MAPPING AND CHARACTERIZATION OF MIRES AND FENS IN NORTH PARK, JACKSON COUNTY, COLORADO

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PREFACE TO THE REVISED AND EXPANDED VERSION OF THE NORTH PARK MIRE AND FEN SURVEY REPORT

This report represents a revised and expanded version of the Johnson and Gerhardt (2003) report on inventory and mapping of fens and mires on US Bureau of Land Management properties in North Park, Jackson County, Colorado. THIS REPORT REPLACES THE 2003 REPORT. Text revisions included here are based on a second mapping effort that occurred during the summer of 2003. In general the text of this report remains little changed from the 2003 report. Changes to the 2003 report are summarized as follows:

- Update of mapping figures and text to reflect the current status of investigation. As of this document, all US BLM lands have been surveyed for fen/mire habitat
- Inclusion of one additional fen/mire – Spring Creek Mire
- Revision of site condition assessments based on additional investigations
- Correction of minor errata

For detailed information on selected North Park fens/mires, including Spring Creek, Peterson Ridge, Sheep Creek and Mansfield Draw mires, the reader is directed to a separate report, Johnson and Gerhardt (2004).
EXECUTIVE SUMMARY

The goal of this project was to survey BLM properties in North Park, Jackson County, CO for the presence of mire and fen wetlands. **Fens** are high-elevation, peat-soil wetlands that are supplied with continual supplies of groundwater owing to their hydrogeological setting. Perpetual water-logging slows decomposition and causes organic soil (i.e., peat) accumulation within the fen. Because of the particular geologic and hydrologic conditions required, fens are a rare and environmentally important type of wetland, providing unique soil types, hydrologic conditions, and vegetation communities within the local and regional landscapes. The slow accumulation rate of peat and the dependence on groundwater, make these wetlands particularly at risk to changes in land use and watershed management. Because of their irreplaceability, sensitivity and environmental importance, fens are given special regulatory and management attention by Colorado and other government entities throughout the world.

Frequently, organic soil fens are imbedded within larger wetland complexes which may include areas of both mineral and organic soils. Although mineral and organic soil areas may sometimes be reasonably distinct, many times the two systems intermix subtly and are practically indistinguishable. In contiguous wetlands, the organic and mineral soil systems are generally interdependent and critically linked. Interlinked wetlands containing significant areas of both organic and mineral soils are called **mires**.

The BLM became aware that numerous mires and fens existed on agency-managed lands in South Park during wetland investigations relevant to the proposed South Park Conjunctive Use water project (SPCUP) and associated trial (Johnson 2000, CCJM 2000). Following that case’s dismissal from Colorado Water Court, BLM sponsored an expansion of the wetland mapping project which surveyed areas outside of the SPCUP area (Johnson and Gerhardt 2002). Those projects identified a total of 14 mires located partly or wholly on BLM-managed properties. Suspecting that BLM’s holdings in the physiographically-similar North Park might possess similar wetland resources, BLM commissioned wetland surveys of North Park during the summers of 2002 and 2003.

Unlike South Park, wetland resources on BLM’s North Park properties were relatively undescribed. North Park is the second largest of the four major inter-mountain parks in Colorado, including The San Luis Valley, North Park, South Park, Middle Park. While a number of wetland studies and surveys have now occurred in South Park and the San Luis Valley, wetlands in North Park have scarcely been examined. The few surveys related to wetlands that have been completed, have mainly focused on riparian areas or wetlands on state and federal game management areas. Colorado Natural Heritage Program has also conducted sporadic and limited rare species surveys.

North Park is a geographically expansive area and our delineated study area covered 843 sq. mi. For comparison South Park is 612 sq. mi. The BLM owns 240 sq. mi. of land in this study area which accounts for some 28% of the land area. Because of North Park’s size and the lack of existing information on its wetland resources, this study was designed as an extensive but not intensive survey of regional fen resources.
This project surveyed BLM properties in North Park and mapped both the organic soil fens and the expanded mire systems. The primary goals of this project were to: 1) survey BLM properties for mires and fens with remote sensing and field techniques; 2) map identified mires and fens; 3) generally characterize the ecological setting and vegetation of each identified mire; 4) develop a GIS database on North Park mires and fens that incorporates data acquired during this study; and 5) provide general management recommendations.

Target areas for inventory were identified based on satellite image analyses performed by the BLM’s National Science and Technology Center (NSTC). Using Thematic Map (TM) images, NSTC classified areas according to their likelihood of containing fens or mires. This method of remote reconnaissance was found to be a highly effective means to streamline such a large-scale inventory in two prior studies (Johnson 2000; Johnson and Gerhardt 2002).

Using remote sensing and field surveys, we evaluated 339 areas, covering 161,027 acres (252 sq. mi.). Of these areas, 123 could be discounted as potential mire or wetland habitat based on the remote sensing analysis. Of the remaining 216 areas classified as potential mire habitat, 116 were evaluated on-site and 95 were examined remotely using binoculars. Five areas were eliminated from consideration since they are no longer managed by US BLM. It is important to note, that many BLM properties, or portions thereof, were excluded from consideration from this project based on remote sensing analyses. Such exclusion does not demonstrate the absence of fens from those properties, but rather that fen existence appears unlikely.

In total 17 mires were identified during this survey. Nine of these mires are wholly contained within BLM property and six sites cross ownership boundaries. Two additional mires were identified off BLM property.

At each mire site, soil cores were extracted to confirm the presence of organic soils (Histosols). Upon confirmation, dominant vegetational composition was described, site condition and impacts were noted, water pH and electrical conductivity were measured, and the wetland was sketch-mapped. Additional notes, photographs, and measurements were taken as appropriate for site characterization.

Identified mires were generally in good to very good condition. All sites are grazed to varying degrees, although several appear to be grazed lightly or only sporadically. Virtually all significant wetland impacts identified are the result of cattle grazing. At the more disturbed sites, impacts include soil disturbance, often times accompanied by heavy pogging (grazing-induced microtopography creation), biomass removal, and a probable change in species composition and reduction in species diversity. Importantly, all sites are essentially hydrologically intact. Hydrologic impacts when present occurred as pond excavation or small conveyance ditches. As they currently exist, observed hydrologic modifications appear to have little effect on overall hydrologic functioning.

No federally threatened or endangered plant species were observed at any of the mires, although one state-rare plant pale-blue-eyed grass (Sisyrinchium pallidum) was identified at several
sites (see Johnson and Gerhardt 2004 for details). We do strongly caution that systematic plant surveys were performed at only four sites, thus there is potential that additional species of concern occur at unevaluated wetlands.

We conclude that the BLM has significant mire wetland resources located on its North Park properties. The BLM also has unique wetland management opportunities and responsibilities in North Park since it manages the headwaters and water sources for 13 of the identified mires and 9 of the mires are wholly located on BLM lands. This is a very different management scenario than that present in South Park where the BLM usually only manages a small portion of any identified mire. Because of the very extensive BLM holdings in the region, it is also likely that the agency manages the recharge zones for these wetlands. Such landscape-scale recharge areas are the ultimate hydrologic sources for fens and must be maintained intact if these groundwater controlled wetlands are to be preserved. Potential federal management of both wetlands and recharge areas is a truly unique situation. The lack of this situation is one of the greatest impediments to successful mire conservation strategies elsewhere in the country.

We suggest five primary management recommendations: 1) The BLM should retain any property containing a mire or portion thereof, including as much upland buffer as possible; 2) The BLM should retain or adjudicate water rights associated with such properties and preserve their hydrological integrity. We also recommend that BLM undertake studies to identify the ultimate water sources for their mires (“recharge zones”), with an eye towards landscape management of these systems; 3) All identified mires should be throughly characterized, including comprehensive surveys for rare species and communities; 4) BLM should develop a detailed management plan for its properties containing, or in the vicinity of, identified mires.

Along with this report, a primary product of this project are digital Geographic Information System (GIS) files to facilitate the successful management and conservation of these wetlands. An emphasis on digital products was chosen since these data are intended to be an active and adaptable management resource. The structure of the GIS will allow managers to selectively display and analyze data for a variety of needs. Hard copy products are intended to serve as a users guide to the GIS database and provide quick reference summary information.
INTRODUCTION

Background on Fens and Mires

Fens are an environmentally important and irreplaceable type of wetland. Fens are distinguished from other wetlands by two defining characteristics: they are groundwater driven and have organic or peat soils. Groundwater emerging to the surface of these wetlands produces perpetually high water tables that slow decomposition and allow organic soils to accumulate. Because of the slow accumulation of peat, fens form and evolve over geologic time-scales. Most fens in Colorado began forming shortly after the recession of the Pleistocene glaciers when the climate was wetter and cooler than it is today. Compared to fens located in other parts of the world, peat accumulates in Colorado fens relatively slowly. Based on Carbon-14 analyses of six Colorado fens, Cooper (1990) estimated that peat accumulated at a rate of 4 - 11 inches per thousand years. The rare climatic and geologic conditions required for fens to form and the slow rate at which they evolve make them a rare and irreplaceable ecological resource.

Fens are typically imbedded within larger wetland complexes containing both mineral and organic soils. The greater wetland complex is referred to as a “mire”, which includes both the organic and mineral soil areas. Although the boundary between the two areas may be distinct, the two soil systems often intermix subtly and are practically indistinguishable. In the existing literature, the terms “fen” and “mire” are often used interchangeably. In this document we use the term “mire” when referring to a contiguous wetland complex which contains organic soil inclusions. We use the term “fen” in its strict sense to define an area with a known predominance of organic soils.

The organic soils present in fens strongly influence the wetlands’ ecology. Fens and mires perform a multitude of environmental functions including water quality improvement, hydrologic control, plant and wildlife habitat (Johnson 1996, Johnson 1998). In addition to the functions performed within the wetland boundaries, Rocky Mountain fens perform critical functions at the landscape and regional scales. As a unique wetland patch in the landscape matrix, these wetland complexes strongly influence landscape heterogeneity and thereby greatly enrich regional biodiversity.

Rocky Mountain fens have been generally recognized as an outstanding natural resource. The well-studied fens of South Park, Colorado are especially notable and valuable. Because of the unusual hydrogeological conditions, most of the South Park fens and mires are extremely nutrient-rich (Box 1). Across the world, similar extremely-rich mire conditions occur in only a very few areas of the United States, Canada and Northern Europe. These limited areas remain as the only habitat for numerous wetland species, and South Park fens provide habitat for 15 regionally or globally rare plant species, and at least seven rare invertebrate species (Spackman et al. 2001). Being such a rare and important ecosystem component, the mires of South Park have been targeted by the Colorado Natural Heritage Program, The Nature Conservancy, Colorado Open Lands, and the South Park Focus Area Committee as a prime management and conservation concern.
North Park is physiographically and climatologically similar to South Park, thus it was concluded that the region may hold significant, but unknown, wetland resources since the area has seen very little biological survey.

**BLM Management of Fens and Mires**

The BLM became aware that numerous mires and fens existed on agency-managed lands in South Park during wetland investigations relevant to the proposed South Park Conjunctive Use water project (SPCUP) and associated trial (Johnson 2000, CCJM 2000). Following that case’s dismissal from Colorado Water Court, BLM sponsored an expansion of the wetland mapping project which surveyed areas outside of the SPCUP area (Johnson and Gerhardt 2002). Those projects identified a total of 14 mires located partly or wholly on BLM-managed properties. Suspecting that BLM’s holdings in the physiographically-similar North Park might possess similar wetland resources, BLM commissioned wetland surveys in 2002 and 2003.

Unlike South Park, which had seen previous wetland investigations, North Park was nearly unexamined. North Park is the second largest of the four major inter-mountain parks in Colorado, including the San Luis Valley, North Park, South Park, Middle Park. The parks are somewhat ecologically distinct, but share commonalities being atypical relative to most mountain environments and possessing regionally significant wetland resources. While a number of wetland studies and surveys have now occurred in South Park and the San Luis Valley, wetlands in North Park have scarcely been examined. The few surveys related to wetlands that have been completed, have mainly focused on riparian areas or wetlands on state and federal game management areas. Colorado Natural Heritage Program has also conducted sporadic and limited rare species surveys.

Because of their irreplaceability, sensitivity, and environmental importance, fens are given special regulatory and management attention by State of Colorado and other governmental entities throughout the world. For instance, Region 6 of the US Fish and Wildlife Service recently issued a policy statement elevating fens to the Resource Category 1 status (USFWS 1999). Additionally, the Omaha District of the U.S. Army Corps of Engineers has denied individual permit applications due in part to potential impacts to fens.

This study was designed to provide a reconnaissance survey of mire and fen resources on BLM properties in North Park, Jackson County, Colorado. The specific goals of this project were to: 1) survey BLM properties for mires and fens using remote sensing and field techniques; 2) map identified mires and fens; 3) generally characterize the ecological setting and vegetation of each identified mire; 4) develop a GIS database on North Park mires and fens; and 5) provide general management recommendations.
METHODS

Project Location and Scope

The region known as North Park is a large inter-mountain valley approximately 50 miles west of Fort Collins, Colorado, on the east side of the Continental Divide (Fig. 1). The park comprises a large portion of the North Platte headwaters. North Park is the second largest of Colorado’s four major inter-mountain valleys (including San Luis Valley, and North, Middle and South Parks). Our delineated study boundary of North Park covered 843 sq. mi, excluding some high ridges and buttes found within the Park’s interior. The BLM owns 240 sq. mi. (28%) of the land in this study area.

