margins, and long petioles (stem like structure, attaching the leaf to the stem). The stem leaves are deeply lobed and can be greatly reduced in size as they approach the flowers (Hitchcock and Cronquist 1973; Hultén 1968).

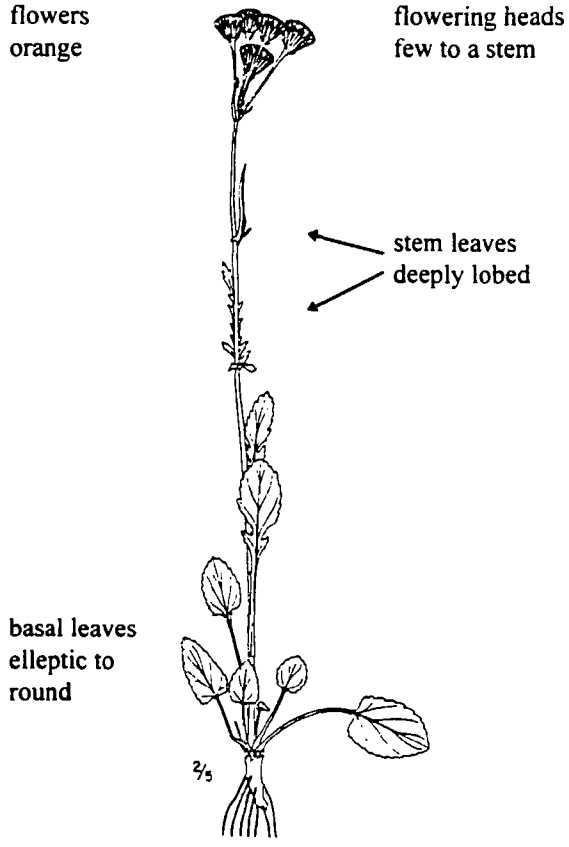
Flowering/Fruiting Period: Approximately July through August.

Habitat/Distribution: Globally, this species occurs in mesic to wet meadows and wet cliffs (Hultén 1968; Hitchcock and Cronquist 1973). It generally does not grow on peat soils, rather it is most commonly found on light colored mineral soils (with high organic content), adjacent to true peat soils.

Senecio pauciflorus occurs in the eastern portion of Alaska and into Canada, south to northern Wisconsin and northern Idaho with disjunct populations reported from California and northwest Wyoming (Hultén 1968; Hitchcock and Cronquist 1973). *Senecio pauciflorus* is relatively common in South Park, though it is more abundant in the more alkaline areas toward Antero Reservoir. It is also found in wet meadows that are not contiguous with extreme rich fens.

Similar or Related Species: *Senecio debilis* is a very similar species but will generally have more flowers (up to 100) on each plant. *Senecio debilis* usually occurs at lower elevations than *Senecio pauciflorus* as well (Hitchcock and Cronquist 1973). *Senecio pauciflorus*, with a reddish tinge around the flowering head and a bright orange, rayless disk, is quite distinctive in South Park.

Figure 21. ***Senecio pauciflorus*** **Pursh (Few-flowered ragwort)**



Ill. from Cronquist 1955

Utricularia ochroleuca **R.W. Hartman**
Northern bladderwort **CNHP Rank: G4?S1?**

Legal Status: No federal legal status.

Synonyms: *Utricularia occidentalis* Gray (Kartesz); Hultén (1968) notes that this species is often regarded as the hybrid *Utricularia intermedia x minor.*

Description: This aquatic herb is found floating, partially submerged in water; the leaves under water are quite different from the leaves above water. The stems growing under the water are finely dissected into linear segments and the leaves above the water are few and reduced to a very small size. The stem above water bears few flowers; the flowers are strongly bilabiate (two-lipped), have a spur or narrow sac-like structure behind the two lips, and are light yellow. In addition to the deeply dissected leaves under the water, there are also stems with "bladders" or ball-like buds attached (Weber 1990; Hultén 1968). It is interesting to note that bladderworts obtain some of their nutrients by using their sac-like bladders to collect and digest microscopic animals like *Paramecium.* These plants are, in part, carnivorous (Weber 1990).

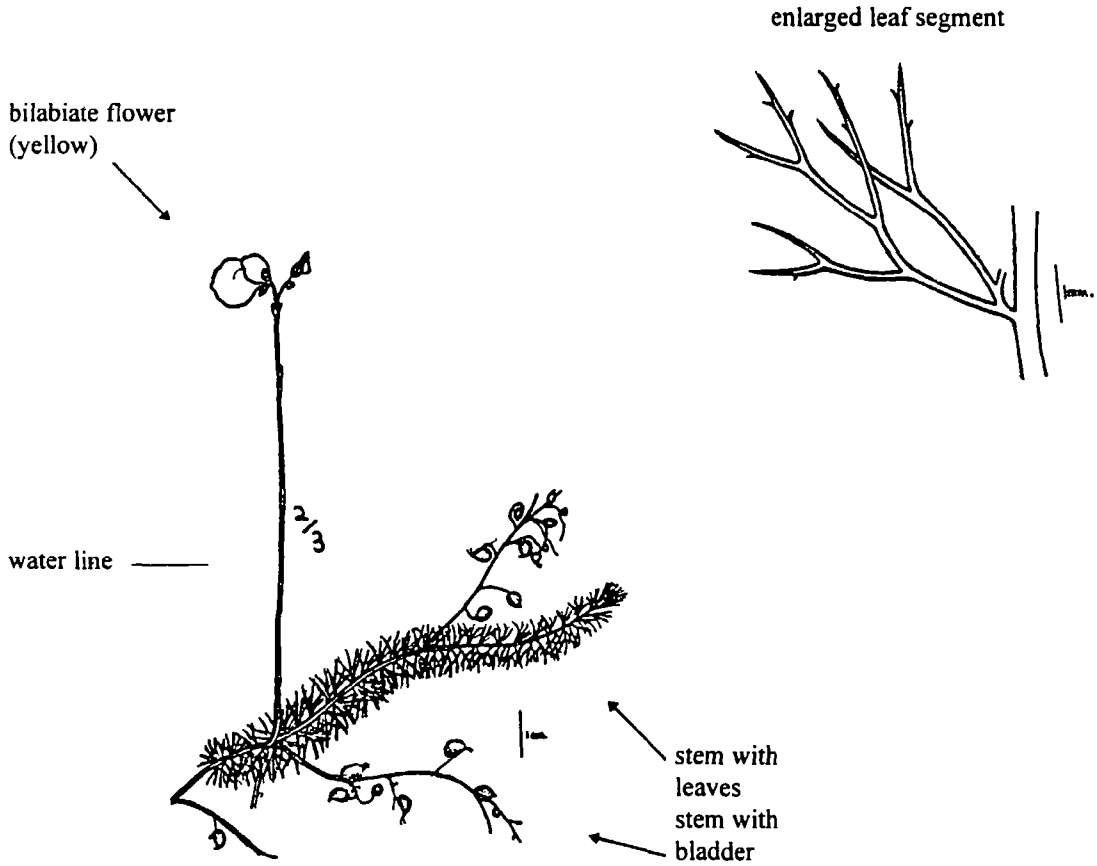
Flowering/Fruiting Period: Late July through August.

