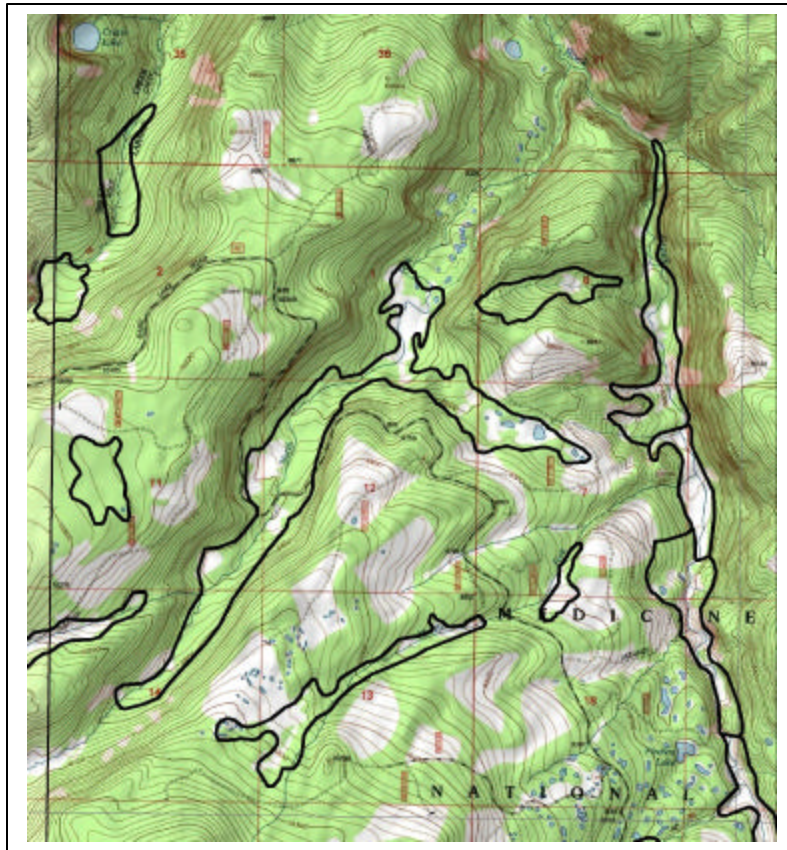


# **Extensive Inventory of Peatland Sites on the Medicine Bow National Forest**



Prepared for:

Medicine Bow-Routt National Forest

By Bonnie Heidel and Robert Thurston  
Wyoming Natural Diversity Database  
University of Wyoming  
Dept. 3381, 1000 E. University Avenue  
Laramie, WY 82071

FS Agreement No. 02-CS-11020600-033

May 2004

## ACKNOWLEDGEMENTS

Study support and coordination were provided throughout by John Proctor (MBNF). Study designs were reviewed and intensive sampling protocols were developed in the field in consultation with John Proctor, Kathy Carsey (Arapaho-Roosevelt National Forest) and George Jones (WYNDD). Bob Mountain (MBNF) started and kept the study on course in the Supervisor's Office. Jim Barrott (previously with MBNF) provided assistance in retrieving the wealth of soils data. Carol Tolbert (MBNF) provided use of the MBNF color aerial photographs in order to copy them for use in field surveys. The GIS work was started by Scott Laursen (WYNDD) with the help of John Proctor and Kathy Roche (MBNF). Joy Handley (WYNDD) contributed polygon calculations and report editing. Gary Beauvais (WYNDD) provided supervisory support and good humor at all stages. The interest and help of all is gratefully acknowledged. This work also benefited greatly by the use of Rocky Mountain Herbarium facilities and resources.

The study was pursued under a challenge-cost share agreement between the Medicine Bow National Forest and Wyoming Natural Diversity Database, Forest Service Agreement No. 02-CS-11020600-033.

### Report citation:

Heidel, B. and R. Thurston. 2004. Extensive inventory of peatland sites on the Medicine Bow National Forest. Prepared for the Medicine Bow National Forest. Wyoming Natural Diversity Database, University of Wyoming, Laramie.

Cover: Histosol-containing soils polygons were overlain on topographic relief maps for peatland inventory fieldwork. This example is from the NW quarter of the Morgan Quad – 7.5', one of 23 quarter-quads where inventory was conducted.

## ABSTRACT

Extensive systematic peatland inventories were conducted in four study areas of the Medicine Bow National Forest (MBNF) in 2003 because peatlands harbor high concentrations of Wyoming rare plant species. The objectives were to develop peatland inventory techniques using digitized natural resource information and aerial photographs, locate and map peatland sites, and collect peatland information for later use in stratifying sites to intensively analyze the array of peatland botanical and ecological features across the study areas. This study also highlights the nature, extent, and distribution of peatlands in the study areas.

The four study areas include two large multiple-use landscapes mainly on the eastern side of the Medicine Bow Range that encompass large areas of the Middle and North Fork of the Little Laramie River watersheds and the Rock Creek watershed. The study areas also include Sheep Mountain at the far eastern side of the Medicine Bow Range which is managed as a game refuge, and Huston Park on the Sierra Madre Range within the Huston Park Wilderness Area.

The field inventories documented that peatlands are widespread in the study areas. A total of 154 peatland sites were documented on the ground and GPS coordinates were recorded at their upper and lower limits, which were later digitized using digital ortho-photographs. The four Medicine Bow Range study areas span about 150 square miles and there is over one square mile of peatland habitat among them. The actual peatland site boundaries span over 1500 acres, and size estimates were adjusted to over 750 acres to allow for inclusions and mosaic patterns within mapped boundaries. Peatland habitat approaches 1% of the land cover in 3 of the 4 study areas, representing a major wetland component on the landscape.

All peatlands in the study areas have vegetation characteristic of circumneutral or alkaline systems, and are classified as fens. The majority of fens and the most extensive fens in both the Medicine Bow and Sierra Madre study areas are associated with water courses (94%). In particular, many of them are associated with first order streams (49%). These fens are fed by groundwater, even though many are in topographic positions and settings that would not seem conducive to stable groundwater discharge. The North Fork study area is the only well-glaciated of the four study areas, and also has fens associated with glacial kettles, i.e., isolated basins.

Soils mapping reliably located most peatlands in drainage settings of the Medicine Bow Range greater than 10 acres (10 of 12; or 83%). Soils mapping did not identify any of the small kettle peatlands in the Medicine Bow Range, a function of the mapping scale rather than the accuracy of soil classification determinations. In addition, the soils mapping units that indicated peatlands in the Medicine Bow Range did not identify peatlands in the Sierra Madre, so *de novo* peatland inventory was conducted in that study area. Initial field reconnaissance in the Stillwater area, a glaciated area on the northwest side of the Medicine Bow Range outside the scope of study, indicated that the soils polygons that contain peatlands on the east side of the Medicine Bow Range did not occur on different landscapes of the same mountain range.

A synthesis of methods is provided from this extensive inventory study, accompanied by map products and electronic files. The resulting peatland dataset has been sorted by a suite of criteria for stratified intensive botanical and ecological documentation in 2004.

## TABLE OF CONTENTS

<b>INTRODUCTION</b> .....	1
<b>METHODS</b> .....	2
<b>STUDY AREAS</b> .....	9
<b>RESULTS</b> .....	14
<b>DISCUSSION</b> .....	25
<b>LITERATURE CITED</b> .....	27

### Appendix

Appendix A. Peatland raw data - subset
Appendix B. Peatland mapping, by quarter-quad
Appendix C. Peatland settings – site examples
Appendix D. Species distribution maps – <i>Carex paupercula</i> and <i>Epilobium oregonense</i>

### Tables

Table 1. Medicine Bow National Forest peatland study areas
Table 2. Soils units of the Medicine Bow National Forest that include histosol components
Table 3. Tally of soils polygons and peatland sites
Table 4. Extent of peatland sites
Table 5. Prospective site priorities for intensive peatland inventory
Table 6. Wyoming species of concern in Medicine Bow National Forest peatland study areas

### Figures

Figure 1. DRG image of Morgan (NW) Quad with soils unit polygons superimposed
Figure 2. Color aerial photo 301-136; centered on Morgan (NW) Quad
Figure 3. Medicine Bow National Forest peatland study areas
Figure 4. Allotments that overlap with initial peatland study area boundaries
Figure 5. Schematic cross-section of southern Medicine Bow Range – first eon of Precambrian
Figure 6. Schematic cross-section of southern Medicine Bow Range – close of Precambrian
Figure 7. North Fork Study Area peatland sites
Figure 8. Middle Fork Study Area peatland sites
Figure 9. Sheep Mountain Study Area peatland sites
Figure 10. Huston Park Study Area peatland sites
Figure 11. <i>Rana sylvatica</i> photo
Figure 12. <i>Epilobium oregonense</i> photo

## INTRODUCTION

The objectives of this study were to develop peatland inventory techniques using digitized natural resource information and aerial photographs, locate and map peatlands, and collect peatland site information that might be used for stratifying sites in a separate study phase to intensively analyze the array of peatland botanical and ecological features across these areas. The study results also highlight the nature, extent, and distribution of peatlands in the four study areas, though it was not the definitive mapping for any of the four study areas or the boundaries of individual peatland sites within them. This study represents an extensive data-collecting stage that followed from previous pilot inventory (Heidel and Laursen 2003) and that lays the ground work for intensive analysis of peatland botanical and ecological diversity.