When funding the study, the BLM realized that a complete survey of the North Park study area was unlikely because of the size and lack of previous wetland surveys. Consequently, BLM developed and provided a priority list for inventory. Survey priorities are listed in order of decreasing priority.

Survey Priority List Developed by BLM

1. Potential mires located wholly or partially on public lands owned and managed by the Bureau of Land Management.

2. Potential fen and mire complexes located wholly or partially on public lands owned and managed by the Bureau of Land Management.

3. Potential fen and/or mire complexes located on lands owned and managed by the State of Colorado adjacent to lands owned by the Bureau of Land Management.

4. Potential fen and/or mire complexes located on lands owned by private parties adjacent to lands owned by the Bureau of Land Management.

Only BLM lands (Priorities 1 and 2) could be systematically surveyed, although properties under other ownership were incidentally examined whenever possible. Permission was obtained whenever field survey required the crossing of private lands to gain access to isolated federal property.
Figure 1. Map of Colorado showing county boundaries and the North Park study area (shaded). The study area has been enlarged to the left showing major roads and rivers.
Regional Setting

Physical Setting

North Park is an intermountain valley set between the Medicine Bow Mountains on the north and east, the Park Range on the north and west, the Rabbit Ears on the South, and the Never Summer Mountains on the southeast. Compared to these mountains, topography within the Park is relatively flat, and the valley floor slopes shallowly northward. The plains are often broken by large glacial moraines which form high ridges or hills and tall bedrock rises.

The Park is dissected by four major river systems (Canadian, Michigan, Illinois, and North Fork of the North Platte Rivers) which conflux and form the main stem of the North Platte River (Fig. 1). The North Platte exits the ringed valley between Independence and Watson Mountains through a water gap known as Northgate.

Climate

The climate of North Park is semi-arid, characterized by cold, dry winters and warm, dry summers. Average precipitation for the area is 10.53 in. (Walden weather station), with most precipitation occurring during the summer months (Fig. 2). During the 2001 - 2002 water year, generally considered one of Colorado’s most severe droughts, the Walden station received a surprising 90% of its normal precipitation (9.53 in.), with July and August receiving above normal moisture.

Eight additional rain gauges scattered in the park are monitored by BLM from May-September. According to these data (Paula Belcher, US BLM, personal communication) summer moisture ranged from 74-95% of normal in 2002. More telling was the distribution of rain and the temperatures. At the Walden station, for example, May received 80% of normal precipitation, but the rain came almost exclusively on two days – the 16th and the 24th. June received only 11% of normal precipitation and again most of that moisture came during one storm. July was 123% of average, but the vast majority of that moisture came on three days. Exacerbating the sporadic and low precipitation was the heat load. The average maximum temperature was 7.3 degrees higher than average. Further compounding the effects of the summer drought was the extremely low snowpack in the surrounding mountains. Snowmelt from those mountains is truly the primary source of water for the region’s wetlands. The effects of these drought conditions are also shown by USGS stream gauge data which show extremely low summer flow volume along the North Platte River near Northgate (Fig. 3).

Previous Studies

Few previous studies of North Park wetlands exist. Most surveys of wetlands and riparian areas have been conducted on either the Arapaho National Wildlife Refuge and/or in the Colorado State Forest and National Forest Lands on the perimeter of North Park. No summary reports of these data have been completed, and it was beyond the scope of this project to summarize this information.
Figure 2. Precipitation data from the Walden Station comparing long-term monthly averages with those of 2002.

Figure 3. Stream discharge data from the North Fork of the North Platte River, near North Gate. Data compares the long-term hydrograph with that of 2002.
Previous studies apparently did not survey BLM lands and so would only be peripherally significant to this project.

An environmental assessment (EA) of BLM lands slated for exchange in Jackson County was prepared by Western Ecological Resource, Inc. (WER 2002). That EA explicitly assessed wetland resources located on targeted properties, recording dominant species composition and the presence of rare, threatened, or endangered species. WER (2002) did not locate any mires on BLM properties scheduled for exchange, and our survey corroborates their finding. No lands targeted for exchange were found to be adjacent to mire-containing properties either.

The Colorado Natural Heritage Program (CNHP) has performed various rare plant surveys across North Park. The precise extent and intensity of these surveys is not known, but they appear to have been coarse and focused on general reconnaissance. Figure 4 shows the location of CNHP rare species occurrences and the boundary of Potential Conservation Areas (PCAs). Note that the rare species occurrences (“Element Occurrences”) are included within a buffer to obscure the precise location of the sensitive species.

Only six PCAs have been delineated in North Park (Fig. 4). This is a surprisingly small number considering the biological resources found in the area, and is probably due to the lack of survey effort in the area. The three main PCAs located near the center of the valley are associated with the federally-listed plant the North Park phacelia (*Phacelia formosula*). The three small PCAs on the margin of the valley are associated with riparian willow carrs. No PCAs have been designated based on the presence of fens and mires, again, probably owing to a lack of ecological surveys. The relationship between the CNHP PCAs and element occurrences and the mires identified in this survey will be described in the Results section.
Figure 4. Map of the North Park Study area showing ownership data overlaid with Colorado Natural Heritage (CNHP) conservation data. Only six (three very small) potential conservation areas (PCAs) are currently defined in North Park. Hatched boxes are rare species occurrences, including a buffer area.
Inventory Methods

Reconnaissance Image Analyses

North Park covers a large geographic area. As described above, most of the park possesses vegetation associated with dry, semi-arid conditions. The BLM properties targeted in this survey are commonly quite large and often contain large roadless areas. Wetlands in the area are often small, remote and hidden from view by surrounding topography. The combination of these characteristics made accomplishing a mire survey with a solely ground-based approach prohibitively time consuming and highly inefficient. To focus our investigation and improve project efficiency, the National Science and Technology Center (NSTC) of the BLM performed satellite image analyses of North Park land cover types. These analyses highlighted areas of potential fen and mire habitat based on surface reflectance. The effectiveness of this reconnaissance approach was shown in mire surveys for the BLM in South Park (Johnson and Gerhardt 2002). It is important to note that many BLM properties, or portions thereof, were excluded from consideration from this project based on remote sensing analyses. Such exclusion does not demonstrate the absence of fens from those properties, but rather that fen existence appears unlikely.

The first step in reconnaissance image analysis was to digitally transform the raw Landsat imagery obtained on 8/31/95 with a “Tasseled Cap” (TC) transformation. The result is an index of 3 band ratios that creates an image displayed in three colors. Band 1 (red) indicates brightness in the scene, band 2 (green) indicates greenness in the scene, and band 3 (blue) indicates wetness. After processing, the TC image was clipped to include only areas within the North Park project area.

Based on the findings of Johnson and Gerhardt (2002), the wetness band (3) alone was used to classify areas as potential mire habitat. Band 3 data were sub-setted and 13 wetness levels were defined in an Erdas Imagine Spatial Modeler criteria table (Table 1). Wetness ranges were determined by cutting the histogram tails off and then dividing the remaining DN values into subjective levels. Removing the histogram tails filtered drier areas from the analyses.

Pixel misclassification was common in the South Park survey. It occurs when darkly colored tree foliage is interpreted as water by the analytical software. To mitigate this issue, classified pixels found on slopes greater than 4% – where most trees occur – were reclassified as having a low probability of containing fen habitat. Fens are not thought to occur on these relatively steep, dry sites since they are removed from regional groundwater flow paths.

The TC image was partitioned corresponding to the coverage of U.S. Geologic Survey 7.5' quadrangle maps. Hard copy plots of the TC image overlain with the wetness classification were created by NSTC and used for field mapping.

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1 Information provided by Pam Clemmer of the U.S. BLM National Science and Technology Center (written comm. March 2002)
**Table 1.** Band width from band 3 of the Tassel Cap transformed image included within each of the three wetness categories used in image classification.

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<td>98 - &lt;101</td>
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<td>13</td>
<td>101 - &lt;186</td>
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</table>

**Survey Protocol**

The field inventory was carried out systematically, quadrangle by quadrangle. We traveled using a four-wheel drive vehicle equipped with a laptop computer, real-time GPS tracking software (3-D TopoQuads), an ArcView GIS database containing TC images, pixel classifications, property ownership, digital line graphics (DLGs) of roads streams and other features, and digital raster graphics of USGS 7.5' quadrangles. Use of these navigational technologies proved key to project success since roads and property boundaries are usually poorly marked in the region, and navigation to remote areas using conventional maps proved sketchy. In addition, we wanted to take every precaution to avoid accidental trespassing.

7.5' quadrangle-sized maps of the analyzed TC image indicated all potential mire areas and were used to guide the inventory and mark sites which had been evaluated. We used the following procedure to select sites and conduct preliminary evaluations.

1. Identified an area classified during image analysis as a potential fen/mire.
2. Checked for obvious errors in the classification using topographic maps.
(3) If the site was not ruled out in step 2, we traveled to the most convenient vantage point from which the site could be remotely viewed – often the immediate edge of the site. From this vantage, we determined if mire- or fen-like habitat was present.

(4) If the site was obviously not a mire or fen, we described it based on cover type, approximate extent, and other general characteristics. If the site appeared to be a fen or mire but was inaccessible due to property ownership issues, it was evaluated remotely. If the site appeared to be a fen and was accessible by vehicle or foot, we proceeded with an on-site evaluation. A description of the characteristics evaluated during this study is contained in Appendix 2.

On-site Evaluation Protocol

The main goal of field evaluation was to confirm or refute the existence of a fen or mire. A secondary goal was to describe the major ecological characteristics of the wetland, including its landscape position, vegetation structure, impacts, and obvious presence of rare plants. Due to the extent of the study, intensive sampling of vegetation, soils and hydrology could not generally be completed; although see Johnson and Gerhardt (2004) for detailed site evaluations of four mires. Fen and mire boundaries were determined on the ground using surficial wetland indicators and sketched in a data book, but we made no attempt to formally delineate jurisdictional wetland boundaries. Our mapping approach is consistent with the 1999 U.S. Fish and Wildlife Service’s (FWS’s) Region 6 Policy on the protection of peatlands (USFWS 1999).

We evaluated fen/mire sites using the following general procedures:

(1) All major springs, inlets and outlets, and areas of potential organic soils were located.

(2) Major ecological characteristics of the site were recorded, including geomorphic position, hydrologic inputs and outputs, vegetation structure, and historical impacts and current threats.

(3) Presence of organic soils (Histosols) was determined at one or more locations. Soil composition was characterized by extracting soil cores from the upper 1 m using either a piston-corer or gouge auger. Soils were determined to be organic using the criteria set forth in Soil Taxonomy (Soil Survey Staff 1998). No attempt was made to map the extent of organic soils.

(4) Pore water chemistry was sampled using an Orion Model 250A field pH meter and a YSI Model 30 electrical conductivity (EC) meter.
(5) Vegetation was characterized by recording the presence of the dominant species and rare or sensitive species (if present).

GIS Development and Mapping Protocol

All survey and inventory information was compiled into an ArcView v. 8.3 GIS database\(^2\). Mires were located in the GIS based on field mapping and acquired GPS points. Wetland boundaries were drawn based on the above data in conjunction with Landsat and tasseled cap images of the study area. Because satellite images are constructed with 30 m pixel resolution they provide only a rough approximation of actual wetland boundaries. Digital line graphics (DLGs) were obtained from the BLM. DLGs were based on 100 k USGS quadrangles. Evaluation areas and mires were digitized as polygon shapefiles in ArcView.

Ecological site information was compiled into a Microsoft Access database (file name = North_Park_Mire_Database). This database was then incorporated into ArcView as a “geodatabase”. Additional information on this database file (and other GIS files) can be found in Appendix 1.

\(^2\)All geographic data were projected into the Universal Transverse Mercator (UTM) system, using the North America Datum of 1983 (NAD 83). Additional projection information is included in each GIS file’s metadata file.
RESULTS AND DISCUSSION

Overview of Project Findings

The products of this project are intended to form a working tool, readily adaptable to meet developing management needs and able to incorporate new data as it becomes available. As such, the primary products of this project are the GIS and database files. The documentation that follows is intended to provide a summary of the major findings and serve as a user guide to the GIS and data files. Appendix 2 provides technical information about the GIS files and data structure.

Using the combined remote sensing and field surveys we evaluated 339 areas (“North Park evaluation areas”), covering 161,207 acres (252 sq. mi.; Fig. 5). The vast majority of the property surveyed is currently under the management of the BLM. Of the 339 evaluation polygons, 123 could be discounted as potential mire or wetland habitat based on the remote sensing analyses. The remaining 216 polygons were remotely classified as potential mire habitat. One hundred and sixteen such areas were evaluated on-site, 95 were examined remotely using binoculars, and 5 were eliminated from consideration since they no longer are managed by BLM.