Habitat/Distribution: This species occurs on muddy and peaty shores, in shallow water (Hultén 1968). In extreme rich fens such as High Creek Fen it grows in shallow, sparsely vegetated pools.

Little information is available for this particular species' distribution, possibly in part because while not in flower this plant is somewhat inconspicuous. Hultén (1968) notes that this species probably occurs throughout Alaska and neighboring Canadian territories. The only Colorado reports are from the upper Arkansas drainage and South Park (Weber 1990).

Similar or Related Species: Other members of the *Utricularia* are very similar. Fortunately, *Utricularia vulgaris* is probably the only other species that may be confused with *U. ochroleuca* in South Park. The major difference between these species is *Utricularia ochroleuca* bears *either* bladders *or* leaves on the underwater stems, whereas *Utricularia vulgaris* bear both leaves and bladders on the same underwater stems.

Figure 22. ***Utricularia ochroleuca*** **R.W. Hartman (Northern bladderwort)**



Ill. from Polunin 1959.

Extreme Rich Fen Diagnostic Species

Kobresia myosuroides (Villars) Fiori & Paoli
Bellardi kobresia **CNHP Rank: No rank**

Legal Status: No legal status.

Synonyms: *Kobresia bellardii* (All.) K. Koch; *Elyna bellardii* (All.) Degl. (Kartesz 1994)

Description: This grass-like plant is densely bunched, and in some extreme rich fens forms large hummocks. Stems are generally short, but may reach nearly 50 cm. Leaves are narrow and wiry. Flowering heads or spikes are solitary on the top of the stem, very slender and cylindrical, resembling spikes of the genus *Carex*. In autumn, the foliage of this species can become a rich, yellow-bronze (Cronquist 1994; Weber 1990).

The appearance of this species in South Park is often quite anomalous in comparison with the typical alpine form in that the stems and leaves are generally much longer in the park.

Flowering/Fruiting Period: June through August.

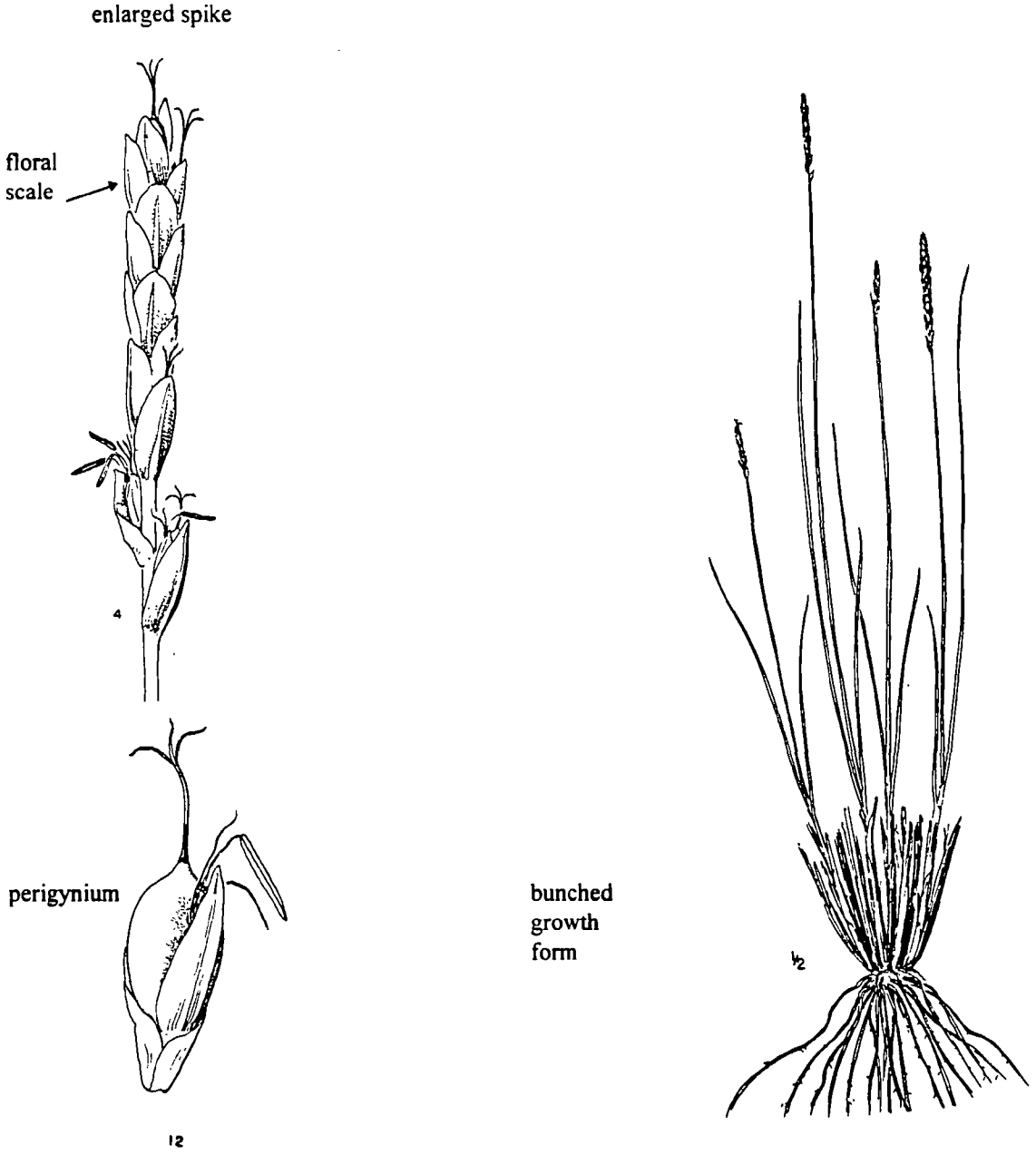
Habitat/Distribution: *Kobresia myosuroides* typically occurs in open dry or moist places at high altitudes in the mountains, usually above timberline (Cronquist 1994). In South Park, this species was found dominating peaty hummocks in slightly drier portions of the peatland. The only other place where *Kobresia myosuroides* has been reported in a wetland habitat is in the Convict Creek Basin, Mono County, California.