Peatlands are biologically important in harboring high concentrations of Wyoming plant species of concern, as well as for their wildlife values and hydrological functions in maintaining water quality and flow (briefly reviewed in Heidel and Laursen 2003). Peatlands have been recognized as wetlands that are not practical to restore in mitigation (USDI Fish and Wildlife Service 1996). The only prior peatland inventory in the Medicine Bow National Forest was a pilot study limited to five known sites identified via peatland indicator species, published literature, and unpublished communications (Heidel and Laursen 2003). The objectives of this earlier work were to document the rare species, the local floras, and the vegetation attributes of these subjectively chosen sites as a framework for larger-scale study. The pilot study led to documentation of seven Wyoming plant species, including two species of concern that were not previously known from southern Wyoming, a preliminary vascular flora of over 180 vascular species, and the collection of a rare moss known from only one other collection station in Wyoming. The pilot study also documented large peatland sites. One of the original peatland study sites is 1.5 miles in length. An additional large peatland was discovered incidental to the pilot study. The results of the initial study indicated a need for baseline peatland inventory to systematically collect basic information on an under-documented and biologically important system. Pending land management decisions, including allotment management planning in the North Fork Allotment, were also considered in launching the baseline peatland inventory. Thus, extensive inventory was initiated to quickly provide information on the status of the peatland resource, as well as noting livestock utilization at peatland sites.

The original plans for this project were to complete both extensive peatland inventory and intensive floristic and ecological documentation at a subsample of peatland sites all during the 2003 growing season. It became apparent after the first two days of fieldwork locating and mapping peatlands that peatlands were much more frequent and extensive than imagined. Rather than reduce the size of study areas, or eliminate any one of the four study areas, it was decided to keep the original scope of extensive inventory and to conduct the intensive fieldwork separately in the following year. This report represents the results of extensive inventory conducted in 2003.

## METHODS

Digitized soils and wetland mapping data were compared for locating peatland areas. Soils mapping was available as a GIS layer on file at the Medicine Bow National Forest (MBNF), prepared by the University of Wyoming. Wetland mapping was available as a GIS layer with a complete set on file at the MBNF, prepared as part of the National Wetlands Inventory by the U.S. Geological Survey EROS Data Center in Brookings, South Dakota. Two of the soils mapping units were defined as containing a peatland component and two of the wetland layers were defined as saturated soils indicating peat-forming conditions. The peat-containing soils and wetland GIS layers were overlain with the five mapped peatland sites. One of the five peatland sites was too small to be captured in soils mapping. The soils data were selected because field verification data were on file to support the soils mapping. Wetland mapping identified all five peatland sites as having saturated soils but the mapping units were far larger and the mapping patterns did not match as well with topographic patterns so it was not incorporated in the study. Ideally, both GIS layers would have been used if it would have been possible to make GIS preparations before the field season.

We also considered using plant distribution data of peatland indicator species as indication of peatland sites. The indicator list was developed from overlap between lists in Chadde et al. (1998) and in Fertig and Heidel (2002). The set of peatland indicator species locations represent records for those Wyoming plant species of special concern that are peatland obligates. However, the small number of species and few occurrences documented in the Medicine Bow Range limited its utility. In select cases, the species' distribution data were used to locate peatland sites in the study areas.

Peatland soils are classified as Histosols, and two soils units that have histosol components are identified on the Medicine Bow National Forest (Bauer et al. 1986). They are discussed further in the study area section. For convenience, a separate shapefile was created that contained just these two soils units. For purposes of this study, the polygons containing either of the two soils units are generally referred to as "the soils polygons", selected out from all others based on their peat component, even though Histosols are only minor components. The soils polygons were overlain onto Digital Raster Graphics (DRG) hill-shaded quarter-quads that were labeled by their USGS quad name and quarter for use in the field (Figure 1). The soils polygons that indicate peatland ranged in size from less than 1 acre to 644 acres as present within the study areas, and were not consistently associated with major landforms except that they were continuous for the length of the North Fork of the Laramie River and Rock Creek valley bottoms.

Complete U.S. Forest Service color aerial photograph coverage was available for the four areas at the same scale as the U.S. topographic maps (2.5"-1 mile), and the original color photos were borrowed for high-resolution color copying. Each soil polygon potentially containing peatland was made a target for survey, and color aerial photographs were used for identifying and navigating between potential peatland habitats within and between polygons. The color aerial photographs were taken late in the 2001 growing season (August-September), which is optimal for distinguishing saturated soil conditions. In these photos, the peatland habitat appeared as openings in the forest with an olive-green color, compared to dry meadows or

seasonally-moist meadows that had paler, whitish green colors indicating which indicated they had dried out by late in the season. Peatlands sometimes had a distinguishable texture associated with shrub cover and in rare cases with graminoid cover. Also discernable on the aerial photos were small pools without major inlets or outlets and widely-scattered, stunted trees, both of which usually corresponded with peatland sites.

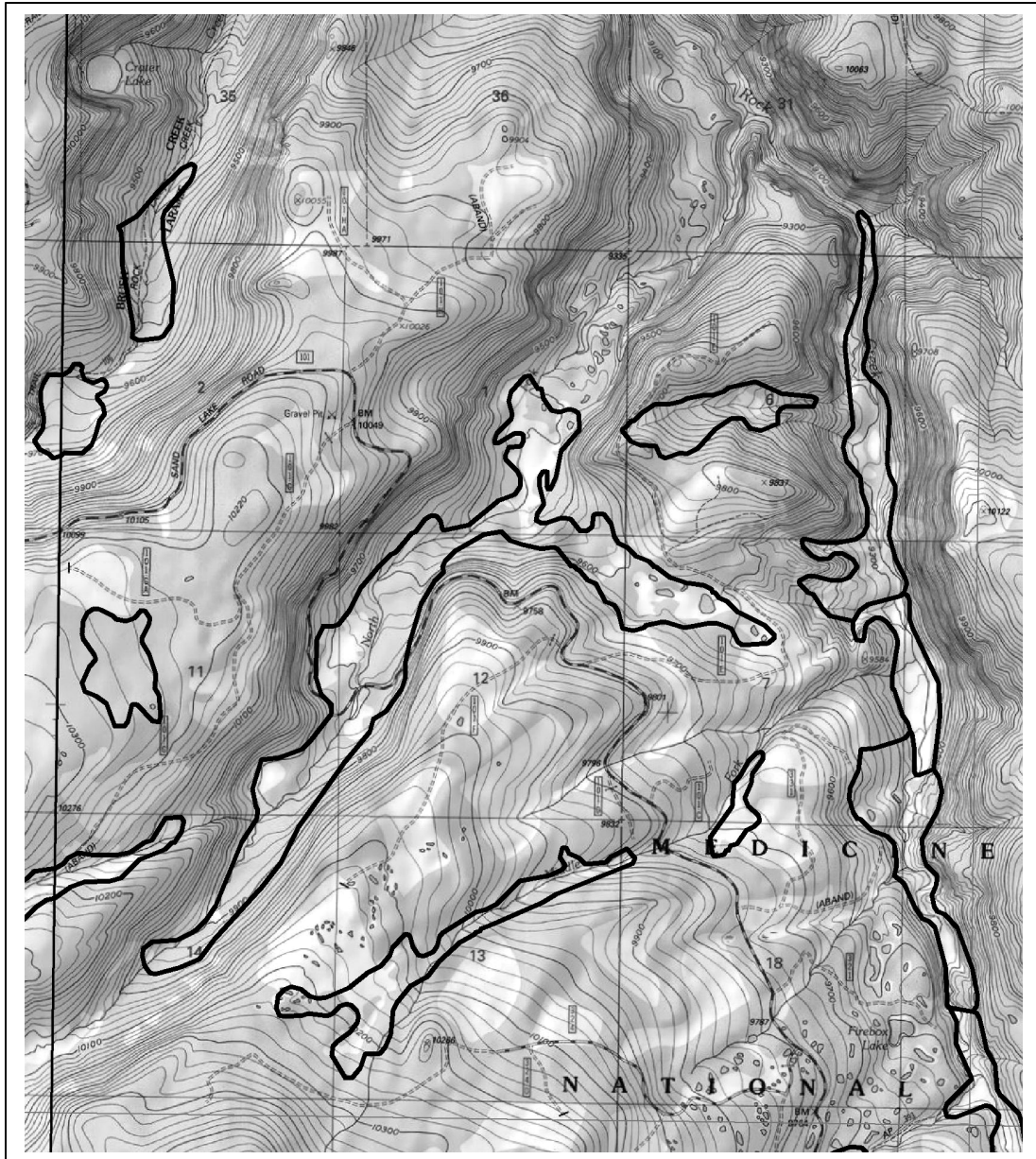
Both the color aerial photographs and the DRG quarter-quads were approximately the same scale as USGS topographic quad maps (7.5' @ 1:24,000) for ease of cross-referencing. Maps and photos were printed onto 8 ½" x 11" pages that were carried in plastic sleeves for easy, durable use in the field. An example of these references carried in the field is presented in Figures 1 and 2, including the DRG quarter-quad for the Morgan (NW) Quad overlain with soil polygon units, and the corresponding U.S. Forest Service color aerial photograph, 301-136, identified by flight line number and by frame.

Other investigators have used photo-interpretation for identifying peatland sites (e.g., Cooper and Andrus 1994) or remote sensing (e.g., Johnson and Gerhardt 2003). For the purposes of this investigation, the study area extent would have made photo-interpretation from aerial photographs a lengthy undertaking. The color aerial photos provided great benefit in setting priorities within polygons and critiquing whether the polygons included or excluded peatland habitat. The prospect of remote sensing using aerial photos or Landsat imagery hinged on baseline data for peatland distribution that did not exist. The results of a peatland remote-sensing project in the North Park of Jackson County, Colorado were not available in time to consider it for this purpose, and the application of remote-sensing signatures in fundamentally different landscapes and settings remains to be evaluated.