Seventeen mires were identified during this survey (Fig. 6; Table 2). Nine of these mires are wholly located on BLM property and six sites intersect BLM land but cross ownership boundaries. Two additional mires were identified off BLM property.

Identified mires were generally in good to very good condition. All sites are grazed to varying degrees, although several appear to be grazed lightly or only sporadically. Virtually all significant wetland impacts identified appear to be the result of cattle grazing. At the more disturbed sites, impacts included soil disturbance, often times accompanied by heavy pogging (grazing-induced microtopography creation), biomass removal, and a probable change in species composition and reduction in species diversity. Importantly, all sites are essentially hydrologically intact. Hydrologic impacts when present occurred as pond excavation or small conveyance ditches. As they currently exist, observed hydrologic modifications appear to have little effect on overall hydrologic functioning.

No federally threatened or endangered plant species were observed at any of the mires, although one state-rare plant pale-blue-eyed grass (*Sisyrinchium pallidum*) was identified at several sites (see Johnson and Gerhardt 2004 for details). We do strongly caution that systematic plant surveys were performed only four sites, thus there is potential that additional species of concern occur at unevaluated wetlands.

General ecological characteristics of each mire and fen were initially described in the field and subsequently augmented with geographic data. The following subsections narratively summarize each identified mire. This information is also included in the Microsoft Access database (file name: “North Park Mire Database”) and GIS shape files. Appendix 2 provides descriptions of the information contained in fields of the database tables.
Figure 5. Map showing the North Park study area. Shown on the map are polygons delineating the areas surveyed during this study and areas classified as likely mine or wetland habitat (see text for further details). In most cases, polygon boundaries correspond to BLM property boundaries. Polygons have been color-coded according to their likelihood of holding wetlands or mines.
Table 2. A list of mires found to intersect BLM lands. Mires have been named during this study for convenience. Mires have generally been named after significant associated features. The mire ID # is a unique identifier that is found in the ArcView GIS and Access database. The EPID is the mire’s unique evaluation polygon identification number. The ownership is listed in order based on the approximate percentage of the mire site owned by each entity. The “acres” column contains the mire area based on satellite image delineation. The X and Y coordinates indicate the approximate mire center using Universal Transmecator coordinates.

<table>
<thead>
<tr>
<th>Mire Name</th>
<th>Mire ID</th>
<th>EPID</th>
<th>Acres</th>
<th>Hectares</th>
<th>Ownership</th>
<th>X Centroid- UTM</th>
<th>Y Centroid - UTM</th>
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</thead>
<tbody>
<tr>
<td>Indian Creek Mire</td>
<td>1</td>
<td>1</td>
<td>90.5</td>
<td>36.6</td>
<td>BLM</td>
<td>376939.04</td>
<td>4476565.84</td>
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<tr>
<td>Buffalo Creek</td>
<td>2</td>
<td>15</td>
<td>34.3</td>
<td>13.9</td>
<td>State/Private/BLM</td>
<td>382341.87</td>
<td>4483588.34</td>
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<tr>
<td>Lost Cove</td>
<td>3</td>
<td>16</td>
<td>4.4</td>
<td>1.8</td>
<td>BLM</td>
<td>382023.79</td>
<td>4483307.84</td>
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<tr>
<td>Beaver Creek Mire</td>
<td>4</td>
<td>37</td>
<td>373.7*</td>
<td>151.2*</td>
<td>Private/BLM</td>
<td>372987.99</td>
<td>4501810.63</td>
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<tr>
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<td>5</td>
<td>38</td>
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<td>29.1</td>
<td>Private/BLM</td>
<td>369565.09</td>
<td>4501690.38</td>
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<tr>
<td>Peterson Ridge Mire</td>
<td>6</td>
<td>61</td>
<td>3.7</td>
<td>1.5</td>
<td>BLM</td>
<td>386268.45</td>
<td>4498535.75</td>
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<td>Antelope Spring Mire</td>
<td>7</td>
<td>60</td>
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<td>2.6</td>
<td>BLM</td>
<td>387634.24</td>
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<td>Sheep Mountain Mire</td>
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<td>8.4</td>
<td>3.4</td>
<td>BLM</td>
<td>372128.24</td>
<td>4517569.36</td>
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<tr>
<td>Troutman Draw Mire</td>
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<td>85</td>
<td>16.8</td>
<td>6.8</td>
<td>BLM</td>
<td>371197.14</td>
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<td>Mansfield Draw Mire</td>
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<td>95</td>
<td>15.4</td>
<td>6.2</td>
<td>BLM</td>
<td>382903.29</td>
<td>4524951.12</td>
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<td>Southern Lake Creek</td>
<td>11</td>
<td>86</td>
<td>11.9</td>
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<td>4531707.66</td>
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<td>Northern Lake Creek</td>
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<td>88</td>
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<td>2.7</td>
<td>Private/BLM</td>
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<td>4532746.78</td>
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<tr>
<td>Soap Creek Mire</td>
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<td>306</td>
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<td>10.4</td>
<td>FWS/BLM(?)</td>
<td>392386.67</td>
<td>4488766.30</td>
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<tr>
<td>California Gulch</td>
<td>14</td>
<td>111</td>
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<td>1.0</td>
<td>BLM</td>
<td>381172.08</td>
<td>4523070.52</td>
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<tr>
<td>Government Creek</td>
<td>15</td>
<td>127</td>
<td>32.6</td>
<td>13.2</td>
<td>Private</td>
<td>395360.38</td>
<td>4525927.23</td>
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<td>Dry Fork Mire</td>
<td>16</td>
<td>135</td>
<td>14.3</td>
<td>5.8</td>
<td>BLM/Private</td>
<td>400403.43</td>
<td>4507762.29</td>
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<tr>
<td>Spring Creek Mire</td>
<td>17</td>
<td>1000</td>
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<td>12.8</td>
<td>BLM/State</td>
<td>399620.07</td>
<td>4494941.54</td>
</tr>
</tbody>
</table>

* The size of the Beaver Creek Mire is probably significantly inflated. The extent included here is the maximum probable size.
Descriptions of North Park Mires

The following narratives provide a general characterization of each identified mire site. The descriptions consider wetland attributes in the following general order: 1) ownership; 2) geomorphology/soils; 3) hydrology; 4) vegetation; and 5) site-specific management recommendations. To avoid redundancy, a section on general recommendations, applicable to all identified mires, will be provided in the General Recommendations and Conclusions section. Following each site narrative, site photographs and a wetland summary sheet developed from the project GIS are provided. Appendix 1 provides dominant species lists.

Indian Creek Mire (Mire ID #1)
The Indian Creek Mire is mapped entirely on BLM managed lands, however, the greater riparian system extends off the property. This wetland is primarily a riparian and beaver pond complex which is supplied by small, discrete springs along the southeastern terrace of Indian Creek (Fig. 7 - 8). Areas of organic soils are sparse and isolated and occur only at spring locations. The character of this wetland is atypical of mire sites, being almost exclusively riparian.

Wetland vegetation is dominated by a canopy of tall willows, punctuated by grass or sage openings. Recent grazing made determining even dominant species difficult.

In general, this site is in good condition. Most importantly, the wetland hydrology appears to be intact. A diversion channel is present in the vicinity of the channel, but this does not appear to affect the stream and riparian zone. Grazing has caused some channel degradation and soil disturbance, especially around the most sensitive spring areas, and it has likely affected plant species composition. These grazing impacts are likely reversible with alternate grazing management.

The current level and type of land use activity occurring at this site appears generally appropriate, although the site would benefit from proactive grazing management. Other on-site rehabilitation or management actions are probably not necessary to protect the mire, but more intensive investigations may identify concerns.
## North Park Mires

### Mire Name: Indian Creek Mire

#### Ownership: 
State/Private/BLM

### Geographic Information

- **USGS 7.5' Quadrangle Name:** Spicer
- **Mire ID #:** 1
- **Evaluation Polygon ID # (EPID):** 1
- **Mire Area (ha):** 36.61
- **Mire Area (acres):** 90.47
- **X-Coord. (UTM):** 376939.0
- **Y-Coord. (UTM):** 4476565.8

### Mire Characteristics

#### Geomorphic Position: 
Located along a stream terrace, slope break.

#### Outlet or Receiving Waters: 
Grizzly Creek Tributary Mire

#### Hydrology Notes: 
Point springs located up-gradient of the stream water level.

#### Wetland Type: 
Riparian mire

#### Mire/Fen Classification: 
Moderate Fen

#### Vegetation Physiognomy: 
Riparian Carr/meadow

#### Water pH: 
6.27

#### Soil Composition: 
Organic soils 50-65 cm deep. Small patches widely scattered at springs.

#### Water Electrical Conductivity: 
109.1

### Impacts:
Site is moderately grazed but otherwise in good shape. There are stream diversions in the area, but none that appear to affect the mire.

### Notes:
This site is intact and a good example of a riparian seep area. Patches of organic soil are very uncommon, and the site has more affinity to riverine system than it does to a slope (GW) or mire system. Many seeps exist along the reach, but they lack the discharge volume to support organic soils. No rare plants found, but grazing presence made ID of many species impossible. Numerous, active beaver are present complexes along the stream.
Figure 7. View southwest across the Indian Creek Mire. Springs areas can be identified along the far valley side (SE) where willows extend up the slope.
Figure 8. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Indian Creek Mire (Mire #1).
**Buffalo Creek Tributary Mire (Mire ID #2)**

This is one of the typical swale mires found in North Park. It begins near the head of a swale where the wetland has been dredged and dammed to form a small pond (Fig. 9). Below the pond significant ground water discharge occurs and quaking soils are present (Fig. 10). While surface water is present on the wetland, it does not appear to form organized channels anywhere within its boundaries. The majority of the wetland is on State land, and it apparently ends at a groundwater recharge zone on adjacent private property. The recharge zone could not be closely examined due to access limitations. The wetland intersects BLM property only along its extreme northeast edge.

The mire appears to be in very good condition and is dominated by graminoids with low shrubs (*Pentaphylloioides floribunda*) on the mire margins. Based on our two site visits, grazing pressure was not excessive and a good standing crop of vegetation existed on the wetland. Soils were minimally disturbed with only occasionally significant pogging. Grazing induced microtopography is present but not severely developed. The only observed hydrological impact to the site is the pond, and it appears to have little effect on the wetland as a whole, because it is located near the head of the swale and avoids the large spring area which currently provides the main hydrologic input to the wetland.

Since this mire only barely intersects BLM property, the agency has limited authority over site management, however, we recommend that BLM retain this property as a wetland buffer. BLM ownership can help insure that extant hydrology is maintained. Alerting the State to the presence of this important wetland on their property may provide an opportunity for cooperative management.
North Park Mires

**Mire Name:** Buffalo Creek Tributary Mire  
**Ownership:** State/Private/BLM

### Geographic Information

- **USGS 7.5 ' Quadrangle Name:** Spicer
- **Mire ID #:** 2  
  - **Mire Area (ha):** 13.89  
  - **X-Coord. (UTM):** 382341.8
- **Evaluation Polygon ID # (EPID):** 15  
  - **Mire Area (acres):** 34.33  
  - **Y-Coord. (UTM):** 4483588.3

### Mire Characteristics

**Geomorphic Position:** Begins at the head of a narrow swale, eventually spilling out on to a wide valley.

**Outlet or Receiving Waters:** None

**Hydrology Notes:** No inlet. Springs evident in the form of peat aprons.

**Wetland Type:** Mire  
**Mire/Fen Classification:** Rich Fen

**Vegetation Physiognomy** Meadow  
**Water pH:** 6.55

**Soil Composition:** 0 - 20cm fibric peat. 20 - >90 cm aqueous peat.  
**Water Electrical Conductivity:** 123.3

**Impacts:** A pond exists near the mire head. Grazing is moderate, but otherwise the site is in good condition. Land use seems sustainable.

**Notes:** Organic soils begin below the pond. Fen shows a terrace-apron pattern. Relatively homogeneous vegetation.
Figure 9. View south toward the head of the Buffalo Creek Tributary Mire. The initial seep can be seen at the head of the swale indicated by the lush green vegetation. This seep feeds the excavated pond to the right.

Figure 10. View northwest across the main springs of the Buffalo Creek Tributary Mire. Water-filled hollows can be seen in the foreground as can the lateral boundaries of the site (indicated by the rows of big sagebrush).
Figure 11. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Buffalo Creek (to NE) and Lost Cove Mires (Mires 2 & 3).
Lost Cove (Mire ID #3)

This small but well preserved mire begins at the head of a shallow swale and is wholly located on BLM property (Figs. 11-12). The draw eventually confluaxes with that of the Buffalo Creek Tributary Mire (Mire # 2), but the confluence was dry during the survey. Since the confluence is on private land it was not investigated on site. Spring discharge is evident at the mire head producing strongly quaking organic soils and a terraced surface configuration. Terrace patterning consists of relatively flat peat aprons, which have quaking soils and are generally the sites of groundwater discharge, alternating with low, steep scarps. Terraced surfaces are common in subalpine fens.