Kobresia myosuroides is circumboreal, extending south to Newfoundland and Quebec and irregularly to Colorado, Utah, Oregon and California (Cronquist 1994). It extends far south in alpine areas, into central Europe, China, and elsewhere.

Similar or Related Species: *Kobresia* spp. can be confused with *Carex* spp. very easily. The difference can be seen in the fruit of the female flower. The fruits of both species are achenes (a dry fruit or seed) and are encased by a covering called a perigynium. These are usually shaped like a vase and are located beneath the floral scales of the female flower. The perigynia of *Kobresia* spp. are open (like an open coat) while the perigynia of *Carex* spp. are completely closed, with no opening except at the apex. Weber (1990) notes that *Carex elynoides* and *Kobresia myosuroides* are very similar, but the former is not known to occur in extreme rich fens.

Kobresia myosuroides can also be easily confused with *Kobresia simpliciuscula* based on both habitat and growth form. Contrary to what is seen in some floras, both species form dense tussocks. However, *Kobresia myosuroides* has a simple inflorescence (all the flowers attached directly to the central stalk) while *Kobresia simpliciuscula* has a compound inflorescence (flowers attached to spikelets that come off the central stalk).

Figure 23. ***Kobresia myosuroides*** **(Villars) Fiori & Paoli (Bellardi kobresia)**



Ill. from Hitchcock et al. 1969

Kobresia simpliciuscula **(Wahlenb.) Mackenzie**
Simple kobresia **CNHP Rank: No rank**

Legal Status: No federal legal status.

Synonyms: *Kobresia bipartita* (All.) Dalla Torre; *Kobresia simpliciuscula* var. *americana* Duman (Kartesz 1994)

Description: This grass-like perennial is strongly rhizomatous (having horizontal roots) and densely tufted. The stems stand 1-3.5 dm tall (or slightly taller) with cinnamon brown bases, and exceed the leaves. The leaves are erect to curved and about 1 mm wide. The flowering heads or spikes are composed of interrupted "spikelets" with the uppermost spikelets being composed of male flowers. The scales are small and brownish (Fertig and Jones 1992; Weber 1990).

Flowering/Fruiting Period: June through August.

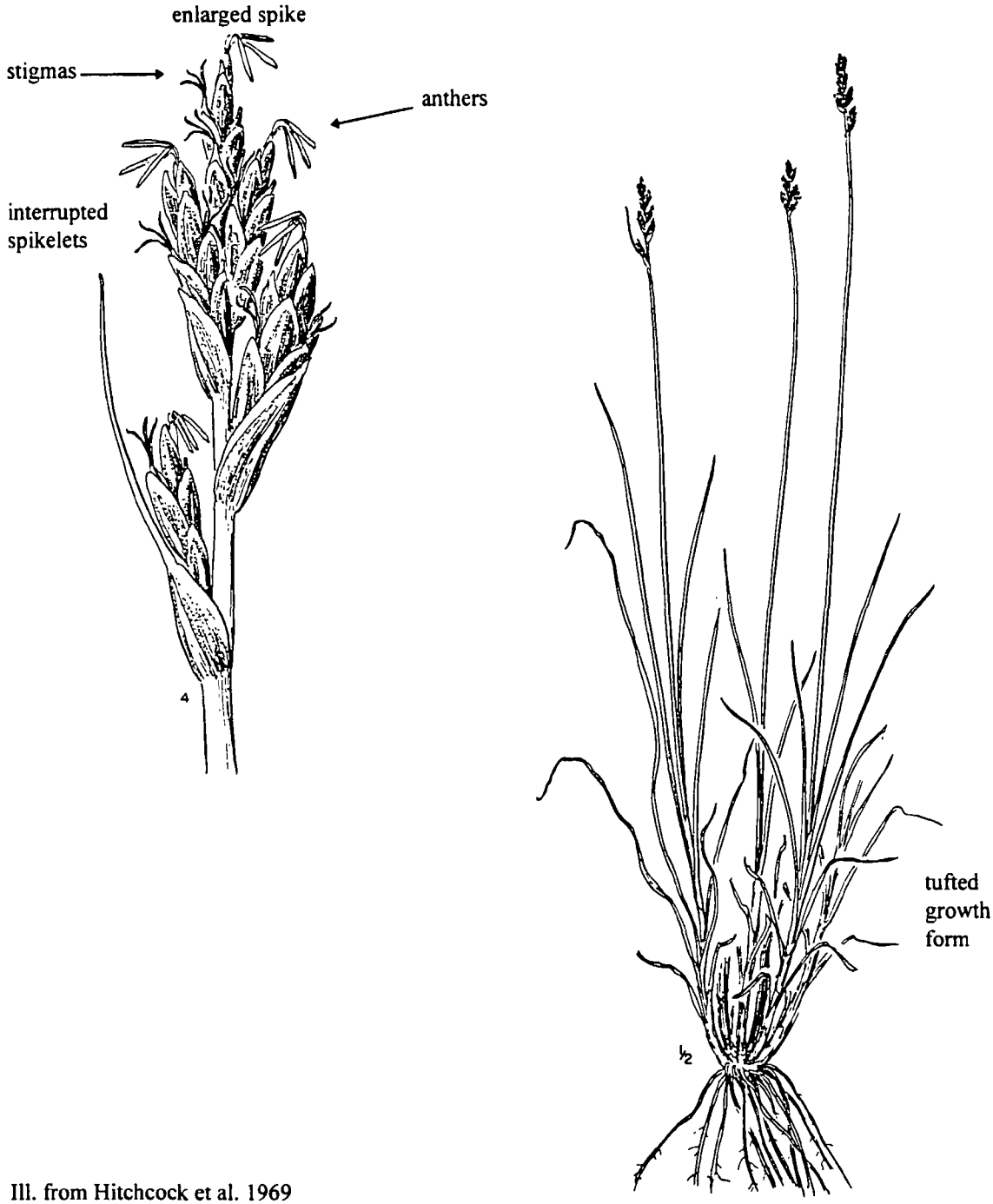
Habitat/Distribution: *Kobresia simpliciuscula* occurs in bogs and wet meadows in montane areas (Hitchcock et al. 1969). It is also found in moist, gravely tundra (Weber 1990). In South Park it grows exclusively in extreme rich fens.

Kobresia simpliciuscula is circumpolar extending to Newfoundland, Quebec, and Alberta (Porsild and Cody 1980). It also occurs in the central Rocky Mountains in Montana, Wyoming, Utah, and Colorado (Fertig and Jones 1992).