For purposes of this report, peatlands are defined as wetlands with saturated organic substrate (peat) evident at the surface. Peatlands are widely referred to as mires in the literature outside of North America (e.g., Grunig 1994). The term "fen" is the appropriate technical term for the minerotrophic peatlands in the study areas. Fens are further classified by water chemistry data as poor, rich, or extremely rich (Windell et al. 1986, Chadde et al. 1998). The wetlands of this study are referred to as peatlands because this is a widely-recognized term in technical North American literature, and the inventory at this stage does not provide a basis for technical classification.

The technical definition of peat soils, or Histosols, hinges on their organic content (18% or more by weight if the mineral fraction contains 60% or more clay; or 12% or more if the mineral fraction if soil contains no clay; USDA SCS 1992). Soils mapping for Medicine Bow National Forest was available, and it included two soils mapping units that were described as containing histosols across at least 25% of the soils map unit area. The sampling data used to support the mapping effort collected and documented peat soils at seven locales that fell within the study areas, six of which were mapped as peatlands in this study. Peatlands also have distinguishing vegetation characteristics but a peatland vegetation classification has not been developed for Wyoming. The vegetation information documented in the pilot inventory across an array of peatland study sites (Heidel and Laursen 2003) and peatland vegetation information from adjoining states (Chadde et al. 1998, Carsey et al. 2003) was referenced.

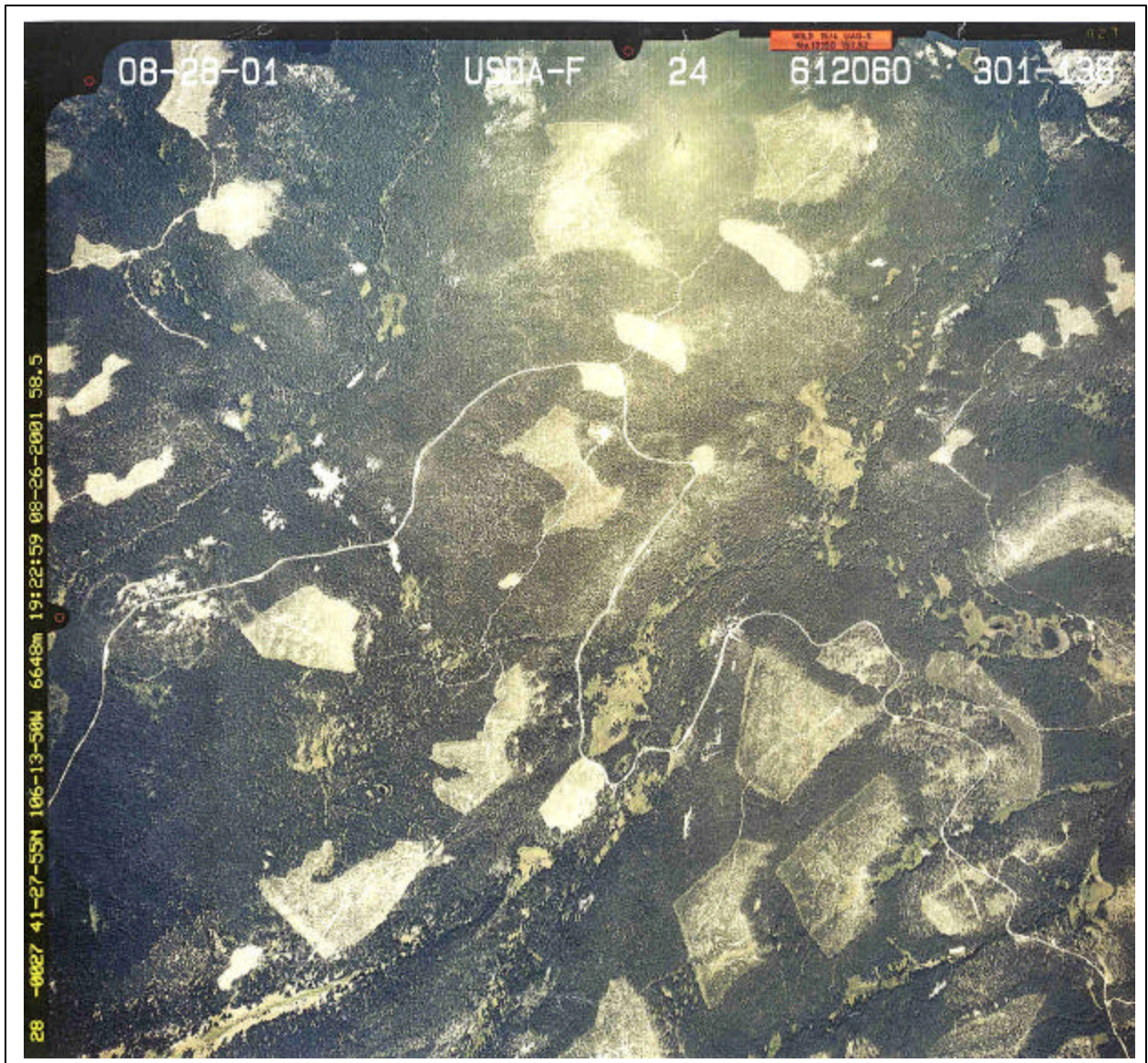
Figure 1. Digital Raster Graphics (DRG) image of the Morgan (NW) Quad, with soils unit polygons that contain histosols superimposed; an example of maps carried into the field<sup>1</sup>



<sup>1</sup> This represents most of the northwestern quarter of the Morgan Quad (7.5'). It is the same area as the map on the report cover. Rock Creek runs south to north on the righthand side of this map; its upper reach is traced by a series of polygons. The North Fork of Rock Creek runs diagonally through this map from southwest to northeast. Note the 3-armed polygon in the center, further discussed in the text. Also note Firebox Lake in the lower righthand corner surrounded by many small wetlands, but with no peatland-containing soils polygons.



Figure 2. Color Aerial Photo 301-136; U.S. Forest Service aerial photo centered on the Morgan Quad; an example of the color aerial photograph copies carried into the field<sup>2</sup>



In the field, peatlands were determined based on saturated soils at or near the surface and vegetation composition and structure models developed from pilot peatland inventory. Fieldwork took place within a 10-week period, starting on July 12 in the North Fork study area. The last

---

<sup>2</sup> This figure corresponds with part of the area in the preceding figure. Note the three-armed pattern in the center-right as it corresponds with the soil polygon superimposed on the preceding map. The copy of the color aerial photograph provided extremely high resolution in the field, while this scanned version is of much lower resolution.

peatland inventory of 2003 was conducted on September 27 in the Middle Fork study area. Survey was conducted by Bonnie Heidel and Rob Thurston. The total number of investigator days spent in field inventory was 27 days.

Survey was conducted within all major peat-containing soils polygons in the four study areas, using aerial photographs to identify wetland openings and to set an itinerary aimed at visiting a series of all prospective wetlands within or between soils polygons in a day's traverse. It quickly became apparent that there were peatland sites outside of soils polygons, so the methods and time allocations were focused on visiting all of the large soils polygons and mapping the largest peatland sites. A separate record of field survey work by polygon is presented as a separate data spreadsheet. Using this approach, the mapping is not exhaustive, but it is a robust representation of peatlands in each study area.

To map peatlands, GPS readings were taken at opposite ends of the peatland, determined with help of aerial photos, and recorded as latitude-longitude values using the NAD27 datum. Since most peatlands were associated with drainage courses, the two points were recorded as "upper" and "lower". The margin of error was also recorded, striving for accuracy between 4-10 ft radius. Single readings were taken at a few small sites and in series that were later divided. The transition from peatland to forested upland was often extremely abrupt around the perimeter. Mapping notes were often taken if there were boundary irregularities with other non-forested vegetation. In the course of mapping, the length of the peatland was traversed, and questionable vegetation patterns evident on the aerial photographs were examined on the ground.

GPS readings and all other data were recorded on field forms that contained 25 information fields (see p. 8). Each peatland site was assigned a unique identification number based on the 4-digit soil polygon used in soils mapping, and a 2-digit tie-breaker. For example, the soil unit polygon that follows the North Fork of the Laramie River is polygon 1910 and the first peatland site visited within the soil polygon was 01, for a unique site identifier of 191001. Peatland sites that did not fall within polygons were placed in a "9999" series followed by a unique pair of numbers. The corresponding soil polygon map (topographic map quarter) and the color aerial photo identification number were also recorded for each peatland site.

A narrative describing the landscape setting was recorded for each peatland site, categorized by setting after the field season. The peatlands were associated with drainage courses (the majority), kettle settings, and a miscellaneous category that did not fit in either.

The vegetation structure was characterized as graminoid-dominated or shrub-dominated. Usually one or the other predominated but both were often present. Shrub-dominated communities were also categorized by shrub height (short = less than 0.5 m, mid = 0.5-1.5 m, and tall = greater than 1.5 m) and shrub density (low = density with less than 25% cover, mid = density of 26-75% cover, and high = density with 75-100% cover). Scattered trees or tree islands were also noted. Initial plant identifications were made using Dorn (1996, 2001), Hurd et al. (1998) and Johnson (2001) in order for both investigators to have a vocabulary of dominant plants they were likely to encounter. Specimens or fragments were collected as vouchers for later determination to make provisional determination of dominants or co-dominants. Beyond that, partial species lists were recorded as time and familiarity permitted.