The vegetation is dominated by graminoids, with a scattered canopy of shrubby cinquefoil around the margins. No disturbances to this site were detected. As with apparently all North Park mires, the site is grazed, but grazing pressure appears minimal.

This wetland is a rare example of a minimally disturbed park mire. The wetland should be preserved in its extant condition. This may require no more effort than continuing the current management policy for the site and retaining property water rights.
# North Park Mires

<table>
<thead>
<tr>
<th><strong>Mire Name:</strong>  Lost Cove</th>
<th><strong>Ownership:</strong>  BLM</th>
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</table>

## Geographic Information

<table>
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<tr>
<th>USGS 7.5' Quadrangle Name:</th>
<th>Spicer</th>
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<tr>
<td>Mire ID #: 3</td>
<td>Mire Area (ha): 1.795</td>
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<td>Evaluation Polygon ID # (EPID): 16</td>
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<td>X-Coord. (UTM): 382023.7</td>
</tr>
<tr>
<td></td>
<td>Y-Coord. (UTM): 4483307.8</td>
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</table>

## Mire Characteristics

**Geomorphic Position:** In a shallow swale. Mire starts at a slope break above the foot of a hill.

**Outlet or Receiving Waters:** None - Evident recharge zone.

**Hydrology Notes:** No inlet. Springs evident forming peat aprons.

**Wetland Type:** Mire  
**Mire/Fen Classification:** Rich Fen

**Vegetation Physiognomy** Meadow  
**Water pH:** 6.65

**Soil Composition:** 35 cm fibric to hemic peat, over 60 cm aquatic peat.  
**Water Electrical Conductivity:** 121.8

**Impacts:** Site is in excellent condition. Apparently little grazed.

**Notes:** This site seems essentially pristine and is an excellent example of a North Park fen.
Figure 12. View northwest across the Hidden Cove Mire. The main springs are located in the dark green vegetation just below the center of the photograph. The mire recharge zone can be seen in the vicinity of the white soil (marl) at the center of the photograph.
Beaver Creek Mire (Mire ID #4)

This is an expansive riparian mire system that intersects three corners of a large, irregularly shaped BLM property. The majority of this wetland lies on private land. The mire initiates near the base of the northwest terrace of Beaver Creek and extends into a number of large coves sculpted into the channel terrace (Figs. 13 - 15, 17).

Near Beaver Creek, the mire vegetation is typical of that found along North Park streams, dominated by tall willows interspersed with meadow areas. Near the spring discharge areas along the terrace base, the vegetation is sedge dominated with interspersed low shrubs (Fig. 16).

The hydrology of this site appears complicated, consisting of groundwater discharge, fluvial inputs and irrigation. The wetland lies below a very large irrigated terrace (Fig. 14 - 15) and probably receives irrigation return flow from that land surface. In spite of the hydrologic modifications, the site is in good condition and appears highly functional, containing a diverse array of habitats. This wetland is an important hydrologic source for Beaver Creek. Grazing impacts vary with landownership along the approximately 2 mile length of the wetland.

This site should be characterized to the extent possible, including investigating mire areas on private land if access could be secured. The role of irrigation in the mire’s hydrology and the extent of other hydrologic modifications should also be closely evaluated.
## North Park Mires

<table>
<thead>
<tr>
<th>Geographic Information</th>
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<tbody>
<tr>
<td>USGS 7.5' Quadrangle Name:</td>
</tr>
<tr>
<td>Mire ID #: 4</td>
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<tr>
<td>Evaluation Polygon ID # (EPID): 37</td>
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<table>
<thead>
<tr>
<th>Mire Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geomorphic Position:</td>
</tr>
<tr>
<td>Outlet or Receiving Waters:</td>
</tr>
<tr>
<td>Hydrology Notes:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wetland Type: Riparian Mire</th>
<th>Mire/Fen Classification: Moderate Fen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation Physiognomy Meadow and Carr</td>
<td>Water pH: 6.78</td>
</tr>
<tr>
<td>Soil Composition: Soils are heterogeneous. Organic soils (&gt;50 cm peat) are mixed in with alluvial and other mineral deposits.</td>
<td>Water Electrical Conductivity: 122.6</td>
</tr>
</tbody>
</table>

**Impacts:** Little grazing occurs on the BLM portion of the mire. Grazing intensity varies on private property. Several ditches are present in the mire and mire water source is, in places, heavily augmented by irrigation and perhaps return flow from a large irrigated plateau above the site.

**Notes:** This riparian mire seems rather expansive, although its actually extent is unknown since the majority of the mire lies on private land. Patterns of hydrology are complicated on the site, and the role of irrigation and return flow hydrologic inputs are unknown, but may be significant. In all the mire and associated riparian areas are an important wetland resource for the region.
Figures 13 -15. A sequence of photographs taken along the Beaver Creek Mire. Figure 13 is a southwest view, Fig. 14 is a view west, while Fig. 15 looks northwest. The BLM property is mainly on the right side of the creek ending near the riparian zone. The property boundary crosses the creek in three places extending to the far hill slope base. Notice the large irrigated plateau above the wetland.
Figure 16. View north across hummocky fen lawn at the Beaver Creek Mire. Springs can be seen along the slope break beginning at the center right of the photograph and extending toward the middle. Willows along Beaver Creek are above the photograph center and to the right.
Figure 17. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Beaver Creek (to E) and Raspberry Creek Tributary Mires (Mires 4 & 5).
Raspberry Creek Tributary Mire (Mire ID #5)

This wetland begins on BLM land, but the majority of it lies on private land. This wetland may not possess organic soils of sufficient depth to be classified as a fen or mire. Soil samples showed a 25 cm organic layer subtended by an organic rich clay. Deeper areas of organic soils could be present on the site. The site met all other criteria of a fen or mire. Taking a conservative approach we included this site as a mire with the above caveats. Presence of organic soils should be confirmed or refuted with additional evaluation, possibly using lab analyses.

The site begins abruptly at the base of a valley bottom step (Figs. 17 - 18). No inlet channel exists and spring discharge and strongly quaking soils are present at the head of the wetland. Surface water was also present in hollows near the head of the wetland. Discharged waters gradually recharge down-gradient from the springs, and the site becomes progressively drier until wetland conditions are lost. No surface outlet is present.

The site is in relatively good condition. The vegetation consists of a fairly homogenous sedge lawn. Grazing has caused widespread but not extreme soil disturbance and has probably affected plant species richness and composition. A ditch traverses the valley along the upper extent of the wetland, but it does not appear to affect the wetland. At the time of our survey, the ditch was dry and had been so for at least several weeks. Thus it is not an important hydrologic sources for the wetland, even though ditch leakage could augment wetland hydrology. Since the ditch was located above the wetland it does not serve any drainage function.

The organic soils of this site should be further investigated to determine if the site is a true mire. Regardless of the finding, the wetland should be surveyed for the presence of rare and sensitive plant species since it possess all or most fen habitat characteristics. Because this wetland performs the primary functions of a mire, we recommend that it be managed as one.
### North Park Mires

**Mire Name:** Raspberry Creek Tributary  
**Ownership:** Private/BLM

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<td>Evaluation Polygon ID # (EPID):</td>
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<td>Y-Coord. (UTM):</td>
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<td>Outlet or Receiving Waters:</td>
<td>Tributary to Raspberry Creek</td>
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<tr>
<td>Hydrology Notes:</td>
<td>No inlet. Groundwater discharge indicated by quaking soils. A ditch runs just above the head of the site but it was dry during site evaluation, thus it is not a primary water source for the site.</td>
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<tr>
<td>Wetland Type:</td>
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<tr>
<td>Vegetation Physiognomy:</td>
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<td>Mire/Fen Classification:</td>
<td>Meadow/mire?</td>
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<tr>
<td>Water pH:</td>
<td>5.91</td>
</tr>
<tr>
<td>Soil Composition:</td>
<td>0-25 cm fibric to hemic peat, underlain by organic rich clay. This soil appears to not be organic but rather just a histic epipedon</td>
</tr>
<tr>
<td>Water Electrical Conductivity:</td>
<td>129.3</td>
</tr>
</tbody>
</table>

**Impacts:** Site is moderately grazed, and significant pogging exists.

**Notes:** This site does not appear to meet the soil criteria for a fen, but all other criteria are met. Organic soils could exist within the site but were not located during this field evaluation. Site has homogeneous, species poor vegetation.
Figure 18. View west across Raspberry Creek Tributary Mire. The head of the mire and primary springs are located in the middle of the photograph near the left edge. That area is on BLM property. The wetland continues north (right in photograph) onto private land and was not investigated.
Peterson Ridge Mire (Mire ID #6)

This is an important and fairly well preserved mire located wholly on BLM managed lands. The mire is located at the bottom of a high, broad valley (Figs. 19, 21 - 22). It begins at a large spring, and no surface inlet is present (Fig. 20). Surrounding the spring is an expanse of strongly quaking soils which coalesce into Carex simulata dominated water track vegetation. Water begins to recharge two-thirds of the way down the length of the wetland, and the site becomes progressively drier. A dry outlet channel exists near the toe of the wetland, although it is blocked by a very low (1.5 ft) dam. At the time of our evaluation, the dam was not affecting the wetland, but during wetter years it may cause minor ponding.

The mire vegetation essentially lacks shrubs and is rather homogeneously dominated by Carex simulata. At the time of evaluation the site was being rested from cattle grazing, thus standing crop was good. Mild to significant cattle-induced soil pogging and microtopography formation are present.

A detailed evaluation of this wetland is included in Johnson and Gerhardt (2004). This site is known to contain the rare plant species pale blue-eyed grass (Sisyrinchium pallidum), therefore, management options for this site should closely considered.
North Park Mires

**Mire Name:** Peterson Ridge Mire  
**Ownership:** BLM

### Geographic Information

**USGS 7.5' Quadrangle Name:** Walden

- **Mire ID #:** 6  
- **Mire Area (ha):** 1.487  
- **Mire ID # (EPID):** 61  
- **Mire Area (acres):** 3.675  
- **X-Coord. (UTM):** 386268.4  
- **Y-Coord. (UTM):** 4498535.7

### Mire Characteristics

**Geomorphic Position:** Located in the bottom of a swale coming off Peterson ridge.

**Outlet or Receiving Waters:** Sub-tributary of Grizzly Creek

**Hydrology Notes:** No surface inlet. Fen begins at a major spring with quaking soils. Diffuse spring flow is present below as well.

**Wetland Type:** Mire  
**Mire/Fen Classification:** Moderate Fen

**Vegetation Physiognomy:** Meadow  
**Water pH:** 6.5

**Soil Composition:** Between 40 and 100 cm peat, underlain by sandy clay and clay.  
**Water Electrical Conductivity:** 83

**Impacts:** Site is in good condition, although grazing and associated impacts are present.

**Notes:** This is an excellent and remote mire site. Much of the fen is covered by C. simulata water-track vegetation, with standing water in hollows and small pools. Numerous small pools and springs exist on the site. The water table is generally perched on a clay aquitard. A strong recharge zone exists about a third of the way down the fen, and no surface water was seen leaving the fen during this evaluation. The mire ends at a low (0.25 cm) dam which spans the dry outlet channel. This dam does not seem to affect the mire.
Figure 19. An overview of the Peterson Ridge Mire showing the landscape setting of the wetland. The wetland is the green swath spanning right to left near the middle of the photograph. The large hills surrounding the mire are glacial deposits.
Figure 20. View south toward the mire head, standing on a relatively flat peat apron. The mire begins near the upper left hand corner of the photograph.

Figure 21. View south down Peterson Ridge Mire from near the wetland toe. The shape and geomorphic position of this mire is very typical of North Park Swale mires. Notice the abrupt wetland edge.
Figure 22. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Peterson Ridge (to S) and Antelope Spring Mires (Mires 6 & 7).
**Antelope Spring (Mire ID # 7)**

The Antelope Spring Mire appears to be located wholly on BLM land, in the bottom of a very large valley system, although it may also extend onto the Arapaho National Wildlife Refuge. The site has no surface inlet, and the mire begins at a small spring at the extreme west end of the wetland (Figs. 22 - 23). Discharged water infiltrates quickly, and a relatively dry section separates the western spring from the main spring in the east. The majority of the mire is fed by a main spring located near the middle of the wetland (Antelope Spring; Fig. 24).

The mire is strongly graminoid dominated, but vegetational composition is fairly heterogeneous and zonation is pronounced. The site is in very good condition and appears to be mostly unimpacted. Excavation has occurred near the spring to create a small pond (Fig. 25b). Other than the immediate impacts caused by excavation, this pond appears to have a negligible effect on overall wetland functioning. A channel leads out of the wetland from this pond. It is unclear whether the channel is man-made, natural, or an enhanced natural channel. The potential effects of this channel were not evaluated.

A very small ditch exists between the western spring and the main wetland (Fig. 25a). The ditch was dry at the time of this survey, but it may have caused limited wetland drying between the two portions of the wetland. A fence surrounding the wetland appears to prevent cattle grazing.