Similar or Related Species: In general *Kobresia* spp. can be confused with *Carex* spp. very easily. In South Park, however, their growth forms (generally dense tussocks on hummocks) and habitat (only extreme rich fens for *Kobresia simpliciuscula*) allow them to be distinguished rather readily. Technically speaking, the two genera are separated because the perigynia (covering of the achenes or seeds) of *Kobresia* spp. are open along their length while the perigynia of *Carex* spp. are completely closed, with no opening except at the apex. A hand lens is suggested for careful observation.

Kobresia simpliciuscula can also be easily confused with *Kobresia myosuroides* based on both habitat and growth form. Contrary to what is seen in some floras, both species form dense tussocks. However, *Kobresia simpliciuscula* has a compound inflorescence (flowers attached to spikelets that come off the central stalk) while *Kobresia myosuroides* has a simple inflorescence (all the flowers attached directly to the central stalk).

Figure 24. ***Kobresia simpliciuscula*** **(Wahlenb.) Mackenzie (Simple kobresia)**



Ill. from Hitchcock et al. 1969

Extreme Rich Fen Plant associations

***Kobresia simpliciuscula–Scirpus rollandii* plant association**
Extreme rich fen plant association **CNHP Rank: G2S1**

Related Communities from Other Studies: Fertig and Jones (1992) include the *Kobresia simpliciuscula–Scirpus rollandii* plant association in their *Triglochin-Eleocharis* vegetation type.

Geographic Extent: This community is restricted to extreme rich fens, and is known definitively from only two locations: South Park, Colorado, and the Swamp Lake Botanical Areas, Shoshone National Forest, Wyoming (Fertig and Jones 1992).

Site Features: This community is generally found growing on hummocks (mounds of organic soil) in wet parts of the fens. Swales beneath the hummocks may contain stands of *Carex aquatilis*, *Carex simulata*, or *Eleocharis quinqueflora-Triglochin* spp. communities. These swales are inundated to the surface throughout most or all of the growing season.

Vegetation: *Kobresia simpliciuscula* is the most conspicuous, and generally dominant, species growing in these hummock communities--it is nearly 100% constant and has cover ranging from 15 to 60%. *Scirpus rollandii* occurs almost exclusively in this community, but it is not present in every stand. Even when present it may remain inconspicuous, though it may also be the dominant species in the stand. Other species frequently seen in this community are *Thalictrum alpinum, Salix candida,* etc.

Element Conservation and Management: Stands of this plant community appear to be sensitive to heavy grazing, especially from mid-June through the end of the summer.

Stand Data*:

Table 15. *Kobresia simpliciuscula–Scirpus rollandii* plant association.

STAND #	12	16	50	188	211	217	230	236	252	Avg.
SPECIES										
Kobresia simpliciuscula	25	25	25	15	60	30	40	60	30	34
Thalictrum alpinum	60	10	30	20	25	15	-	10	30	22
Trichophorum pumilum	7	1	5	30	-	15	5	-	-	7
Juncus arcticus	10	2	-	-	10	5	10	2	5	5
Kobresia myosuroides	-	-	-	-	10	5	15	-	-	3
Salix candida	-	-	7	5	-	-	-	5	-	2
Bistorta vivipara	-	2	3	-	2	10	3	-	1	2
Campylium stellatum	-	-	-	-	-	-	-	-	20	2
Ptilagrostis porteri	+	-	-	-	-	5	1	-	3	1
Carex scirpoidea	3	-	10	-	-	-	-	+	-	1
Triglochin maritimum	1	1	5	5	-	-	-	-	-	1
Carex simulata	5	3	-	-	-	-	-	+	5	1

*Data from Cooper (1990a). Only species with 1% or greater cover are shown.

Figure 25. The *Kobresia simpliciuscula–Scirpus rollandii* plant association occurring on the tops of low hummocks. A *Carex* spp. community dominates in the swales between the hummock.

Figure 26. Another view of the *Kobresia simpliciuscula–Scirpus rollandii* plant association (foreground), this time with *Salix brachycarpa* and *Salix candida* co-occurring with low cover on hummock tops. At the upper edge of this peatland there is a taller willow community, with an aspen grove behind it.

***Kobresia myosuroides–Thalictrum alpinum* plant association**
Extreme rich fen plant association **CNHP Rank: G1S1**

Related Communities from Other Studies: A closely related community was reported in the Convict Creek Basin in California (Major and Taylor 1977). Nothing similar to it has been reported from any other extreme rich fen.

Geographic Extent: This community is best developed in the northern South Park, although it occurs throughout the range of the extreme rich fens in the park.

Site Features: The *Kobresia myosuroides–Thalictrum alpinum* plant association tends to occur on the outer, somewhat drier edges of the peatland. Where best developed it forms large hummocks (up to 50 cm high). This community almost always grows on the tops of these hummocks.

Major and Taylor (1977)report that in Convict Creek Basin the related plant association "is found in depressions which are well supplied in early summer with water, which is often standing, and have a long-persisting snow cover and a peaty sod, with hummocks or solifluction."

Vegetation: *Kobresia myosuroides* dominates this community, growing much taller than its typical form in the alpine. *Thalictrum alpinum* is included in the plant association name because it is 100% constant and it separates this community from alpine communities dominated by *Kobresia myosuroides*. *Juncus arcticus* almost always occurs in this community, with average cover around 15%. Although *Salix brachycarpa* does not appear in the stand table (Table 16), it too is frequently associated with this plant association.

Major and Taylor (1977) indicate that the vegetation type of the calcareous soils in Convict Creek Basin is "differentiated by *Gentiana amarella, Kobresia myosuroides, Epilobium latifolium, Salix brachycarpa, Calamagrostis canadensis, Carex hassei*, and *Scirpus rollandii*. This is a rare type of Sierra Nevadan vegetation.

Conservation and Management: The *Kobresia myosuroides–Thalictrum alpinum* community is a much less prominent community at most extreme rich fens, but at two (near Como) it is very robust and dominant. The rarity of this community and the threats it still faces strongly suggest that all of the locations where it occurs should be protected, especially the occurrence at Fremont's Fen. This community appears to tolerate grazing, but heavy trampling should be avoided when the soil is heavily saturated. Hydrologic modifications in the direction of the water source supporting this community should be avoided.

Stand Data*:

Table 16. *Kobresia myosuroides - Thalictrum alpinum* plant association.