Mapping was initially planned around assumptions that peatland habitat was continuous over short distances and could be precisely mapped in a short amount of time. However, there were settings where peatland habitat was interrupted by inclusions, interrupted by beaver dams in irregular patterns, or widely-scattered; sometimes without breaks in gross vegetation structure or topography. For these reasons, the extent of peatland within each peatland site was bracketed in coarse terms of 0-10%, 11-50%, 51-90% and 91-100% based on an estimate made after traversing the area.

It was not the purpose to survey rare species but it readily became evident that two Wyoming plant species of concern were recurrent over the largest study areas. For these two species, *Epilobium oregonense* (Oregon willow-herb) and *Carex paupercula* (bog sedge), GPS readings were recorded when they were encountered so that the opportunity to document the breadth of their distribution was not lost. A limited number of vascular plant collections were made as vouchers for these two species, to document the species determinations at the test site of intensive vegetation sampling, to make modest additions to the running list of Medicine Bow peatland species as presented in Heidel and Laursen (2003), and to help document species-rich sites. Incomplete efforts were made to locate other rare plant species and to locate wood frogs (*Rana sylvatica*) as an animal species of concern.

Additional space was on the peatland survey form for recording directly-adjointing land-use, the hydrological affects of beaver, and mapping comments. The study was not designed as a grazing study but signs of livestock and pack animal use were noted (trampling, grazing, droppings). Distinguishing peatland features were also noted (floating mat, open water pool, spring complex, ~steep slopes). The presence of any *Sphagnum* species was noted with vascular species composition. A column was added to score sites for intensive-sampling revisit purposes, with yes/no marks or else 1-5 scales. It was not practical to standardize these scores between investigators or over time, and criteria were defined after the field season targeting all large peatland sites, the range of structure features and composition features, and the range of settings.

Fieldwork started on the North Fork of the Little Laramie River and on the contrasting landscape of Rock Creek, both with high numbers and densities of peatland sites in an array of settings. They provided search images for photo-interpretation of peatland sites that were used in a limited number of cases to rule out the presence of peatlands in soils polygons that were not evaluated on the ground.

Two sites in the North Fork Study Area were re-visited in the company of John Proctor (Medicine Bow National Forest), Kathy Carsey (Arapaho-Roosevelt National Forest), and George Jones (Wyoming Natural Diversity Database). At the first site, intensive vegetation sampling was conducted in a modified Whittaker plot (Stohlgren et al. 1995) as a model for next year's phase of intensive work involving vegetation documentation. At a second site with a relatively complex set of peatland features, including the largest floating *Carex limosa* mat known in the Medicine Bow Range, habitat heterogeneity and species composition were investigated by the same team in considering the next year's phase of both the intensive floristic and vegetation documentation.

## PEATLAND SPEADSHEET FIELDS

(The following information was recorded on survey field forms during extensive peatland inventory and entered into data spreadsheets.)

PEATPOLYID	peatland polygon identification number, which is a combination of the soil polygon identification number (SOILPOLYID) and the polygon segment (POLYSEG).
STUDYAREA	study area (Elk Creek, North Forth, Sheep Mountain, or Sierra Madre).
SOILPOLYID	soil polygon identification number from the mb_soils_ field of the shapefile mb_soils (85,92).shp, which includes soil map units 085 and 092. Peatland areas surveyed outside of polygons are assigned "9999".
POLYSEG	polygon segment (a number N indicating the Nth area of mapped peatland within the soil polygon).
QQUAD	USGS quarter-quadrangle (a combination of the USGS 24K quadrangle name plus NW, NE, SW, or SE, for example, Centennial NW).
PHOTONUM	aerial photo identification number.
SITE	general description of the location of the peatland site.
VISITOR	investigator(s) that visited the site.
DATE	date that site was visited.
LATUPPER	latitude of upper point of peatland site (a GPS reading).
LONGUPPER	longitude of upper point of peatland site (a GPS reading).
ERRORUPPER	error in feet of upper GPS reading.
LATLOWER	latitude of lower point of peatland site (a GPS reading).
LONGLOWER	longitude of lower point of peatland site (a GPS reading).
ERRORLOWER	error in feet of lower GPS reading.
SETTING	setting of peatland site, often described as the position along the drainage course, for example, middle of drainage course, head of drainage course, isolated wetland at head of drainage, basin at head of drainage, kettle.
VSTRUCTURE	vegetation structure (graminoid or shrub, including shrub height and density).
PFEATURES	peatland features observed at site (floating mat, paludified forest, lake/pond/pool, spring, stream from spring). Wildlife-induced patterns in peat induced caused by rutting or rubbing antlers were also noted.
PPERCENT	estimate of percent of digitized polygon that is peatland (0-10%, 10-50%, 50-90%, or 90-100%)
DOMINANTS	dominant plant species.
OTHERSPEC	other plant species (including Sphagnum).
LANDUSE	land use notes (logging, grazing, etc.).
FIELDNOTES	supplemental field notes.
BEAVER	presence of beaver dams as they curtail or interrupt peatland extent
MAPCOMMENT	comments concerning the GPS points relative to the digitized peatland boundary.
REVISIT	score or comments on whether the site should be revisited for additional study.

After the field season, all of the data recorded onto the field forms were entered into Excel spreadsheets by the investigators. The Excel spreadsheets were converted into dBase tables so the GPS data could be used in ArcView GIS (3.2). The GPS points were re-projected to UTM Zone 13 NAD83 and displayed for quality-control of point locations. Then peatland boundaries were digitized using digital ortho-photograph quarter-quads (DOQQs) as the background display. The NAD83 datum was used for digitizing because the map projections of the DOQQs use this datum. The NAD83 dataset was then converted to UTM Zone 13 NAD27 to match the projection of the GIS datasets that were originally provided by the Medicine Bow National Forest.

In the process of digitizing peatland boundaries, it became apparent that prospective peatland sites that were not surveyed had similar pattern to nearby digitized sites. Addition of 21 peatland sites was made in the course of digitizing primarily to fill in gaps in the middle of the study areas. A column was added to the spreadsheet to record whether the site was field verified or not.

The acreage of each study area and each soil polygon within them was calculated using the ArcView tabulation function. The area of each peatland site was calculated using the same function. The resulting peatland site area calculations were multiplied by the estimated extent of peatland habitat within each site (i.e., the mean values for the coarse categories; 5, 30, 70, and 95% as averages for the 0-10, 11-50, 51-90, and 91-100 ranges, respectively) for a conservative adjustment to peatland area determinations.

Three sets of data were identified for sorting and stratifying all 2003 peatland sites for an intensive study phase in 2004. We did not have a consistent standard for gauging the degree of peatland development because characteristics such as peat depth and floristic diversity were not measured. Peatland size was interpreted as some indication of development, using either actual peatland area, or peatland length. The second criterion was based on setting (drainage, kettle, or other). The third criterion was based on vegetation (structure and/or dominance).

## **STUDY AREAS**

The extensive peatland inventory was conducted the Medicine Bow and Sierra Madre ranges in Albany and Carbon counties of southeastern Wyoming. The Medicine Bow National Forest (MBNF) lands on the Medicine Bow Range encompass app. 540,170 acres (218,600 ha) and range in elevation from 2500-3700 m (8200-12140 ft; Alexander et al. 1986). The MBNF lands on the Sierra Madre Range encompass app. 336,280 acres (136,090 ha) and range in elevation from 2080-3355 m (6825-11005 ft).

Four study areas were selected in Medicine Bow National Forest that have peatland sites and peatland obligate rare plant species, extensive wetland habitat in the vicinity as indicated on U.S. Geological Survey topographic maps, and which were thought to have recurring peatland habitat. Three of the four study areas lie mainly on the eastern side of the Medicine Bow Range and encompass study sites in the pilot peatland research reported in Heidel and Laursen (2003). They encompass much of the headwaters of the North Fork and Middle Fork of the Little

Laramie River. The fourth study site is on the Continental Divide in the Sierra Madre Range, with peatland features documented by Jankovsky-Jones et al. (1995). The location, size and elevation ranges of the study areas are shown in Figure 3 and summarized in Table 1. In total, the four study areas comprise app. 10% of the Medicine Bow National Forest in these two mountain ranges. They overlap with 12 U.S. Geological Survey topographic quad maps (7.5').