We recommend that this site be characterized in detail and surveyed for the presence of rare species and communities. Current management appears to be appropriate for the site, and the mire seems to have benefitted from the exclusion of cattle. We recommend that the ditch connecting the two portions of the wetland be filled. We do not recommend filling the excavated pond, but rather allowing it to fill naturally.
## North Park Mires

### Mire Name: Antelope Spring Mire

| Ownership: | BLM |

#### Geographic Information

- **USGS 7.5' Quadrangle Name:** Walden
- **Mire ID #:** 7
- **Mire Area (ha):** 2.563
- **Mire Area (acres):** 6.334
- **Evaluation Polygon ID # (EPID):** 60
- **X-Coord. (UTM):** 387634.2
- **Y-Coord. (UTM):** 4500570.7

#### Mire Characteristics

- **Geomorphic Position:** In a broad, shallow swale at the base of a lava flow.
- **Outlet or Receiving Waters:** Antelope Creek
- **Hydrology Notes:** No surface inlet. Spring discharge is evident and documented
- **Wetland Type:** Mire
- **Mire/Fen Classification:** Rich Fen
- **Vegetation Physiognomy:** Meadow
- **Water pH:** 7.19
- **Soil Composition:** 0-20 cm hemic peat, 20 - >100 cm sapric peat with a high silt content.
- **Water Electrical Conductivity:** 117.6

#### Impacts:

- Site is lightly grazed. A shallow pond has been dug at the main spring. Portions of the mire head may have been dewatered by a small ditch that has been cut between the upper spring and the main spring fen.

#### Notes:

- In spite of the excavations that have occurred on-site, this wetland is in good condition, and is probably a very important piece of wildlife habitat.
Figure 23. View southeast across the upper section of Antelope Spring Mire. Mr. Gerhardt is standing at the upper spring. The connection between the upper and main wetland sections can be seen near the center of the photograph and the main wetland is visible above the photograph middle.

Figure 24. Looking east over the main section of Antelope Spring Mire. The excavated pond can be seen left of center and the outlet extends off the top of the wetland vegetation.
Figure 25 A & B. Impacts present at the Antelope Spring Mire. (A) shows the small ditch connecting the upper and main wetland areas. Small portions of the wetland appear to have been dewatered by this ditch. (B) shows the excavated pond at the primary discharge site.
Sheep Mountain Mire (Mire ID #8)

The Sheep Mountain Mire is a fairly well preserved mire residing entirely on BLM land. The mire lies at the base of the summit ridge of Sheep Mountain on a plateau-valley above the main floor of the park (Fig. 26, 28). One point spring and diffuse discharge near the mire head supply the wetland with abundant water. Surface water was present throughout much of the mire during this survey (Fig. 27). Near the middle of the mire a raised area is present covered with precipitated salt and tall hummocks (Fig. 28). We speculate that this may be a secondary spring area, or a spring that is becoming extinct.

The vegetation is generally graminoid dominated, but fairly heterogeneous, and marked vegetation zonation is present. The condition of the mire is good with moderate cattle-induced impacts present. At the time of our surveys grazing had been light to moderate. The soil covering the springs near the head of the mire has been significantly disturbed by cattle activity, leaving a muddy hole where once a floating vegetated mat existed (Fig. 27a). Elsewhere on the wetland, soil disturbance in the form of microtopography creation was evident and in places strongly developed.

In spite of cattle impacts, overall this wetland is in good condition and possesses vegetation structure consistent with that of ungrazed mires. For a detailed site evaluation of the Sheep Mountain Mire consult Johnson and Gerhardt (2004). The current condition of this site can likely be maintained under the current grazing regime, but the site would benefit by tighter grazing management. Otherwise, site conservation may require no more effort than continuing the current management policy for the site and retaining property water rights.
# North Park Mires

## Mire Name: Sheep Mountain Mire

### Geographic Information

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### Mire Characteristics

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<thead>
<tr>
<th>Geomorphic Position:</th>
<th>At the base of a shoulder of Sheep Mountain, surrounded by two other low hills.</th>
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<tbody>
<tr>
<td>Outlet or Receiving Waters:</td>
<td>No surface outlet. The swale continues to the North Fork of the North Platte drainage.</td>
</tr>
<tr>
<td>Hydrology Notes:</td>
<td>No inlet. One main spring and a broad apron of diffuse discharge evident. The site is very wet at the upper end with standing water in the hollows.</td>
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<tr>
<td>Wetland Type:</td>
<td>Mire</td>
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<tr>
<td>Mire/Fen Classification:</td>
<td>Rich (Extremely-rich?) Fen</td>
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<tr>
<td>Vegetation Physiognomy:</td>
<td>Meadow; shrubby margins</td>
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<td>Water pH:</td>
<td>6.76</td>
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<td>Soil Composition:</td>
<td>At the main spring: 30 - 35cm hemic peat; 30-35cm to 50 cm sapric peat; &gt;50 coarse sandy material (could not obtain a sample). Below the spring: 0-65 cm hemic peat; &gt;65 cm silt.</td>
</tr>
<tr>
<td>Water Electrical Conductivity:</td>
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</table>

**Impacts:**

This site is in fairly good condition. Grazing is light to moderate in intensity. Cattle-induced microtopography is present throughout much of the wetland.

**Notes:**

This is an excellent and interesting site. It appears hydrologically unaltered and in good condition. The wetland is reminiscent of an extremely-rich fen in South Park. Below the wettest area the surface is carpeted with mosses, punctuated by hummocks. Near the center of the site there is what may be a large extinct spring. It is currently dry with a salty substrate and very tall, marly hummocks.
Figure 26 A -B. Two views down Sheep Mountain Mire looking north. (A) shows the wetland’s setting on a plateau of Sheep Mountain. (B) is a closer view. The mire head is in the foreground. The main springs and scattered pockets of surface water are visible in the foreground (brown, exposed soil).
Figure 27 A and B. Springs and possible impacts at the Sheep Mountain Mire. (A) is looking south from the head of the mire, across the main springs. The vegetation and soil at this spring has apparently been disturbed by grazing. (B) looks north toward the head of the mire from a central spring area. This spring was dry at the time of survey and it may be extinct or declining. Hummock development in this area is extreme and may be the result of natural or grazing effects.
Figure 28. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Sheep Mountain Mire (Mire # 8).
Troutman Draw Mire (Mire ID #9)

This mire is entirely on BLM land in a shallow swale at the bottom of a broad valley (Figs. 29, 31). The wetland begins at a slope break that forms the head of the swale. The initial groundwater discharge zone is at the slope break, and no surface inlet is present. Two other major springs were identified near the center of the mire. An outlet exists at the toe of the mire where the valley begins to narrow sharply. This outlet is blocked by a culvertless road grade.

The vegetation is generally dominated by graminoids, with a band of tall willows along the eastern edge. Other scattered willows exist throughout the wetland. Species identification, even of dominant herbs, was impeded by the high intensity of grazing that had occurred before the survey.

Grazing has caused significant impacts to this wetland mainly in the form of severe soil disturbance, removal of plant biomass, and a likely alteration of species composition (Fig. 30). Fortunately, the wetland appears to be hydrologically unaltered. The road grade blocking the outlet channel apparently does not have a significant effect on the wetland. At the time of this survey, no surface water was present up- or downstream of this road. During wetter periods, the road could cause some ponding, but effects are probably local in extent.

We recommend that grazing be more strictly controlled or decreased at this site to mitigate existing impacts and help rehabilitate the site. Particularly, heavy grazing at the sensitive spring areas should be reduced. Since the hydrology and the vegetation are seemingly intact, the wetland should recover without additional active restoration.
North Park Mires

**Mire Name:** Troutman Draw Mire  
**Ownership:** BLM

### Geographic Information

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<th>USGS 7.5' Quadrangle Name</th>
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<td>Mire Area (ha):</td>
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<td>Evaluation Polygon ID #:</td>
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### Mire Characteristics

**Geomorphic Position:** In the bottom (swale) of a fairly wide valley.

**Outlet or Receiving Waters:** Troutman Draw

**Hydrology Notes:** Site forms the headwaters of Troutman Draw Creek. GW discharge evident about 200 m down-gradient of the wetland start. Two other major, lateral springs were also located. Mire drains into the Troutman draw channel, but no surface water was noted leaving the site during the survey.

**Wetland Type:** Mire  
**Mire/Fen Classification:** Moderate Fen

**Vegetation Physiognomy** Meadow/carr  
**Water pH:** 6.94

**Soil Composition:**  
1) 0 - 35 cm hemic peat; 35 - 60 cm sapric peat.  
2) 0 - 30 cm hemic peat; 30 - 45 cm heavy clay; >45 cm clay-sand  
**Water Electrical Conductivity:** 125.1

**Impacts:** This site is heavily grazed. Soil is highly disturbed from intensive grazing, and pogging is severe in many places. Springs have been heavily trampled and disturbed. Hydrology appears intact.

**Notes:** Few species could be identified owing to the heavy grazing. This site would significantly benefit from reduction of grazing intensity. It is otherwise an excellent site.
Figure 29 A and B. (A) shows a panoramic view of Troutman Draw Mire (left is south, right is north). The head of the mire is to the left of the photo, and the toe is just visible at the extreme right. (B) is a view southwest near the edge of the mire showing the character of the vegetation and one of the lateral springs.
Figure 30 A and B. Impacts at the Troutman Draw Mire. (A) shows the tall, steep hummocks indicative of pogging. (B) Heavy soil and vegetation disturbance caused by cattle grazing.
Figure 31. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Troutman Draw (#9), and Northern (#11) and Southern Lake Creek (#12) Mires. Mires have been labeled with their identification codes. Yellow hatching indicates BLM property, blue is state.
Mansfield Draw Mire (Mire ID #10)

The Mansfield Draw Mire is a fairly well preserved wetland located entirely on BLM property. At nearly one mile in length, this is the longest mire system located during this survey, with the possible exception of the Beaver Creek Mire. The wetland is located in the bottom of Mansfield Draw, beginning in the middle of the draw (Figs. 32, 34). The initiation of the mire does not appear to be associated with any obvious surficial geomorphic features.

Like most of the North Park mires, this one lacks a surface inlet and begins abruptly at a zone of groundwater discharge. The upper portion of the mire strongly resembles the aprons and quagmires of extremely-rich fens in South Park (Fig. 33a). From this upper discharge zone, the mire continues several hundred meters down-valley in a terraced configuration. Following this, the slope becomes fairly even to the toe of the mire. Although very long, the mire is relatively narrow and ends abruptly on the margins when it encounters the relatively steep side-slopes of the draw.

The mire’s vegetation is entirely composed of graminoid communities. Near the head of the mire quagmire communities dominate. Most of the remaining wetland is dominated by sedge water track communities. The overall condition of the wetland is good. Extant impacts are from grazing, the excavation of a small pond near a lateral spring, and a narrow ditch along the northern edge. Grazing impacts do not seem severe, although they are ubiquitous. Soils were moderately disturbed with impacts taking the form of microtopography creation. Interestingly, a fenced exclosure exists near the toe of the mire. Between the fenced and un-fenced areas a strong fence-line contrast is evident, that highlights the strong effect that even moderate grazing can have on vegetation structure and physiognomy (Fig. 33b). The excavated pond lies midway down the mire. The pond is small and appears to exert only local impacts. The ditch along the northern edge appears to dewater small portions of the wetland.

We recommend that this site receive special management considerations, and that the BLM preserve the ecological integrity of the site. Filling the northside ditch would seemingly restore hydrology to dewatered portions of the mire, but no additional site modifications or restoration activities appear necessary.
### North Park Mires

**Mire Name:** Mansfield Draw Mire  
**Ownership:** BLM

#### Geographic Information

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#### Mire Characteristics

**Geomorphic Position:** Mire begins near the head of Mansfield Draw

**Outlet or Receiving Waters:** Mansfield Draw

**Hydrology Notes:** Site forms the headwaters of Mansfield Draw. GW discharge is evident on several aprons. Surface water is present across much of the site and a (artificial?) pool exists near the middle of the wetland. The recharge (source) area for this fen may be Independence Mountain.

**Wetland Type:** Mire  
**Mire/Fen Classification:** Rich (Extremely-Rich?) Fen

**Vegetation Physiognomy:** Meadow  
**Water pH:** 6.49

**Soil Composition:**
- > 100 cm fibric peat near the head spring
- > 55 cm hemic to sapric peat

**Water Electrical Conductivity:** 123.6

**Impacts:** This site is in fairly good condition, although grazing impacts in the form of microtopography creation are present throughout the site. A ditch running along the northern edge of the wetland dewaters limited areas.