STAND #	216	222	52	135	153	168	201	210	228	244	253	Avg.
SPECIES												
Kobresia myosuroides	40	40	40	40	60	50	40	40	60	60	60	48
Juncus arcticus	30	25	10	10	10	10	5	15	15	10	15	14
Thalictrum alpinum	20	5	5	5	7	10	5	15	5	15	10	9
Muhlenbergia richardsonis	+	-	20	-	7	-	25	15	-	2	-	6
Kobresia simpliciuscula	5	-	-	-	-	-	5	-	3	-	-	4
Ptilagrostis porteri	10	3	-	-	-	-	10	-	2	-	10	3
Deschampsia cespitosa	5	-	5	-	-	-	7	10	-	-	2	3
Carex capillaris	1	5	-	5	-	-	+	3	1	-	2	2
Antennaria microphyllus	-	7	-	+	5	1	-	5	-	-	-	2
Festuca arizonica	-	-	-	-	-	-	-	5	1	-	10	2
Bistorta vivipara	5	-	-	1	5	1	-	2	2	-	-	1
Eleocharis quinqueflora	-	-	-	10	-	-	-	-	-	-	-	1
Parnassia parviflora	1	1	-	2	-	-	-	-	+	-	1	1
Elymus trachycaulus	1	-	-	-	-	-	5	-	-	+	-	1
Argentina anserina	-	-	3	-	-	-	-	-	-	5	-	1

*Data from Cooper (1990a). Only species with 1% or greater average cover are shown.

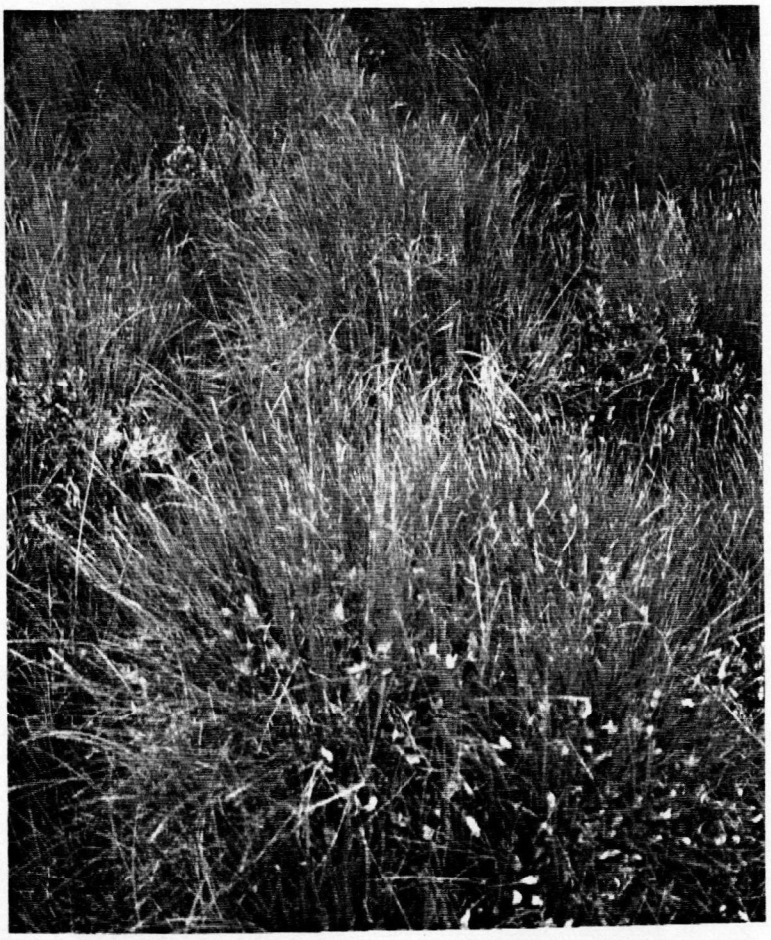


Figure 27. A close view of the *Kobresia myosuroides–Thalictrum alpinum* plant association on the tops of hummocks that are nearly 50 cm tall. The globally rare plant *Ptilagrostis mongholica* ssp. *porteri* also grows on these hummocks. The shrub is *Salix brachycarpa*.

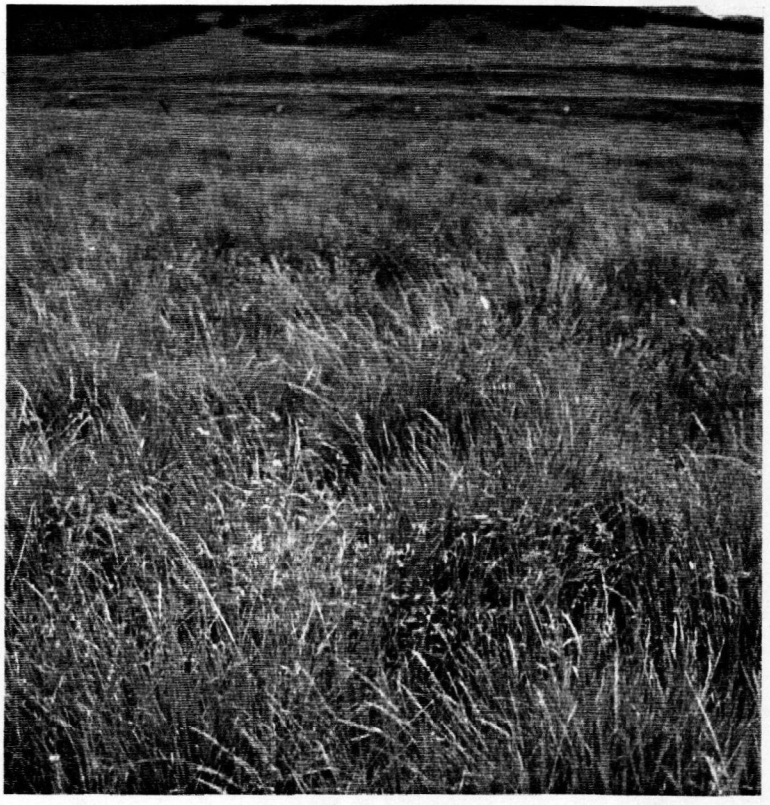


Figure 28. The setting of the above *Kobresia myosuroides–Thalictrum alpinum* plant association. The area in the background below the hills has had the peat completely mined out.

***Eleocharis quinqueflora–Triglochin* spp. plant association**
Alkaline spring plant association **CNHP Rank: G?S2**

Related Communities from Other Studies: The *Triglochin maritimum* plant association and the *Eleocharis quinqueflora* plant association of Cooper (1990a) are both similar to or synonymous with *Eleocharis quinqueflora-Triglochin* spp.. Cooper (n.d.) characterized a *Triglochin maritimum–Triglochin palustris* plant association and a *Carex microglochin–Eleocharis quinqueflora* plant association that we consider synonymous with the *Eleocharis quinqueflora–Triglochin* spp. plant association. This plant association is included within the *Triglochin-Eleocharis* vegetation type of Fertig and Jones (1992). This plant association is similar to, but distinct from, the *Eleocharis quinqueflora* plant association found throughout the subalpine and lower alpine of the southern Rocky Mountains (see Sanderson and Kettler 1996, Kettler and McMullen 1995, Kittel et al. 1994, Komárková 1976, and Padgett et al. 1989).