Figure 3. Medicine Bow National Forest peatland study areas

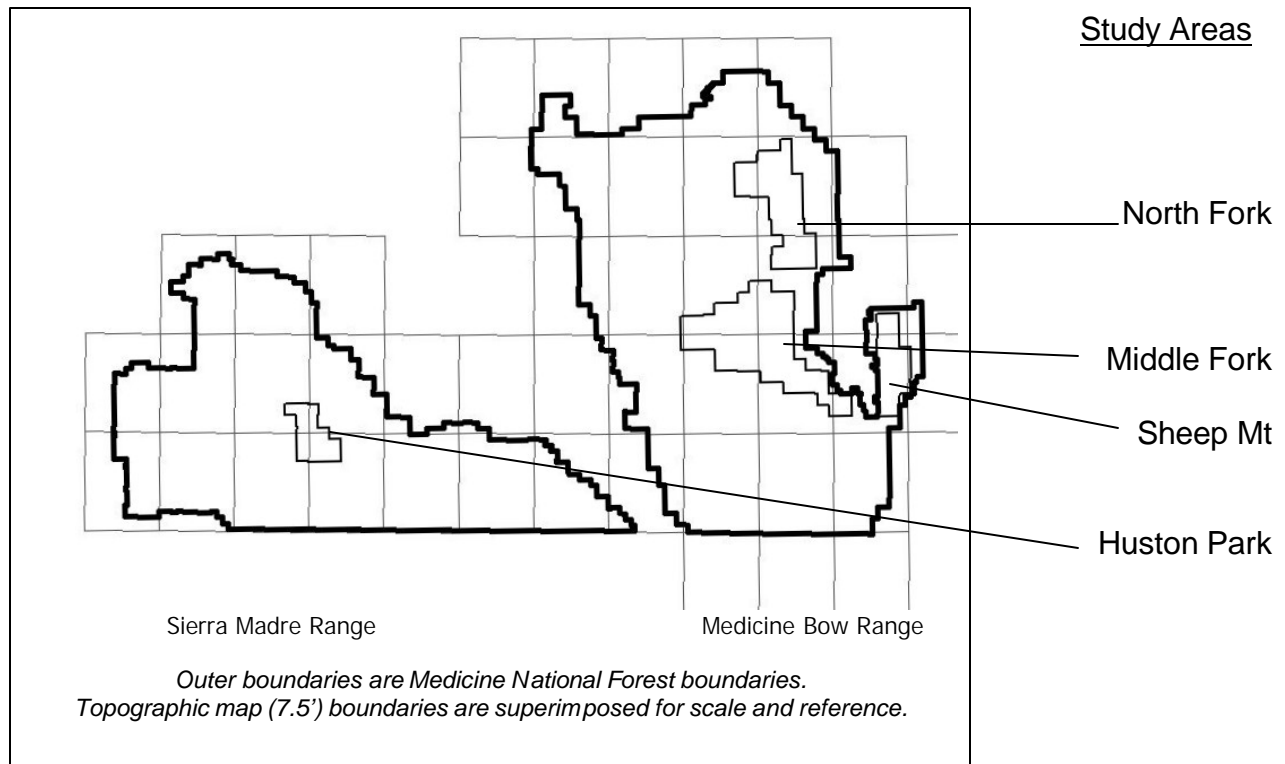


Table 1. Medicine Bow National Forest peatland study areas

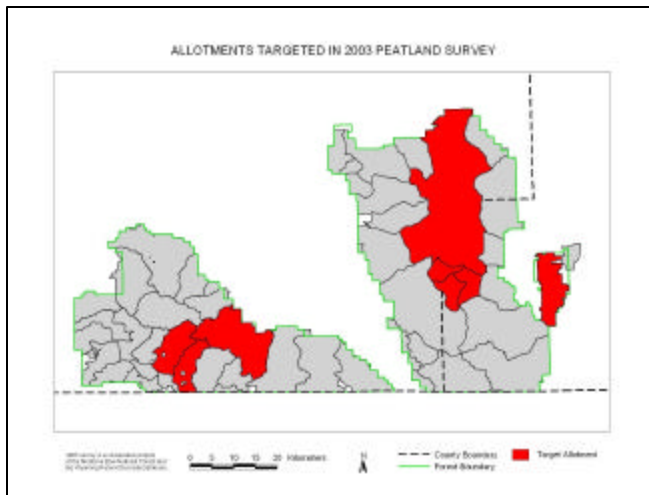
Study area	Range	Ranger District	Size (acres)	Size (sq. miles)	Elevation (ft)
Huston Park	Sierra Madre Range	Hayden	9,829	15.4	8,800-10,510
Middle Fork	Medicine Bow Range	Laramie, Brush Creek	46,265	72.3	8,500-10,000
North Fork	Medicine Bow Range	Laramie, Brush Creek	26,324	41.1	8,800-10,670
Sheep Mountain	Medicine Bow Range	Laramie	13,660	21.3	7,960-9,585
TOTAL	2 ranges	3 districts	96,079	150.1	7,960-10,670

Montane habitat was made the priority for inventory because most management activity takes place in this range of elevations, the pilot peatland study indicated that most rare species and species diversity were in this zone, and it is by far the most extensive zone. Allotment maps were overlain for reference to help determine shape and extent of the North Fork and Middle

Fork study areas and the preliminary study area boundaries overlapped with at least eight allotments (Figure 4). The biggest of these, the North Fork Allotment boundaries, are under review. The survey was not delimited by allotment boundaries. The isolated Sheep Mountain study area was the only study area that encompasses a single landform. The boundaries of the Huston Park study area were artificial insofar as areas of extensive peatland habitat were sought, and it was the last of the four study areas in which work was initiated over a single visit due to the fact that it was the most distant and remote of the study areas.

The North Fork and Middle Fork fieldwork was planned initially around allotment boundaries. Boundary expansions were made that reflected potential peatland habitat. The final study area boundaries were drawn along the nearest outer section line for clear reference. As a result, there are soils polygons that were not field-verified, most of which lie near the outer margins of the study areas. The Middle Fork Study Area straddles the Continental Divide, but less than one full day was spent west of the Divide. The extensive survey was not systematic in surveying every soil polygon, but every effort was made to field-verify the largest soil polygons and the largest prospective peatland sites within them.

Figure 4. Allotments that overlapped with initial study area boundaries



The only detailed soils data for peatlands in the Medicine Bow National Forest is represented by the gradient research in and above the Sand Lake Road Fen (Reider 1983). In addition, unpublished histosol soil samples were collected by soils mapping crews, on file in MBNF, with location specified to the nearest quarter-section. After the field season, the soil sample locations were matched with peatland mapping results. Of the nine histosol samples, seven are from the study areas and six correspond with peatland sites that are mapped in the same quarter-section. The seventh histosol sample came from Willow Park on Hat Creek, a setting in which only dense willow thicket under the influence of beaver activity was found, rather than well-developed peatland.

The two soils units recognized in Medicine Bow National Forest soils classification and mapping that contain histosols are profiled in Table 2, and their mapping polygons were selected

out for this study. The soil units cover 3.5% of the study areas, as determined in ArcView. The term “soils polygons” as used in this report refers implicitly to the mapped polygons for these two soils units that (sometimes) contain histosol members. The hemist histosol suborder is defined as containing 12.5%-75% plant fiber content (excluding coarse materials) by volume, retained when the soil is sieved with a 100-mesh sieve (openings 0.15 mm in diameter) after dispersion in sodium hexametaphosphate (USDA Soil Conservation Service 1992), intermediate between fibrist and saprist suborders.

Table 2. Soils units of the Medicine Bow National Forest that include histosol components

Soils unit	Histosol components	Total extent (acres)	Total extent (%)	Map unit no.
Argic Cryaquolls -Typic Cryohemist, eucic association, 0 to 10% slope	Incl. 30% Typic Cryohemists, eucic and 5% Histic cryaquoll	4,429	0.5	85
Typic Cryaquolls -Typic Cryohemists, eucic association, 0 to 15% slope	Incl. 25% Typic Cryohemist, eucic	27,970	3.0	92

The climate associated with the montane elevations of these two soils units is characterized as 25-32 inches mean annual precipitation, with a frost-free period of less than 20 days (Bauer et al. 1986).

Across the Medicine Bow Range, *Pinus contorta* (lodgepole pine) dominates forests at lower elevations and on dry sites, comprising 66% of the forested land (Alexander et al. 1986). In general, *Pinus contorta* forests are attributed to widespread and repeated fires, and thrive best on moderately acid sands or gravelly loams that are well drained to excessively well drained (Marston and Clarendon 1988). *Abies lasiocarpa* (subalpine fir) and *Picea engelmannii* (Engelmann’s spruce) dominate forests at higher elevations and on more mesic sites, covering 27% of the Range (Alexander et al. 1986). Approximately 22% of the land area is nonforested (Bauer et al. 1986). The Sheep Mountain study area is strictly montane, the Huston Park study area is mostly subalpine, and the two large study areas on Middle and North Forks are primarily montane settings that reach subalpine elevations (Table 1). An overview of montane riparian vegetation in Wyoming is provided in Knight (1994), citing thesis research conducted in wet meadow and shrub carr habitat elsewhere in the watershed. The vegetation of peatlands in the Medicine Bow National Forest has not been characterized except in the pilot study in which vegetation microplots were taken and preliminary vegetation ordination was run (Heidel and Laursen 2003).

The prevailing landforms in three of the four study areas are infrequently to moderately dissected mountain slopes that are deeply incised (Marston and Clarendon 1988), i.e., the valleys are much more precipitous in places than hills or peaks on the same landscape. The fourth study area, Sheep Mountain, is an escarpment that represents a snow storage slope (Marston and Clarendon 1988).

The Medicine Bow Mountains rise as high as 12,013 feet above sea level, over 4,000-6,000 feet above surrounding basins. The northern Medicine Bow Range represents a Laramide



uplift with a Precambrian core, derived from continental plate. These very old crystalline rocks are Archean (> 2.5 billion years old), and are mantled over most of the Range by the Snowy Pass Supergroup, metamorphosed marine deposits that are Proterozoic (2.5-1.7 billion years old; Love and Christiansen 1985). The North Fork study area encompasses the array that makes up the Snowy Pass Supergroup including, from north to south (and oldest to youngest), the Deep Lake Group, Lower Libby Creek Group, and Upper Libby Creek Group (Hausel 1993). Quartzite predominates in the two older groups making up the stratigraphic column, interbedded by schist, phyllite, and diamictite. Dolomite predominates in the Upper Libby Creek Group.

Bedrock outcrops in the south of the Medicine Bow Range (also including the Sierra Madre) originated in oceanic island arcs and offshore deposits later metamorphosed and intruded by basalt dikes (Houston 1993, Snoke 1997). The Middle Fork study area is comprised almost entirely of volcanogenic gneiss. The Huston Park study area is also mainly volcanogenic gneiss, surrounded by more extensive granitic intrusives. The Sheep Mountain study area is primarily Sherman granite (Love and Christiansen 1985).