**Notes:** This is an excellent site that is representative of North Park "swale mires". The wetland is generally narrow (< 100 m) but is over 2 km long. The wetland, especially near its upper reaches strongly resembles an extremely-rich fen. This is particularly true of the quagmires located on the aprons. Most of the site is covered by organic soils, and only a thin, mineral soil, mire margin is present due to an abrupt change in gradient as the valley side is encountered. There is an enclosure at the east end of the mire, which exhibits a strong fence-line contrast in vegetation biomass.
Figure 32 A and B. (A) Panoramic view north across the Mansfield Draw Mire. The head of the mire is left of center, with the wetland extending into the distance to the right. (B) View east down the mire from the upper spring area. This portion of the mire forms a peat apron with strongly quaking soils and surface water in the hollows.
Figure 33 A and B. (A) shows the surface character of the peat apron near the head of the Mansfield Draw Mire. The appearance strongly resembles that of an extremely-rich fen in South Park. (B) Near the toe of the mire an exclosure has been constructed. A strong fence line contract exists between the grazed vegetation in the foreground and the ungrazed vegetation in the background (light green).
Figure 34. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Mansfield Draw (to the North; #10) and California Gulch Mires (#14). Yellow hatching indicates BLM property.
Southern and Northern Lake Creek Mires (Mire ID #'s 11 and 12)

These sites were only cursorily examined in a previous reconnaissance by one of the authors (Johnson unpub. data). The wetlands were not examined on-site during this survey due to access difficulties, but both were observed through binoculars from the road right-of-way.

Each site is located along the side of the broad Lake Creek valley, in shallow valley-side coves. Each begins abruptly at a localized zone of groundwater discharge (Figs. 31, 35). No surface inlets exist at either wetland. We think that the main springs for each wetland are located on BLM land, but the wetlands cross onto private land shortly after beginning.

The vegetation of the wetlands is heavily graminoid-dominated, but small patches of willows exist, particularly around the springs. The condition of the sites is poorly known, but apparently the wetlands are grazed fairly heavily. Some minor channelization may have also occurred within the wetlands.

The BLM cannot manage the majority of each site, since they are mostly on private land. We recommend that the BLM-owned portion of each wetland be inventoried, and the location of the springs relative to the property boundaries be determined. If the springs do, in fact, lie on BLM land, we recommend that the integrity of, and water rights associated with those springs be maintained. Minor site modifications such as exclusionary fencing or minor channel filling may be advisable pending further investigation.
North Park Mires

**Mire Name:** Southern Lake Creek Mire  
**Ownership:** Private/BLM

### Geographic Information

- **USGS 7.5' Quadrangle Name:** Pearl
- **Mire ID #:** 11  
  - **Mire Area (ha):** 4.800  
  - **X-Coord. (UTM):** 371699.0
- **Evaluation Polygon ID # (EPID):** 86  
  - **Mire Area (acres):** 11.86  
  - **Y-Coord. (UTM):** 4531707.6

### Mire Characteristics

- **Geomorphic Position:** Starting in a shallow valley-side cove a faintly distinguishable swale leads toward Lake Creek.

- **Outlet or Receiving Waters:** Lake Creek

- **Hydrology Notes:** A point spring is present which forms the headwaters of a small spring creek.

- **Wetland Type:** Mire (?)  
  - **Mire/Fen Classification:** Moderate Fen (?)

- **Vegetation Physiognomy:** Meadow/shrub woodland  
  - **Water pH:** NA

- **Soil Composition:** NA  
  - **Water Electrical Conductivity:** NA

**Impacts:** This site is moderately to heavily grazed. No additional data.

**Notes:** During reconnaissance for any earlier study this site was briefly visited. The site was marked on a sketch map and Hahn's Peak/Steamboat Lake map as a slope wetland and potential fen. It was not given a site code. The site is fairly small but generally intact but for grazing impacts.
North Park Mires

**Mire Name:** Northern Lake Creek Mire  
**Ownership:** Private/BLM

**Geographic Information**

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**Mire Characteristics**

**Geomorphic Position:** Starting in a shallow valley-side cove a faintly distinguishable swale leads toward Lake Creek.

**Outlet or Receiving Waters:** Lake Creek

**Hydrology Notes:** A point spring is present which forms the headwaters of a small spring creek.

**Wetland Type:** Mire  
**Mire/Fen Classification:** Moderate Fen (?)

**Vegetation Physiognomy** Meadow/shrub woodland  
**Water pH:** NA

**Soil Composition:** > 35 cm peat  
**Water Electrical Conductivity:** NA

**Impacts:** This site is moderately to heavily grazed. No additional data.

**Notes:** During reconnaissance for any earlier study this site was briefly visited. The site was marked on a sketch map and Hahn's Peak/Steamboat Lake map as a mire. It was given a site code: HGMNP2. The site is fairly small but generally intact but for grazing impacts.
Figure 35 A and B. (A) view west up to Southern Lake Creek Mire. The wetland can be seen just below the center of the photograph. (B) view west towards Northern Lake Creek Mire. The head of the mire is right of center, trailing down to the left.
Soap Creek Mire (Mire ID #13)

We believe that this mire is located mainly on BLM land, but a portion may overlap Fish and Wildlife Service and private land as well. There is inconsistency between two ownership GIS coverages that we have received, and land exchanges have recently occurred in this area. In this report we maintain the original data that we received, but acknowledge that property boundaries may have changed. Further surveying is required to determine the mire boundaries and confirm ownership. The site is flanked on two sides by BLM land.

The wetland straddles Soap Creek, lying at the base of a low alluvial terrace on the edge of MacFarlane Reservoir (Figs. 36, 37). The fen (organic soil) portion of the mire is located north of the creek, around an area marked as a spring on USGS quadrangle maps. The fen has no inlet and groundwater discharge and quaking soils are evident. The fen’s surface is strongly terraced near the marginal springs which are located on a relatively steep, but low, slope. Slope throughout the rest of the mire is fairly uniform. Groundwater strongly recharges near the toe of the fen before the creek is reached and the organic soils end abruptly.

The shallow pond near the center of the wetland was apparently excavated (Fig. 36), but no side cast material is evident. Vegetation is relatively heterogeneous across the mire with distinct zones occurring on the margin, on the fen lawn, and at the pond. A much more halophytic (salt-loving) vegetation exists down-gradient of the mire in the vicinity of Soap Creek. Grazing pressure precluded the identification of many plant species.

This site is in good condition although it has been subjected to grazing impacts and presumed pond building. Grazing has caused widespread soil disturbance and pogging. The pond excavation has caused local changes to vegetation, soils, and hydrology but these effects seem restricted to the immediate vicinity of the fen.

The current ownership of this site should be determined. If BLM owns the majority of this property, as appears to be the case, the site should be characterized in detail.
# North Park Mires

## Mire Name: Soap Creek Mire  Ownership: FWX/BLM (?)

### Geographic Information

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### Mire Characteristics

**Geomorphic Position:** Situated in a shallow side cove near the base of the Soap Creek Mire and spilling out onto the floodplain.

**Outlet or Receiving Waters:** Soap Creek

**Hydrology Notes:** Groundwater discharges in a series of steps down a fairly steep (5% ?) terrace face. No surface inlet. A small channel leads out of the fen to Soap Creek. Surface water present throughout much of the site. Strong recharge area exists near the mire center (NE of Soap Creek).

**Wetland Type:** Mire

**Mire/Fen Classification:** Rich (Extremely-Rich?) Fen

**Vegetation Physiognomy** Meadow and shallow-water emergent

**Water pH:** NA

**Soil Composition:** 0 - 20 cm fibric peat; 20 - > 100 cm clayey organic soil. It is uncertain without lab analyses whether this lower stratum is truly organic.

**Water Electrical Conductivity:** 120.1

**Impacts:** The site is moderately grazed which has caused some soil and vegetation impacts. A shallow pond is located near the center of the wetland which is almost filled in and is covered with emergent vegetation. This pond is probably artificial but it is not really causing any impacts

**Notes:** This site is fairly small, but in generally good condition. Strongly quaking, almost quagmirey areas are common and the site is reminiscent of an extremely-rich fen. Vegetation is consistent with that of extremely-rich fens but not enough clear species indicators were found during this brief survey to make a detemination of fen type. Grazing effects also made identification of most species impossible.
Figure 36 A and B. (A) view southwest from above the head of Soap Creek Mire. The cattails near the center of the wetland are in the old, excavated pond. MacFarland Reservoir is in the background. (B) view north across the mire. The pond and cattails are left of center and the primary springs are just right and above center.
Figure 37. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Soap Creek Mire (#13). Yellow hatching indicates BLM property. The orange boxed area indicates property likely owned by BLM, but for which conflicting data exist.
California Gulch Mire (Mire ID #14)

California Gulch Mire is located entirely on BLM land in the narrow California Gulch valley. This is the only mire which lies within a CNHP potential conservation area, and it is also within the buffer area for an occurrence of the state-rare *Artemisia tridentata* spp. *vaseyana* - *Pascopyrum smithii* association. The mire is quite small and is generally only a minor component of the larger California Gulch riparian system (Figs. 34, 38). The mire begins at the bases of two opposing creek terraces, with the wetland spanning the creek. While the California Gulch creek flows through the site, the mire does not truly have a hydrologic surface input since the mire groundwater discharge zone lies a meter above the creek water level.

The wetland is entirely graminoid dominated and the vegetation seems quite homogeneous. However, many dominant species could not be identified because of the moderate to high intensity grazing that had occurred prior to survey. The mire is in fairly good condition, although grazing has caused moderate to severe soil disturbance and pogging. We do not have any site-specific management recommendations for this mire, but see the General Recommendations section.
North Park Mires

Mire Name: California Gulch Mire
Ownership: BLM

Geographic Information
USGS 7.5' Quadrangle Name: Lake John

<table>
<thead>
<tr>
<th>Mire ID #</th>
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<th>X-Coord. (UTM)</th>
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<tr>
<td>111</td>
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Mire Characteristics

Geomorphic Position: Located in two terrace base coves on California Gulch Creek; opposite one another. Mire ends where the gulch narrows abruptly.

Outlet or Receiving Waters: California Gulch

Hydrology Notes: Groundwater discharges from two spring areas on opposite sides of the creek. The recharge (source) area for this fen may be Independence Mountain.

Wetland Type: Riparian Mire

Vegetation Physiognomy: Meadow

Mire/Fen Classification: Rich Fen

Water pH: NA

Soil Composition: 0 - 35 cm hemic peat; 35 -39 cm heavy clay (densic layer); >39 cm bedrock.

Water Electrical Conductivity: NA

Impacts: The site is moderately to heavily grazed, and the soil is fairly disturbed and pogged into hummocks.

Notes: This site is small and somewhat understated. It is an important for maintaining base flow in California gulch, though, and may be an important and consistent source of water for wildlife.
Figure 38. View northeast across California Gulch Mire. This wetland is small and the organic soils are heavily pogged. Organic soils begin near where the sagebrush ends near the center of the photograph. Hummock tops are very light blue-green in a darker green (sedge) matrix.
Government Creek Mire (Mire ID # 15)

This wetland is located entirely on private land, thus it could not be field evaluated except for that part lying near the road. The mire is located in a shallow side-swale tributary to Government Creek (Figs. 39, 40). The mire does not have an apparent inlet, although a surface outlet, tributary to Government Creek, may be present.

Vegetation seems fairly diverse, consisting of both willow- and graminoid-dominated areas. The site does not presently appear to be grazed, or only very lightly. Otherwise, the wetland seems to be intact.

The mire is on private land, and no BLM management possibilities exist within the site. However, the BLM, USFS and the State own a considerable amount of land surrounding the site. We recommend that the mire’s recharge area (hydrologic source) be located. Based on geomorphic and landownership patterns, the recharge zone may occur within government lands, and thus an opportunity may exist for the BLM or another agency to help indirectly conserve this site by actively managing this crucial area. We also recommend that the BLM retain property holdings in the vicinity of the site to help maintain an undeveloped wetland buffer. Should the property become available through land exchange or other means, we recommend that BLM consider acquiring the site.
North Park Mires

<table>
<thead>
<tr>
<th>Mire Name: Government Creek Mire</th>
<th>Ownership: Private</th>
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</table>

**Geographic Information**

USGS 7.5' Quadrangle Name: King's Canyon

- Mire ID #: 15
- Mire Area (ha): 13.19
- X-Coord. (UTM): 395360.3
- Evaluation Polygon ID # (EPID): 127
- Mire Area (acres): 32.59
- Y-Coord. (UTM): 4525927.2

**Mire Characteristics**

**Geomorphic Position:** Located in the bottom of a wide, shallow swale, which is tributary to Government Creek.

**Outlet or Receiving Waters:** Government Creek

**Hydrology Notes:** Forms a tributary of Government Creek. No inlet is present but standing water is evident. It is uncertain whether the mire forms a channel down valley.

**Wetland Type:** Mire

**Mire/Fen Classification:** Moderate to Rich Fen

**Vegetation Physiognomy:** Meadow - Carr

**Water pH:** NA

**Soil Composition:** NA

**Water Electrical Conductivity:** NA

**Impacts:** The site appears to be generally intact, although Government Ditch may cut across its head. This may divert some of the head spring water out of the wetland.