Geographic Extent: This plant association is known for certain from only the South Park area (Cooper 1990a, Cooper n.d., J. Sanderson unpublished data) and from northwestern Wyoming (Fertig and Jones 1992). However, it resembles *Triglochin* stands reported from other extreme rich fen. This similarity should be investigated further before reaching conclusions about the global distribution of this plant association.

Site Features: The *Eleocharis quinqueflora–Triglochin* spp. occurs very distinctive water discharge areas (springs). These are "quagmires" in the true sense in that they are unstable and a foot can sink deeply into them with little effort. These communities occur on a floating mat of peat. Calcareous deposits (marl), recognized my white deposits on the site, tend to be prominent in these stands. Stands of this community may appear as contiguous or slightly separated small and large patches over an extensive area, or they may appear as small, discrete units.

Vegetation: Vegetation in this community tends to be sparse to very sparse. In many stands of this type only three species are present. *Eleocharis quinqueflora*, a plant of another frequently seen subalpine peatland, grows scattered in this community. It frequently is the most common species, but also often yields dominance to on of the arrowgrass species. Both of the (alkali-tolerant) arrowgrass species (*Triglochin* spp.) occur in this community. In the most marly sites it is common to see *Triglochin palustris* as the most common species.

Conservation and Management Issues: The rarity of this community and the threats it still faces strongly suggest that all of the locations where it occurs should be protected, particularly at the sites profiled in this report. The "quagmire" nature of this plant association makes it particularly susceptible to physical disturbance by machinery or cattle, so these disturbances should be avoided. The naturally unstable surface under this community provides a moderate level of defense against these types of disturbance, but several small occurrences still show heavy impacts. Hydrologic modifications in the direction of the water source supporting this community could have severe impacts and should be avoided.

Stand Data*:

Table 17. *Eleocharis quinqueflora–Triglochin* spp. plant association.

STAND #	9	10	13	14	16	17	18	19	22	23	Avg.
SPECIES											
Eleocharis quinqueflora	10	6	6	60	24	10	13	40	35	40	24
Triglochin maritima	12	4	2	6	8	3	3	15	5	5	6
Triglochin palustris	1	3	1	1	3	5	+	+	3		2
Carex aquatilis	+	4					3			2	1
Pedicularis groenlandica	+	+							+	1	
Juncus sp.		+									
Carex utriculata	+										
Utricularia ochroleuca				6	+		5	1			1
Potamogeton pectinatus					1		+	2			
Scorpidium scorpioides								12		6	2
Juncus balticus										+	
Carex microptera										2	
Carex simulata										3	

*Stand data gathered at High Creek Fen. These data reflects a community dominated consistently by *Eleocharis quinqueflora*. However, in some areas a *Triglochin* species dominates, especially *Triglochin palustris* in the most marly sites.

Figure 29. A close view of the *Eleocharis quinqueflora-Triglochin* spp. plant association in the low, wet quagmire with an associated *Kobresia simpliciuscula–Scirpus rollandii* plant association standing out prominently on a hummock. Note the marl along all the exposed edges of litter and mud.

Figure 30. The setting of the above *Eleocharis quinqueflora-Triglochin* spp. plant association. The loose organic soil beneath this plant association gives way quickly under the weight of a human foot.

Appendix 3. Diagnostic Features of Extreme Rich Fens.

This appendix provides a guide to diagnostic features of extreme rich fens so that less-experience field personnel will know what main features suggest an extreme rich fen. This features are:

- Characteristic plants/plant associations
- Water chemistry
- Aerial photo signature

If a wetland that has not yet been identified as an extreme rich fen is being assessed or inventoried, these features should be investigated. A handful of plants (see below) are the single best, most-assured indicator of the presence of an extreme rich fen. The most conspicuous plants and their growth forms can be readily learned at an existing site (e.g., High Creek Fen, The Nature Conservancy's preserve) where they are known to exist, then those images can be carried to the site being investigated. Alternatively, a short visit to an herbarium that contains these species will at least suggest a search image, thereby facilitating the search.

Characteristic plants/plant associations.

Plants and plant associations allow recognition of extreme rich fens with a high degree of certainty. To a non-botanist who cannot distinguish between species of willow and sedge, it may not be readily apparent that one is looking at an extreme rich fen. However, a field worker distinguishing among these species will recognize several that have very high fidelity to extreme rich fens. Appendix 2 of this report presents illustrations of each of these species including descriptions of their habitat, habit, and distribution.

Rare plants that in South Park have high fidelity to extreme rich fens and are very diagnostic of these wetlands are listed here. The first two species on this list are relatively easy to recognize once a search image is formed, and they occur in very many of the extreme rich fens.

- Simple kobresia (*Kobresia simpliciuscula)*
- Hoary willow (*Salix candida)*
- Pygmy bulrush (*Scirpus rollandii)*
- Porter's feathergrass (*Ptilagrostis mongholica* ssp. *porteri)*
  Note: Porter's feathergrass is generally found north of Como only.

The next lists of plants shows those rare species known in South Park only from extreme rich fens although their limited distribution in the park reduces their usefulness as extreme rich fen indicators. They are:

- Livid sedge (*Carex livida*)
- Little green sedge (*Carex viridula*)
- Slender cottongrass (*Eriophorum gracile*)
- Low blueberry willow (*Salix myrtillifolia*)
- Autumn willow (*Salix serissima)*
- Northern bladderwort (*Utricularia ochroleuca)*
- A moss (*Scorpidium scorpioides*)

Finally, there are several rare plant species that occur in extreme rich fens but are not restricted to them. They are:

- Pale blue-eyed grass (*Sisyrinchium pallidum)*
- Canadian single-spike sedge (*Carex scirpoidea*)
- Greenland primrose (*Primula egaliksensis*)
- Few-flowered ragwort (*Senecio pauciflorus*)
- Bellardi kobresia (*Kobresia myosuroides*)
  (Note: Bellardi kobresia occurs at very low cover in shrubby cinquefoil (*Pentaphylloides floribunda*) shrublands, but it always quite small in this habitat. In extreme rich fens it commonly grows to culm heights of 30-40 cm)

All three plant communities described in Appendix 2 are highly indicative of extreme rich fens.