Running across the middle of the Medicine Bow Range is a collision zone between the island arcs and continental plate called the “Cheyenne Belt,” an abrupt contact or suture marked by intense metamorphism. The collision was followed by later Medicine Bow Range tectonic activity with thrusts, folds and faults. This activity was, in turn, was greatly obscured by profound erosion, creating montane tablelands where only the Medicine Bow Peak area rises like an island above the planed surfaces. The schematic illustrations by Knight (1990) offer a conceptual model for complex geology in a setting of low relief (Figures 5 and 6), a model representing both the southern Medicine Bow Range and the Sierra Madre Range. Evidence

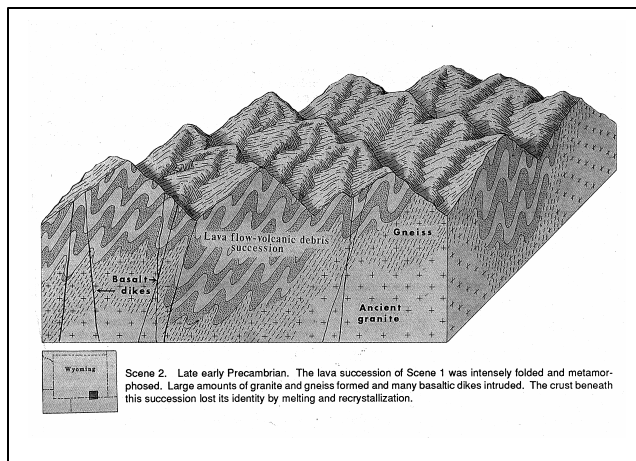


Figure 5. Schematic cross-section of southern Medicine Bow Range in the first eon of the Precambrian, from Knight (1990)

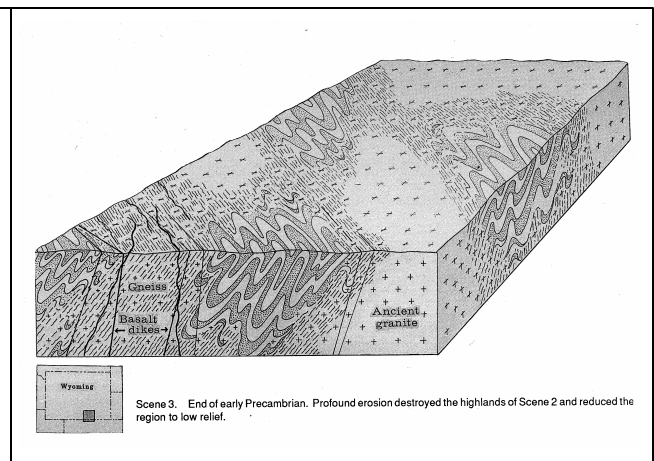


Figure 6. Schematic cross-section of southern Medicine Bow Range at the close of the Precambrian following erosion, Knight (1990)

of glaciers is buried in ancient deposits but Pleistocene glacial deposits persist mainly on the north end of the Medicine Bow Range and parts of the Sierra Madre (Roberts 1989). Small lateral moraines, eskers, and glacial kettles are present in the North Fork study area.

Hydrology has not been given the extensive research as geology of the Medicine Bow Range, but the schematic geological cross-section diagrams in Figures 5 and 6 provide a conceptual model for the formation of complex hydrological patterns on a relatively low-relief montane landscape as well. To date, one peatland site in the Medicine Bow Range has been the subject of intensive hydrological research, including the effects of the peatland on water quality (Sturges 1967), the hydrological properties of the peatland (Sturges 1968) and the concentrations of radioactive materials in the water column (Sturges and Sundin 1968).

## RESULTS

Peatland sites were effectively located using digitized soils mapping. A total of 154 peatland sites were field-verified and 21 in proximity were mapped based on photointerpretation (Table 3). The number, distribution, and characteristics of peatland sites are the primary results. Preliminary summary statistics were also calculated. An overview of peatland mapping in each of the four study areas is presented in Figures 7-10.

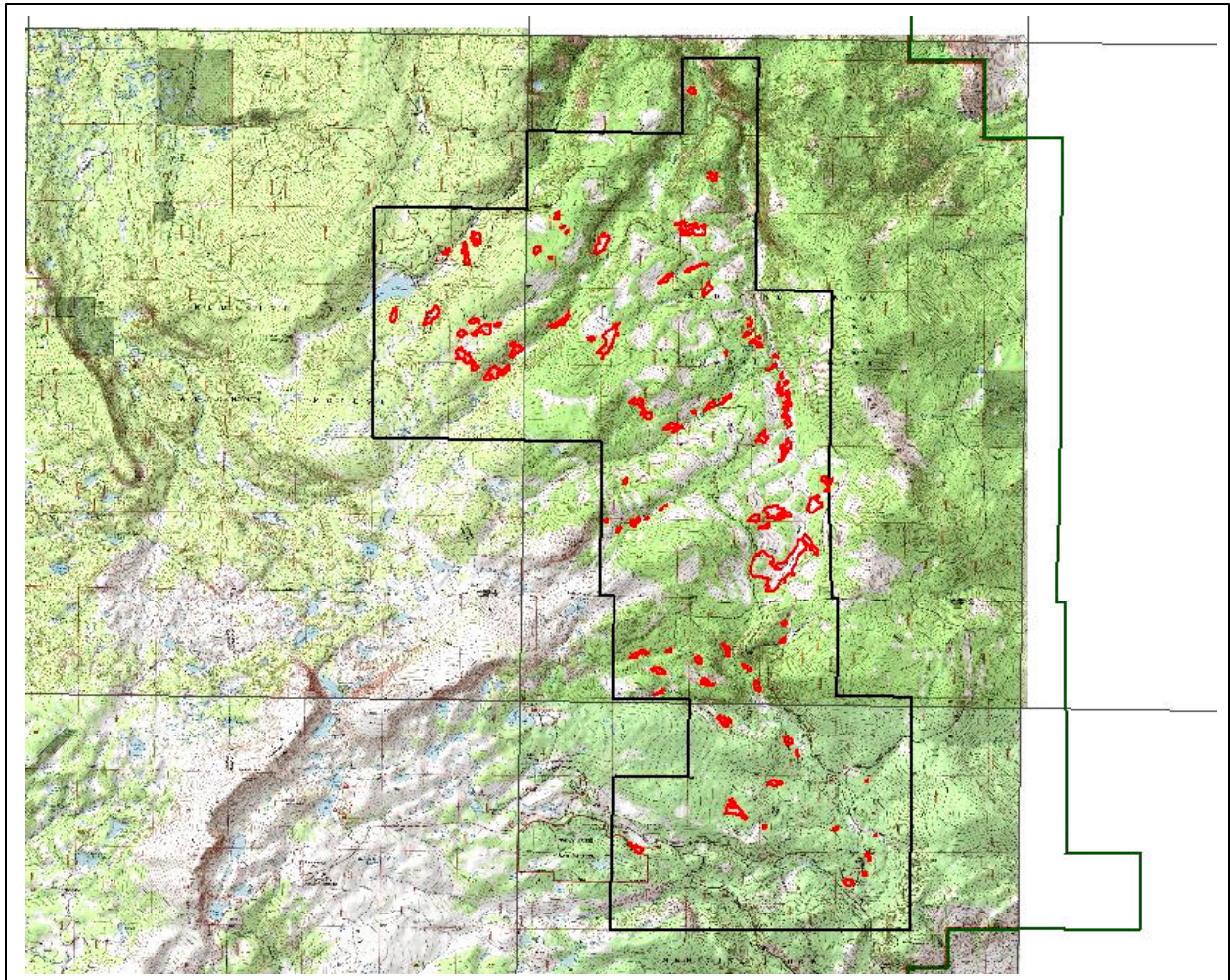
The majority of surveyed soils polygons contained one or more peatland sites in each polygon, with exception of Huston Park. A total of 62 polygons were visited that contained peatland sites and 8 did not. The soils polygons encompassed the largest peatlands, i.e., greater than 10 acres (10 of the 12 large peatlands were located in this way; or 83%), and those in drainage settings that typically had the larger peatlands. However, the soils mapping units that indicated peatlands in the Medicine Bow Range did not identify peatlands in the Sierra Madre Range, so *de novo* peatland inventory was conducted there. Soils mapping did not identify any of the small kettle peatlands in the Medicine Bow Range in the Firebox Lake area, a function of the soils mapping scale rather than the accuracy of determinations made in soils mapping. The smallest soils polygons mapped on the MBNF were 2 acres though the histosol-containing soils mapping units were all larger.

The raw data for the 175 peatland sites and key fields is represented in Appendix A, with the complete data spreadsheet submitted as a separate product. The peatland site mapping is represented in Appendix B by quarter-quad, and the complete ArcView shapefiles are likewise submitted as separate products.