**Notes:** This site is almost certainly a fen, but it was not directly evaluated since it is on private land and no access was secured. The site may continues a long way down valley, but again this was not confirmed.
Figure 39. Photograph towards the head of the Government Creek Mire (to the far left in the picture). The wetland continues for an unknown distance down-valley (to right in photograph).
Figure 40. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Government Creek Mire (#15). Yellow hatching indicates BLM property.
Dry Fork Mire (Mire ID #16)

This mire is located predominantly on BLM land and is an excellent wetland resource. The mire extends onto private land for an unknown distance, however, BLM manages the wetland’s source springs. The site lies in the bottom of the Dry Fork valley, spanning the creek and extending laterally up three shallow side coves (Figs. 41 - 43). These three lobes coalesce into a single arm which follows the creek channel. None of the three lobes possess surface inlets, although all are tributary to Dry Creek either through diffuse surface flow or channelized flow.

The vegetation on this site is quite diverse, although generally graminoid dominated. The coverage of mosses is high in the vicinity of springs. The site is generally in good condition, although a pond and associated berm have been constructed, and a ditch or channelized creek traverses the site. None of these structures seemed to be functioning at the time of our survey and all seemed in disrepair. During wetter seasons these structures could have more effects.

The general hydrology and the nature and impacts of hydrologic modifications at this wetland should be characterized. At the time of our survey, grazing intensity appeared appropriate for wetlands. Upon further study, minor active restoration may be advisable.
### North Park Mires

#### Mire Name: Dry Fork Mire

**Ownership:** BLM/Private

#### Geographic Information

<table>
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<th>USGS 7.5' Quadrangle Name:</th>
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#### Mire Characteristics

**Geomorphic Position:** Mire is in the bottom of a long valley system, at the base of an intra-valley slope break and where it widens suddenly.

**Outlet or Receiving Waters:** Dry Fork Creek

**Hydrology Notes:** The wetland has three headwater lobes which are separated by upland rises. In all three lobes GW discharge is evident and there are no significant surface water inlets. Two of the lobes (NW and SE) have peat aprons domed by GW discharge. Water table is apparently perched on a heavy clay aquitard.

**Wetland Type:** Mire

**Mire/Fen Classification:** Rich Fen

**Vegetation Physiognomy** Meadow

**Water pH:** NA

**Soil Composition:** Soils are variable across the site. Often > 35 cm of hemic to sapric peat over a heavy clay aquiclude.

**Water Electrical Conductivity:** NA

**Impacts:** This site appears to be in good condition. It has a pond near the center of one lobe that is probably artificial and is very similar to the one present on Soap Creek Mire (Mire #13). It, too, has a canopy of emergent vegetation. A channel in the mire, that appears natural may have been subject to active entrenchment. There is a dam on site but it does not appear to be adversely affecting the wetland.

**Notes:** This site is an excellent and diverse example of a North Park mire. The site appears nearly unaltered and it is fairly expansive. Moss coverage is very high in the vicinity of the springs.
Figure 41. (A) View down the southeast lobe of the Dry Fork Mire. The tall vegetation near the middle is cattails growing out of what is probably an excavated pond. The northeast lobe of the wetland can be seen to the right. (B) View of the northeast (left) and northwest (right) lobes of the Dry fork mire. The southeast lobe is out of view to the right.
Figure 42 A and B. (A) View across the hummocky fen lawn vegetation of the southeast lobe of the Dry Fork Mire. (B) View west to the main spring on the southeast lobe. A moss mat is visible at the center of the picture and cattails grow in a mostly filled-in pond.
Figure 43. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Dry Fork Mire (#16). Yellow hatching indicates BLM property.
Spring Creek Mire (Mire ID #17)

The Spring Creek Mire is the largest and wettest mire identified to date in North Park, with the potential exception of the Beaver Creek Mire. The wetland covers some 31.5 ac (12.8 ha), with 14.5 ac (5.9 ha) being comprised of organic soil fen (Fig. 45). The majority of the wetland, including most of the major springs, lies on US BLM land. The lower half of the wetland extends onto state lands. The mire starts gradually near the head of a shallow swale located within a large valley system (Fig. 44). Springs abound within the wetland system, being concentrated toward the south end of the wetland (Fig. 45). Near the center of the site, the wetland narrows considerably and flow becomes channelized, but the wetland widens again beyond the BLM land boundary.

Above the western edge of the wetland lies a depressional wetland that appears to be seasonally flooded (Fig. 45). This distinct wetland was not investigated in any detail but it is striking and odd. Although quite round and located in an unusual landscape position several meters above the valley bottom on a terrace, this wetland does not appear to be artificial. Rather it seems to be a natural depression supported by groundwater discharge in conjunction with precipitation.

Given the size, overall condition, and heterogeneity we consider Spring Creek Mire to be one of the most important mire sites in North Park.

No rare or sensitive species were identified at the Spring Creek Mire. We did note the presence of Sisyrinchium montanum, which commonly grows with the rare S. pallidum. Since the habitat appears ideal for S. pallidum, there is a good chance that the rare species does in fact grow at the site. Thus we suggest that this wetland be managed as if this species were present.

Some 19 springs were identified at this wetland (Fig. 45). Although areas of point discharge could commonly be detected, often springs are so closely nested that it is essentially arbitrary to separate them. Moreover, these point springs were often located within broad areas of apparently diffuse discharge. Thus we consider the entire upper reaches as comprising an integrated network of springs. Below the upper portion of the wetland that bears most of the springs, the Spring Creek channel forms and flows down the center of the wetland.

The site appears to be wholly intact hydrologically with no modifications whatsoever evident. Impacts are mainly related to the effects of cattle grazing, primarily manifested as turf disruption and extreme microtopography development (Fig. 44). It also appears that grazing has affected species composition, favoring weedy forbs over graminoids on the margins.

Near the BLM property border and extending onto State land, grazing appears to have had negligible effects. The adjacent State portion of the wetland appears exceptionally well preserved, with a tall, healthy sward of graminoids and ample shrub coverage. We recommend that grazing practices on the BLM portion of the wetland be revised, perhaps using the state grazing plan as a model. Without additional information on the two grazing plans we cannot be certain about the merits of this recommendation, however.
North Park Mires

<table>
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<tr>
<th>Mire Name:</th>
<th>Spring Creek Mire</th>
<th>Ownership:</th>
<th>BLM/State</th>
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**Geographic Information**

USGS 7.5' Quadrangle Name: Owl Ridge

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**Mire Characteristics**

**Geomorphic Position:** Mire is located in the bottom of a wide valley system.

**Outlet or Receiving Waters:** Mire forms the headwaters of Spring Creek

**Hydrology Notes:** 19 point springs and additional spring fields have been identified. No inlet.

**Wetland Type:** Mire  
**Mire/Fen Classification:** Rich Fen

**Vegetation Physiognomy:** Meadow - carr  
**Water pH:** 6.6

**Soil Composition:** >100 cm  
**Water Electrical Conductivity:** 122.9

**Impacts:** This site is in poor to excellent condition. In the northwest portion of the wetland, grazing impacts to the soils are severe. In the southern arm, grazing impacts subside and soils and vegetation are in excellent condition.

**Notes:** This is the most significant mire site identified on BLM lands. It is a very wet site and vegetation is diverse and mostly in good condition, although cattle impacts are widely present and in areas severe.
Figures 44 and 45. The upper photograph provides a view to the southwest showing the head of the Spring Creek Mire. The division between mire margin and lawn vegetation is readily apparent near the center of the picture. Also apparent is the extent of soil and vegetation disturbance caused by cattle grazing. The lower photograph provides an illustration of the severity of soil impacts. The ecologist is standing in a deep trough created by a cattle trail. Note that the fen surface has been incised more than 75 cm (above knee height in the picture).
Figure 46. A portion of a 7.5 minute U.S.G.S. Quadrangle map showing the location and setting of the Spring Creek Mire (#17)
Conclusions and General Recommendations

This survey located significant, high-quality mires on BLM lands in North Park. Ownership patterns provide the BLM with unique wetland management opportunities and responsibilities since the agency manages the headwaters and water sources for 12 of the mires, and nine of the mires are wholly located on BLM lands.

No federally listed plant species were identified at any of the mires, but the state-rare pale blue-eyed grass (*Sisyrinchium pallidum*) was found growing at two sites and it is suspected to be present at most of the mires. Additional sensitive species would likely be identified pending additional floristic survey.

The wetland management scenario for the BLM in North Park is very different from the scenario in South Park. In South Park, the BLM usually owns and manages only a small portion of identified mires, reducing the opportunity for direct, proactive management. In North Park, BLM holdings are extensive, containing numerous mires and potentially the recharge zones (hydrologic sources) for these wetlands. Landscape-scale recharge areas are the ultimate hydrologic sources for the regions fens and mires and must be maintained intact if these groundwater controlled wetlands are to ultimately be preserved. Potential federal management of both wetlands and recharge areas is a truly unique situation. The lack of this situation is one of the greatest impediments to successful mire conservation strategies elsewhere in the country. The enormous BLM land holdings in North Park provide a unique wetland management opportunity, in which wetlands can be managed on a landscape-scale, rather than simply a site-by-site basis. Implementation of such a management approach would be model example of contemporary strategies in wetland conservation.

Importantly, some of these wetlands may be ruled as “non-jurisdictional” under the U.S. Supreme Court’s SWANCC ruling (U.S. Supreme Court 1999). Under no circumstance should the properties containing these mires be removed from Federal ownership and management.

We suggest five primary management recommendations, each followed by a brief rationale:

1) The BLM should retain any property containing a mire or portion thereof, including as much upland buffer as possible.

The presence of these rare and important wetland resources on federal land offers an extremely important wetland conservation opportunity. Possessing water during even the most severe dry periods (contrast Fig. 3 with site photographs), these wetlands provide an essential habitat component for wildlife and wildlife. One local rancher felt “there wouldn’t be any water for the cattle at all if it weren’t for these wetlands here and there”. The

---

3In these cases, certain hydrologically “isolated” ecosystems which meet the legal definition of “wetland”, may not be regulated by the Clean Water and Interstate Commerce Acts.
groundwater discharge supplied by these wetlands is also critical for maintaining stream base
flow and the health of regional fisheries.

2) The BLM should retain and/or adjudicate all water rights associated with properties
containing mires and preserve their hydrological integrity. Further, BLM should identify
landscape-scale recharge areas for these wetlands and maintain the hydrologic integrity of
such areas if located on Federal land.

The hydrology of mires is inherently complex due to their reliance on groundwater
discharge, which is in turn dictated by regional hydrogeologic patterns. Complex hydrology
makes fen/mire restoration difficult or impossible once impacts have occurred. Without the
preservation of their natural hydrology these mires would be severely impacted or entirely
destroyed.

It is imperative that wetland hydrologic patterns be preserved. We strongly recommend that
BLM maintain the hydrologic integrity of identified mires, retaining property rights, and
prohibiting hydrologic alteration such as pond excavation, ditching, damming, or mining.
We further recommend that mire recharge (hydrologic source) areas be located and
preserved to the extent possible.

3) All identified mires should be throughly characterized, including comprehensive surveys for
rare species and communities.

Direct ecological information for most North Park mires is lacking. For example, this survey
identified 17 mires which were previously undocumented. US BLM has initiated detailed
evaluation of these sites and four mires have been so assessed. We recommend that site
level assessments continue. Successfully defining and defending management strategies for
fragile wetland resources requires quantitative, scientific data and evaluation. Appropriately
developed management plans can strike a balance between resource utilization and resource
conservation. Plans developed with insufficient data have a higher potential to either
unnecessarily restrict allowable uses (grazing, recreation, mining, etc.) or unknowingly
permit non-sustainable or environmentally harmful activities.

4) BLM should scientifically investigate the effects of grazing on mires and seek to develop
grazing plans which better balance resource conservation with utilization.

Every mire evaluated has to various degrees been impacted by cattle grazing. In most cases,
cattle impacts are not extremely severe and continuation of current grazing regimes would
likely not cause rapid degradation of wetland habitat. Yet scientific information on the
effects of grazing are wholly lacking for these systems, and determination of site
management is based on “native wisdom” and personal judgement.

Scientific evaluation of grazing regimes would provide a basis for making informed
management decisions that would better balance the needs of site conservation and resource
utilization.
5) BLM should develop a detailed management plan for its properties containing, or in the vicinity of, identified mires.

As suggested in recommendation 3, management plans should be based on scientific information. However, in the interim critical properties could be identified and given special consideration if land use permit applications concerning those properties are submitted. We recommend that BLM closely consider, and explicitly document, the management approach for each mire and North Park wetland resources as a whole. General policies can be created to dictate the general agency philosophy on regional mire management – for instance, whether mires are to be managed more for conservation or for resource utilization, and how wetland-impacting project applications are to be handled. Property-specific plans, on the other hand, augment general policies, providing individualized strategies for outstanding or highly degraded sites.

Property-specific plans, in particular, require detailed site information, but they yield the most effective approach to management. For example, intact sites with high levels of biodiversity and possibly rare species, may be candidates for active preservation, whereas species-poor sites could be more heavily utilized with minimal ecological impacts.
REFERENCES CITED


Appendix 1

Dominant Species Data
Table A1-1. Presence/absence species composition data. “+” indicates species presence on a wetland.