Water chemistry

The chemistry of the groundwater that discharge into this fens is the single most important physical factor contributing to their character. As seen below in Table 18, there is in general a sharp contrast between extreme rich fens and the more common rich fens.

Cooper (1990b) reports the following water chemistry values from several extreme rich and rich fens in South Park and vicinity. The last five columns require laboratory analysis and thus are not useful for cursory filed reconnaissance, but the first two, pH and conductivity, are easily measured in the field with a handheld instrument. These values can be simply measured in standing or slowly flowing surface water in the peatland (but note, not all peatlands will have pockets of water during all seasons). Measurements should be taken at many points throughout the wetland, because these values can vary greatly from one location to another even in one peatland. After assessing several locations, compare the values to those shown below. In general, values of pH above 7.5 and conductivity above 350 µS suggest the peatland is an extreme rich fen.

Table 18. Water chemistry characteristics for three extreme rich fens and four rich fens in South Park and vicinity.†

Site	pH	Conductivity (µS)	HCO_3^- (mg/l)	SO_4^{2-} (mg/l)	Ca^{2+} (mg/l)	Na^+ (mg/l)	Mg^{2+} (mg/l)
Extreme Rich Fens							
High Creek Fen	7.65-8.60	360-860	248-284	26.2-54.7	56.5-60.3	5.8-6.6	25.7-28.6
Brinkerhoff Site	7.88-8.22	338-600	251-290	3.9-9.9	37.9-86.0	1.9-7.0	16.6-42.2
Fremont's Fen	7.38-8.34	116-576	0.5-3.1	2.8-28.7	14.8-94.9	2.0-9.9	2.2-9.1
Rich Fens							
Sacramento Creek*	6.67-7.59	332-403	152-187	1.4-64.6	35.5-42.2	1.3-2.2	18.2-22.8
East Lost Park‡	6.06-6.89	24-59	NA	NA	NA	1.9-2.3	0.4-0.8
McMaster's	6.95	83-148	28-73	3.4-32.8	7.1-15.7	1.9-2.3	3.4-6.9
Carpenter's	7.0-8.1	163-209	59-117	3.9-9.9	12.3-22.1	1.4-2.6	4.9-9.6

† Data from Cooper (1990b).

*Sacramento Creek can be considered transitional between rich and extreme rich fen.

‡East Lost Park is the only fen listed that is not influenced by the calcareous bedrock of the Mosquito Peaks. It is located in the Tarryall Mountains which consist of granitic bedrock that was not glaciated during the Pleistocene.

Aerial photo signature

Aerial photos can be a useful tool for identifying potential extreme rich fens before a field visit. The three photos included on the following illustrate the three basic settings for extreme rich fens. These photos are included as guidelines only. It is very difficult using aerial photos only to determine definitively the type of wetland in a particular area. In no way can aerial photos serve as a substitute for on the ground species and community determinations.

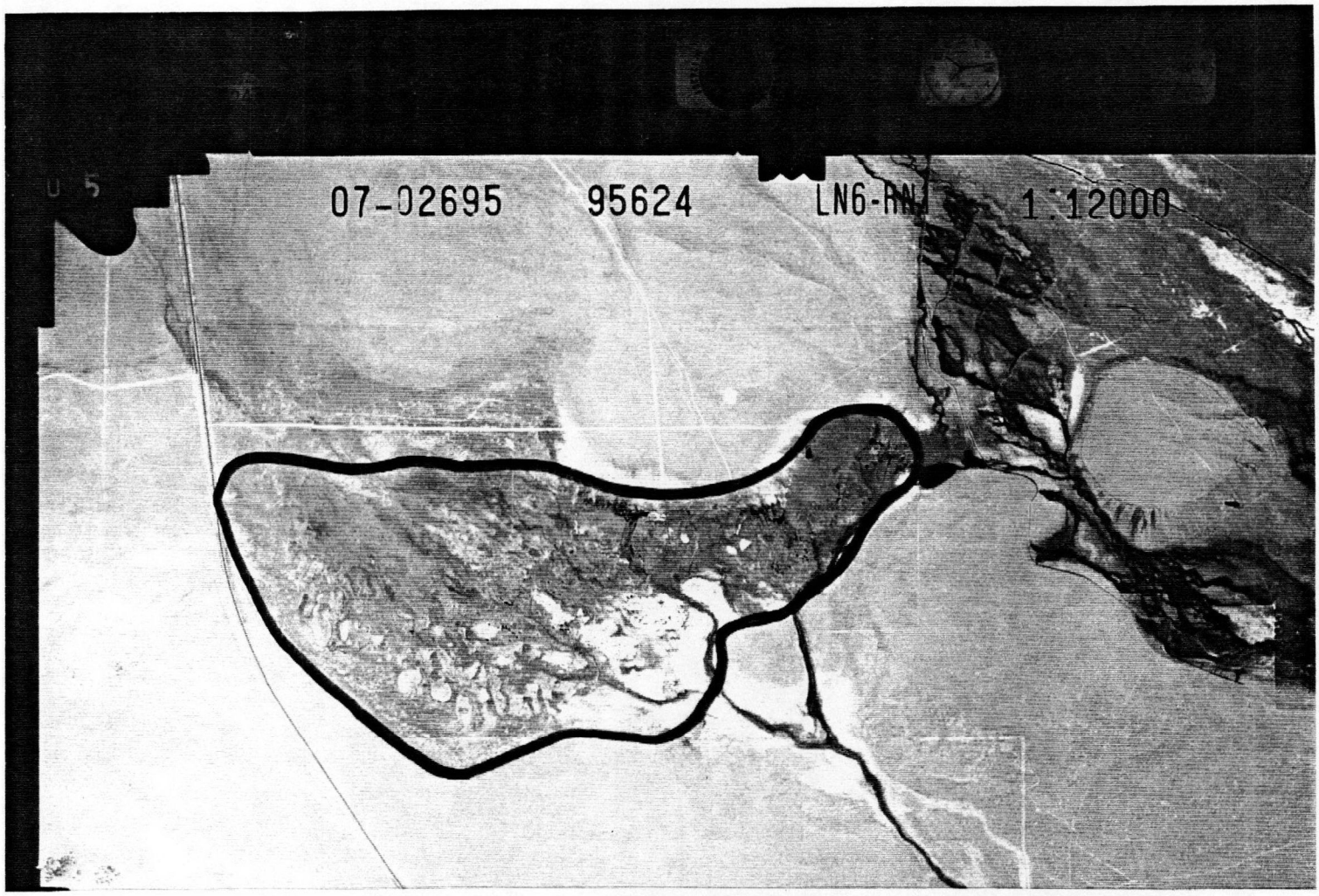
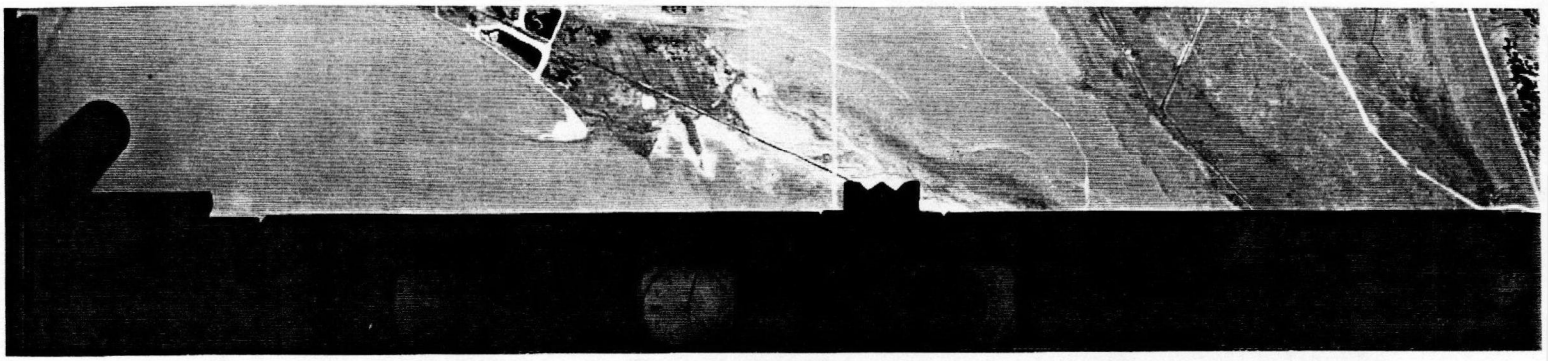