Table 3. Tally of soils polygons and peatland sites

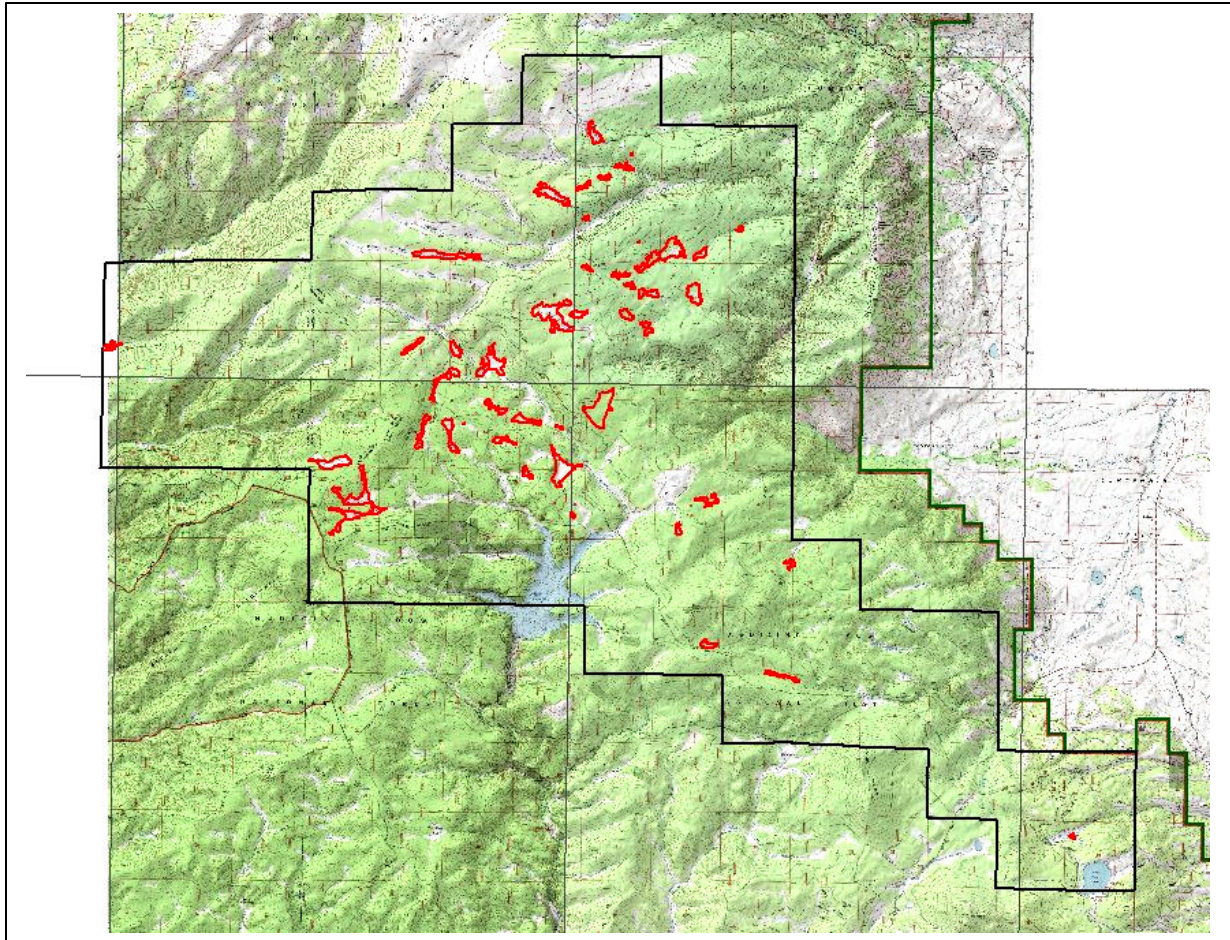
Study area	Total # soil polygons	Total # soil polygons without peatland	Total # peatland sites in soil polygons	Total # peatland sites outside soil polygons	Total # peatland sites field-verified	Total # peatland sites not field-verified
Huston Park	4	4	0	21	17	4
Middle Fork	41	7	36	14	50	0
North Fork	29	3	68	26	78	16
Sheep Mountain	8	2	10	0	9	1
TOTAL	82	16	114	61	154	21

Figure 7. North Fork study area peatland sites



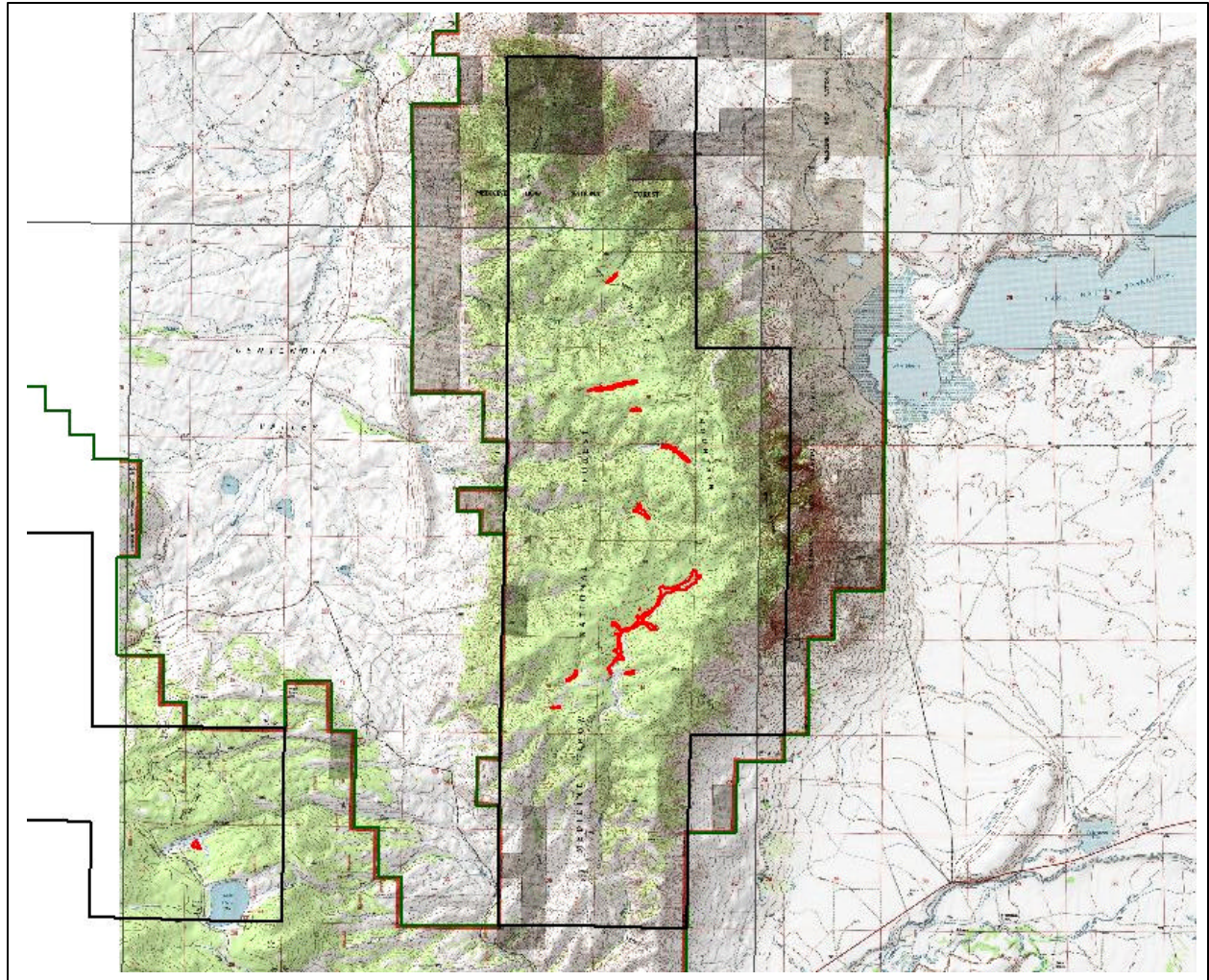
The North Fork study area encompasses headwaters of the North Fork of the Little Laramie River (southern 1/3) and headwaters of Rock Creek (northern 2/3). Peatlands in this area are associated with drainage courses except for glacial kettles, including the southernmost peatland site in this map, and a cluster of glacial kettles around the Firebox Lake area.

Figure 8. Middle Fork study area peatland sites



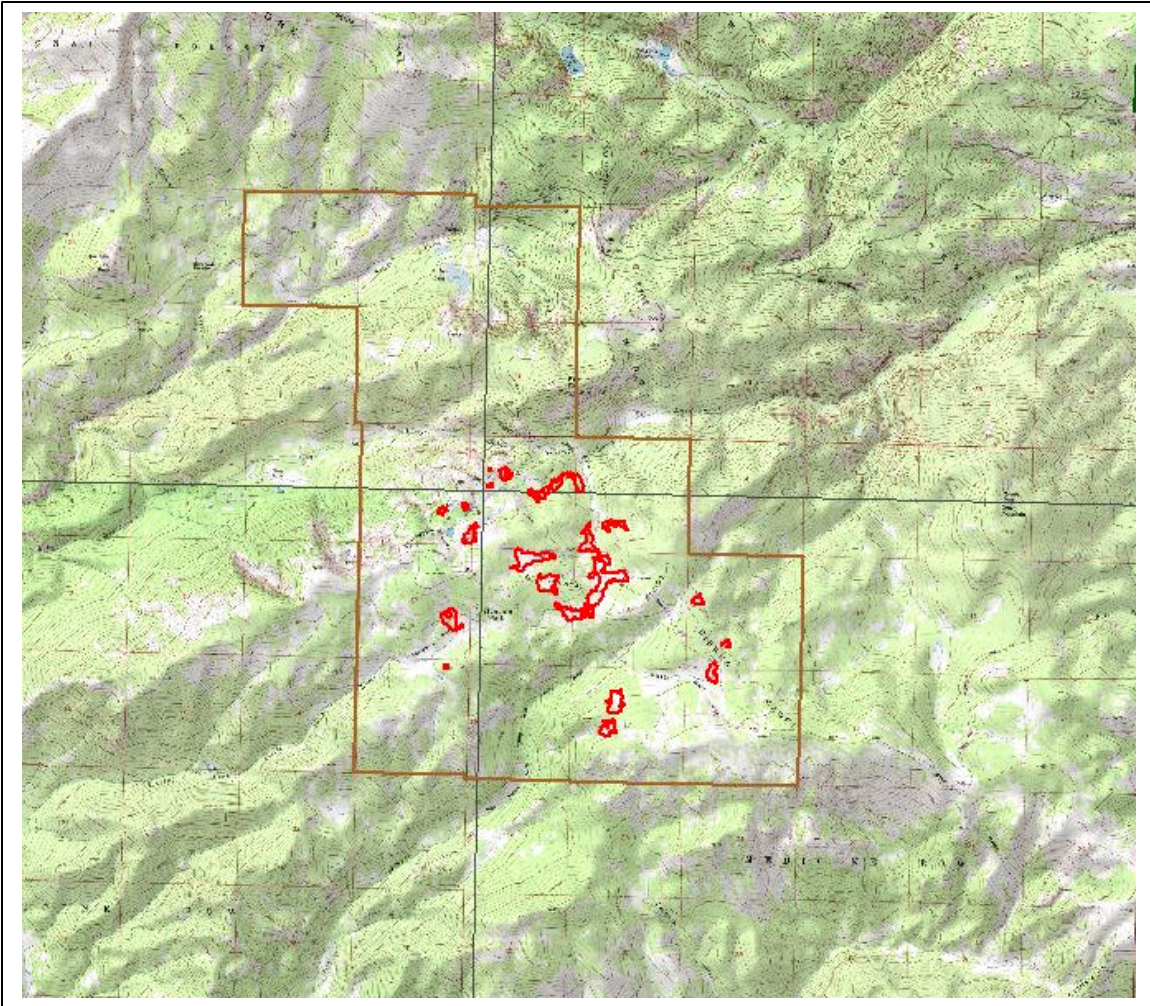
The Middle Fork study area encompasses headwaters of the Middle Fork of the Little Laramie River (northern 4/5), the Southern Fork of the Little Laramie River (southeastern 1/5), and tributaries of the Platte River (western block). Peatlands in this area are associated with drainage courses or isolated areas at heads of drainage courses.