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APPENDIX 2

Technical Information on the ArcView GIS data files and the Microsoft Access Database
File Descriptions

Two GIS themes and Microsoft Access database file were developed during this mapping project. Each GIS theme is in ArcView shapefile format. As with all shapefiles, one shapefile theme may require two to five related files in order to work. All related files will have the same name prefix, but the three letter suffix will vary depending on the file type. Files required for proper display include those with the suffixes: *.dbf, *.prj, *.sbn, *.shx, *.sbx *.shp (e.g. four_mile_creek_mire.dbf, four_mile_creek_mire.prj, four_mile_creek_mire.sbn, etc.). All related files must be kept in the same directory in order for the themes to display properly.

All spatial files use the 1983 North American Datum. Additional projection information is included in the projection (*.prj) and the metadata (*.xml) files associated with each theme. Below, the GIS shapefiles developed during the fen and mire mapping in North Park are listed and described. Following these descriptions the Microsoft Access database file contents are described.

GIS Files

North Park Evaluation Areas.* – This polygon shapefile displays the areas which were evaluated during mapping. Polygons are approximate and based on the landscape area which could be seen from vantage points or which were walked in the field. Many polygon boundaries are simply based on BLM property lines. The shapefile attribute table contains 17 data fields. The contents of each data field is described in Table A2-1.

North_Park_Mires - updated.* – This polygon shapefile delineates mire systems, or contiguous wetland systems which contain groundwater dominated, organic soil areas (fens). These polygons were mapped using a combination of GPS points and satellite imagery. Due to low image resolution, mire boundaries should be taken as rough approximations. The shapefile attribute table contains 20 data fields. The contents of each data field is described in Table A2-2.
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<th>EPID</th>
<th>Eval_metho</th>
<th>Covertype</th>
<th>Wtnd Stat</th>
<th>Sig_feat</th>
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<tr>
<td>Unique identification code for each evaluation polygon (EP)</td>
<td>The method by which a given polygon was evaluated. TM = evaluation from satellite image analysis alone; Remote = viewed the polygon from a remote vantage, often using binoculars; Field = on-site evaluation.</td>
<td>A very general description of dominant habitat cover types located in a polygon. Often based solely on satellite imagery, and thus should be interpreted broadly and with caution.</td>
<td>The likelihood of a property containing wetlands based on satellite analyses, or field reconnaissance. The scale is: 0 = Confirmed Upland or Low Wetland Probability (P) 1 = Moderate P; 2 = High P or Confirmed Wetland; 3 = Confirmed Wetland with Moderate to High P of a Mire; 4 = Confirmed Wetland</td>
<td>Significant features or landmarks associated with an identified wetlands. Lack of data in this field does not necessarily indicate a lack of significant features.</td>
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<th>Notes</th>
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<td>Self-explanatory</td>
<td>The unique identification number given to identified mires.</td>
<td>Code indicating the type and nature of additional evaluation recommended for each site: 0 = no additional mire evaluation needed; 1 = Site was unevaluated during this survey and contains potential mire habitat based on satellite analysis; 2 = site contains a mire on non-BLM land and should be characterized in detail if possible; 3 = Property owned by BLM containing a mire which should be characterized in detail.</td>
<td>Description of additional evaluation. Essentially notes to the Add_Eval_n field.</td>
<td>Description of additional Polygon area in sq. meters</td>
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<th>Hectares</th>
<th>X_Centroid</th>
<th>Y_Centroid</th>
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<td>Polygon area in acres length in meters</td>
<td>Polygon area in hectares</td>
<td>X UTM coordinate for the polygon &quot;center of mass&quot;</td>
<td>Y UTM coordinate for the polygon &quot;center of mass&quot;</td>
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Table A2-2. Description of the data fields contained within the **North Park Mires - updated** shapefile data table.

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<th>Hydrology</th>
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<tbody>
<tr>
<td>Unique record number defined by ArcView</td>
<td>Feature topology (Polygons)</td>
<td>Identification number of the mire</td>
<td>Evaluation Polygons covering the mire</td>
<td>Self explanatory. Some of these names are commonly used, while other are novel, and developed for reference convenience</td>
<td>Name of the USGS 7.5' Quadrangle map</td>
<td>Mire landscape position</td>
<td>Identified groundwater sources or indicators thereof</td>
<td>Major repository for hydrologic outflows from the mire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physiognom</th>
<th>Wetland Ty</th>
<th>Fen Classi</th>
<th>Soils</th>
<th>pH</th>
<th>EC uS</th>
<th>Notes</th>
<th>CNHP_PCA_Name</th>
<th>CNHP_PCA_N</th>
<th>CNHP_Biodi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of mire vegetation structure</td>
<td>See report text for further explanation</td>
<td>Minerotrophic fen/mire classification - General soil composition in the mire</td>
<td>Pore water pH</td>
<td>Pore water electrical conductivity</td>
<td>Self-explanatory</td>
<td>Name of the CNHP Potential Conservation Area in which the mire is located</td>
<td>Identification number for the PCA assigned by CNHP</td>
<td>Site Biodiversity rating according to CNHP. 1 indicates highest diversity. See Spackman et al. (2001) for a full description</td>
<td></td>
</tr>
</tbody>
</table>
Microsoft Access Database

Data Content

Data obtained in identified mires were tabulated into a Microsoft Access database (file name = North_Park_Mire_Database.mdb). The database is composed of three data tables. These tables are similar to common spreadsheets, such as those used in the Microsoft Excel. The tables contain one of two classes of data: 1) explanations of data table fields, such as details of how the data were collected and code legends; and 2) records of field observations from mires.

Data Table Field Explanations - The contents of these tables are provided above in Tables A2-1 and A2-2.

Eval_Polygon_Field_Desc – Provides explanations of the content of each data field in the “North Park Evaluation areas” ArcView shapefile data table. This table is provide above as A2-1.

Mire Char Field Desc – Provides explanations of the content of each data field in the “Mire Characteristics” ArcView shapefile data table and the "Mire Characteristics" database table. This table is provide above as A2-2.

Data Table

Mire Characteristics – Contains the data and descriptions of each mire mapped during this inventory. Note that this data table is redundant with data included within the “North Park Mires - updated” ArcView shapefile data table. It was included as a Access data table for application flexibility.
APPENDIX 4

Brief account of fen classification based on nutrient status
Minerotrophy
Fen hydrology is dominated by groundwater inputs. The chemical characteristics of groundwater sources are strongly dictated by regional hydrogeologic characteristics. The amount and character of water entering a fen highly influences species composition by affecting species richness, the type of species present, and the amount of biomass produced by those species. Some fens may be nearly insulated from ground water due to the accumulation of peat; others may be influenced by topogenous ground water that is low in nutrients, such as that percolating through siliceous parent material, while still others may be subject to both the above conditions. In such cases, fens are typically low in species diversity, contain a high coverage of *Sphagnum*, and numerous oligophilic species.

At the other extreme, fens may be highly influenced by ground water, exposed to a high volume of flowing (soligenous) water, subjected to ground water high in cations due to contact with calcareous or dolomitic parent material, or a combination of such factors. In these cases, fens will typically be vegetated by numerous, minerophilic (“mineral/nutrient-loving”) species and brown mosses – especially those in the Amblystegiaceae.

Due to the cosmopolitan nature of this gradient, it has been widely used to classify fens with the most common divisions being poor, moderate, rich, and extremely-rich fens (Du Rietz 1949, Sjörs 1950a). These terms allude to several related fen attributes. Originally the terms referred to the species richness of a site (Du Rietz 1949, Sjörs 1961b, Sjörs 1963), but later workers also tied them to nutrient status, which is one of the driving factors of species diversity on fens (Gorham and Pearsall 1956, Gorham 1967, Sjörs 1983, Malmer 1986). The concentration of calcium and pH are especially important in this sense (Sjörs 1950a, Heinselman 1970, Vitt et al. 1975, Sjörs 1983, Wassen et al. 1989, Glaseret
al. 1990, Malmer et al. 1992). These terms have also been used to imply the relative number of calciphilous species residing at a site (Vitt and Slack 1975, Slack et al. 1980). These workers have found bryophytes to be especially indicative of stand environment (see also Malmer et al. 1992), although bryophytes can also have surprisingly broad ecological tolerances to pH and calcium content (Kooijam and Westhoff 1995). It should be noted that this gradient is usually manifested as a regional gradient, between fen sites, but minerotrophic gradients can certainly be exhibited within sites too.

Commonly, one or more of the above criteria are used in conjunction to classify fens. Chee and Vitt (1989) provide a comprehensive review of the water chemistry criteria used in defining these fen types. Table 1.1 shows water chemistry summaries for fen classes. As is evident from the overlap in parameters, these criteria provide only an approximate indication of the overall fen nutrient condition. Roughly speaking, typical poor fens have a pH of 4.0-5.5 and calcium concentrations of 2-7 mg/l. The pH of moderate fens is generally 5.5-7.1, while calcium concentration ranges between 10-50 mg/l, rich fens are pH 6.0-7.5 with calcium between 25 - 80 mg/l, while extremely-rich fen pH is between 6.5 - 8.5 and calcium is greater than 30 mg/l.
Table 1.1. Water chemistry values for the four minerotrophic fen classes. EC is specific conductivity reported as microsiemens.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Area</th>
<th>pH</th>
<th>EC (µS)</th>
<th>Ca (mg/l)</th>
<th>Mg (mg/l)</th>
<th>Na (mg/l)</th>
<th>K (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POOR FENS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zoltai &amp; Johnson (1987)</td>
<td>West-Central Canada</td>
<td>4.8</td>
<td>53</td>
<td>2.9</td>
<td>1.2</td>
<td>3.9</td>
<td>1.3</td>
</tr>
<tr>
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<td>Alberta</td>
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<td>0.8</td>
<td>4</td>
<td>0.9</td>
</tr>
<tr>
<td>Comeau &amp; Bellamy (1986)</td>
<td>Eastern Canada</td>
<td>4.3</td>
<td>-</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>0.4</td>
</tr>
<tr>
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<td>-</td>
<td>2</td>
<td>1-3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glaser et al. (1981)</td>
<td>Minnesota</td>
<td>4.0-4.6</td>
<td>25-50</td>
<td>2.0-2.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vitt et al. (1975)</td>
<td>Alberta</td>
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<td>-</td>
<td>2.3</td>
<td>0.4</td>
<td>3.0</td>
<td>-</td>
</tr>
<tr>
<td>Bellamy (1968)</td>
<td>Western Europe</td>
<td>4.5</td>
<td>-</td>
<td>20</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Sjörs (1963)</td>
<td>Ontario</td>
<td>4.1-5.4</td>
<td>16-22</td>
<td>2</td>
<td>0.5</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Sjörs (1948)</td>
<td>Sweden</td>
<td>4.2</td>
<td>-</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>0.4</td>
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<tr>
<td><strong>MODERATE AND MODERATE-RICH FENS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chee &amp; Vitt (1989)</td>
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<td>18-240</td>
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<td>4-5</td>
<td>4-7</td>
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<td>2-12</td>
<td>-</td>
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<tr>
<td>Yefimov &amp; Yefimov (1973)</td>
<td>U.S.S.R</td>
<td>6.1</td>
<td>-</td>
<td>18</td>
<td>8</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Persson (1961)</td>
<td>Sweden</td>
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<td>40-50</td>
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<td>85-93</td>
<td>10</td>
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<tr>
<td>Sjörs (1948)</td>
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<td>6.0</td>
<td>-</td>
<td>68</td>
<td>12</td>
<td>2</td>
<td>0.4</td>
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<td><strong>RICH</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Minnesota</td>
<td>5.1-7.0</td>
<td>23-82</td>
<td>3-56</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bellamy (1968)</td>
<td>Western Europe</td>
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<td>-</td>
<td>183</td>
<td>19</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Sjörs (1963)</td>
<td>Ontario</td>
<td>5.8-7.4</td>
<td>48</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>EXTREMELY RICH FENS</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Glaser et al. (1990)</td>
<td>Minnesota</td>
<td>6.6-7.5</td>
<td>16-30</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Zoltai &amp; Johnson (1987)</td>
<td>West-Central Canada</td>
<td>6.5</td>
<td>374</td>
<td>54</td>
<td>14</td>
<td>6.54</td>
<td>0.1</td>
</tr>
<tr>
<td>Karlin &amp; Bliss (1984)</td>
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<td>-</td>
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<td>10-53</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Slack et al. (1980)</td>
<td>Alberta</td>
<td>6.8-7.9</td>
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<td>4-18</td>
<td>-</td>
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<tr>
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<td>207</td>
<td>32</td>
<td>7</td>
<td>5</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Many species have a high fidelity for one of the minerotrophic classes. Based on this relationship, such species have often been used as indicators of peatland trophic conditions. This approach has been used to reduce the amount of environmental sampling necessary at a site by inferring environmental conditions through the flora. For instance, it is common for researchers to refer to poor or rich fen species.