Figure 31. High Creek Fen illustrating seeps and springs below an alluvial outwash fan. The lobes along the north end of this fen were deposited as Pleistocene glaciers melted and copious amounts of water flowed through the park, carrying with it and depositing large amounts of calcium rich material from the Mosquito Peaks. Extreme rich fens have formed where groundwater discharges to the surface below these lobes. Note especially the variegated surface of the fen and the many small pockets of water.

Figure 32. Small seeps near streams. Many of the smaller extreme rich fens appear in situations similar to this, a small, seepy area adjacent to a stream. This type of extreme rich fen is the one most likely to have been affected by overgrazing because of the small total area of surface water.



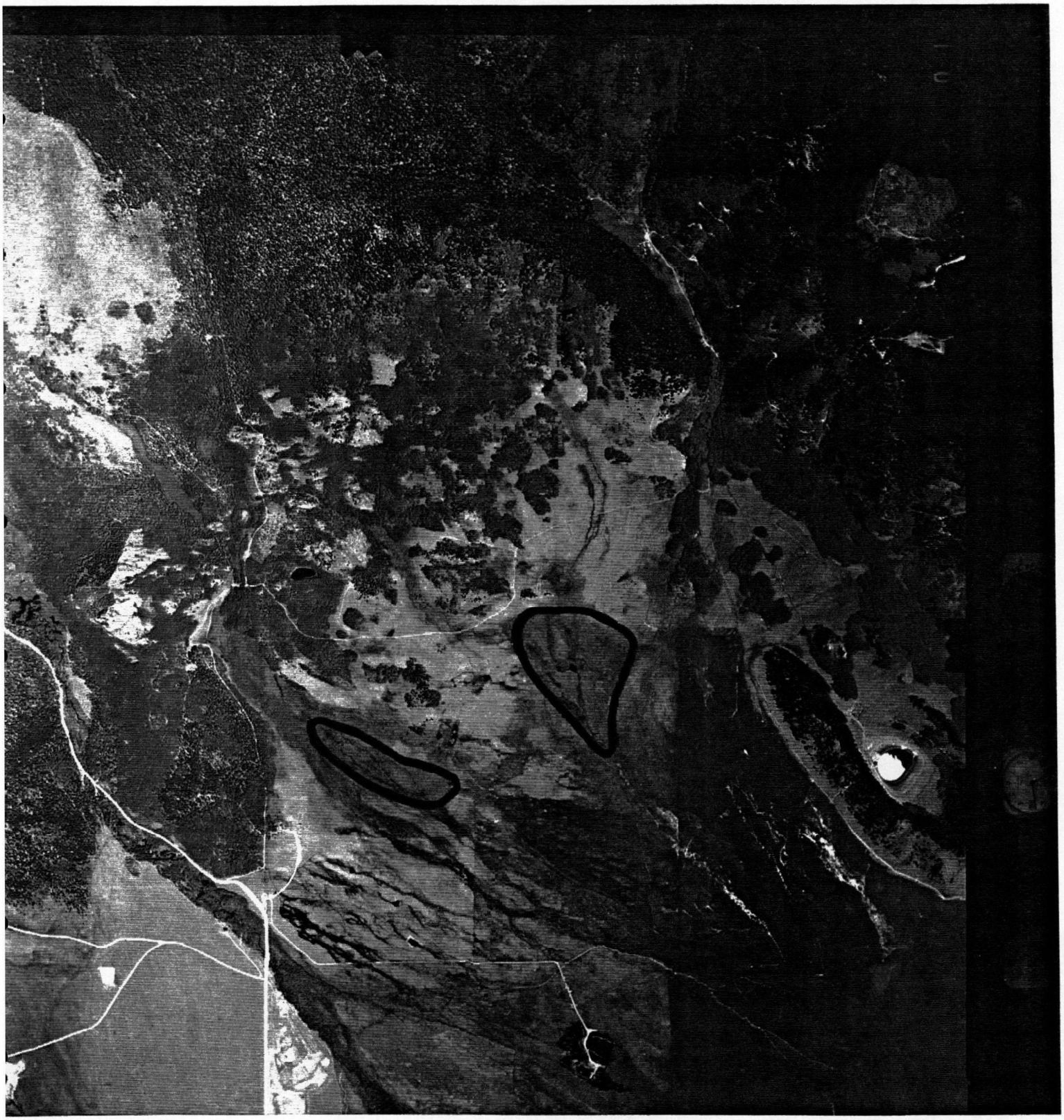


Figure 33. An extreme rich fen at the base of a mountain slope. Groundwater discharging to the surface is commonly seen at the base of mountains and hills, and South Park is no exception. Many of South Park's extreme rich fens are located in such a spot, as is this one. Note the extensive seepy area and lighter zones intermixed with darker spots. The darker spots indicated heavily saturated soils.