Figure 9. Sheep Mountain study area peatland sites



The Sheep Mountain study area is restricted to Sheep Mountain. All peatland sites in the study area are associated with drainage courses, draining into the Laramie and Little Laramie rivers.

Figure 10. Huston Park study area peatland sites



The Huston Park study area encompasses headwaters of the North Fork of the Encampment River and the North Fork of the Little Snake River. All study area peatlands are associated with drainage courses, with exception of basin peatlands. The latter are at the heads of drainage courses and may have a glacial influence as well.

The total area of mapped peatland sites covers approximately 1,530 acres, representing over 1% of each study area except Sheep Mountain. This calculation is considered a coarse estimate of total peatland extent across the four study sites. Portions of habitat within digitized peatland site boundaries are not peatland, so using the coarse estimate of the proportion of peatland habitat within mapped boundaries, as determined in the field, produces an adjusted tally of net peatland area of 754.7 acres (Table 4), i.e., about half of the total area mapped as peatland. This crude estimate of total peatland extent is very rough because the estimated percentage peatland value was in broad categories. These preliminary numbers provide a very conservative characterization of the aerial extent approaching 1% of the total study area. The elongate peatland sites also represent many miles of peatland habitat that have not been tallied by length.

Table 4. Extent of peatland sites

Study area	Peatland sites as % study area	Adjusted peatland area as % of study area	Largest peatland (acres)	Mean peatland (acres)	Net peatland (acres)
Huston Park	1.68%	1.13%	31.8	6.6	111.6
Middle Fork	1.69%	0.65%	51.6	6.0	302.3
North Fork	1.99%	1.13%	89.4	4.2	299.6
Sheep Mountain	0.43%	0.30%	34.0	6.9	41.2

The peatland sites are mainly in settings of drainage ways or glacial kettles. The majority of sites and all of the largest peatland sites are clearly associated with drainageways (94% of those sites surveyed) in very many positions relative to the stream course. Many peatlands were in drainage headwaters positions (49%). Some were only associated with small springs along streams surrounded by thickets or meadows, while others covered 100% of the riparian wetland in the valleybottom. There are also isolated peatlands that are not in any kind of a valley or depression setting but have outlets connecting to drainageways. A couple were perched above the valley in what may be slump blocks, and these are placed with the isolated peatlands. Peatland settings are presented by a set of representative peatland sites as mapped onto nine digital ortho-photographs (Appendix C).

This inventory did not employ a systematic method to surveying peatlands outside of peatland polygons except by conducting photointerpretation in the field and opportunistically surveying those located in the vicinity. Of the total peatland sites, 116 were located within soils polygons and 61 were located outside. Those 116 that were located in soils polygons were distributed among 62 soils polygons. The Huston Park soils polygons were not centered on wetland habitat, so all 21 of the surveyed Huston Park peatland sites were situated outside or barely overlapped with the soils polygon mapping unit. If we exclude the Sierra Madre data represented by Huston Park, then 74.4% of documented peatland sites were located within soils polygons. Of the three study areas on the Medicine Bow Range, only the Middle Fork study area had large peatland areas that did not fall within the target soils polygons. In the North Fork study area, the scale of soils mapping excluded areas less than 2 acres, thus excluding small glacial kettle peatlands in the Firebox Lake area. The only other areas with kettle moraine topography are east of Brooklyn Lake where polygon survey and a preliminary *de novo* wetland survey

outside polygons along an esker failed to document any peatland sites. There is also a large area of kettle moraine topography in the Stillwater area in the northwestern portion of the Medicine Bow Range, outside of the study areas. Preliminary survey in eight Stillwater area wetlands documented that *Menyanthes trifoliata* (bog buckbean) is relatively widespread in semi-permanent sloughs or shallow lakes scattered across this landscape, though peat accumulation is limited or absent from *M. trifoliata* habitat in this area, in contrast to the apparent restriction of *M. trifoliata* to peatland habitat in the North Fork and Huston Park study areas.

As a result of this work, peatlands were documented as widespread and relatively extensive in the four study areas. Incidental to this survey, differences in peatland characteristics among the four study areas were considered for further evaluation. The only shrub peatland communities with a mixture of shrub species as dominants seemed to be in the lowest, easternmost peatland sites (one site in each of the Middle Fork, North Fork, and Sheep Mountain study areas), and they had unique floristic features. The best development of *Salix planifolia* peatland communities were in the North Fork Study Area, and the most extensive developments of low graminoid vegetation were in the Middle Fork and Huston Park study areas. The documentation of floristic and ecological diversity will be pursued next year.

From this array of peatland sites, a subset will be selected as representing the array of conditions that are present for intensive documentation of vascular flora, nonvascular flora, and vegetation. A tentative set of stratification criteria are presented below, including pre-requisite criteria, primary and secondary criteria, and optional criteria. A representative set of sites by these criteria is presented on the following page (Table 5).

#### Stratification criteria

##### Pre-requisite criteria:

- ? Intactness of peatland site
- ? Minimum size of habitat covers at least vegetation sample plot size (10 x 25 m<sup>2</sup>)

##### Primary screening criteria:

- ? Large size of peatland site (net area, or length; as surrogate for level of development)
- ? Structural characteristics of vegetation and species dominants
- ? Settings (as indication of hydrological conditions)

##### Secondary screening criteria:

- ? Unusual peatland characteristics (*Sphagnum* dominance, floating mat, steep slope)
- ? Unusual floristic characteristics (diverse shrubland, uncommon peatland species)
- ? Unusual structural characteristics (high density of trees)
- ? Distribution of peatland sites across four study areas

##### Optional screening criteria:

- ? Classification questions of demarcating *Salix geyeriana* habitat from peatland habitat
- ? Classification questions of demarcating *Eleocharis quinqueflora* marl from peat
- ? Classification questions of demarcating seep slopes from peatlands
- ? Inclusion of benchmark sites that have previous peatland research
- ? Ease or difficulty of access



Table 5. Prospective site priorities for intensive peatland inventory

Study area and Peatland Ident. No.	Place Name(s)	Primary Criteria	Secondary Criteria	Optional Criteria
Huston Park 999901	North Fork Encampment Fen	Basin at head of drainage, unique veg dominance	Unique species, floating mat, open water	Most unique among Huston Park sites, relatively time-consuming to access
Middle Fork 267403	Douglas Creek Fen	Moderate size, mid drainage setting, typical shrub dominance	Large pool	Easy access
Middle Fork 999928, 292606	Elk Creek Study Fens (2)	Large size, head of drainage, typical graminoid dominants		Benchmark; subtle contrasts between pair
Middle Fork 256003	Fall Creek Fen (or June Creek fens)	Large size, isolated headwaters		May be complicated by mosaic patterns, access time
Middle Fork 288301	Isolated fen above Douglas Creek	Moderate size, isolated headwaters	Highest tree component or inclusions	
Middle Fork 386601	Strain Creek Fen	Mid drainage, low shrub and unique veg dominants	Unusual composition, unique species	Small site, relict within altered habitat
North Fork 999934-999940	Firebox Lake area	Small kettles	Low diversity	Extremely small
North Fork 191002, 191005	North Fork Headwater Fens (2)	Head of drainage, pair with unique veg dominants	Extensive Sphagnum, new Carex type	Diverse fen habitats requires multiple samples
North Fork 198101	North Fork test site	Side drainage, typical shrub dominance		Sampling was completed at this test site in 2003
North Fork 173251	North Fork	Large size, head of drainage, typical veg dominants		Relatively
North Fork 164601, 166803	North Fork Rock Creek (2)	Typical size, head of drainage, veg dominants		Pair of contrasts in woody cover
North Fork 164602	North Fork Rock Creek Fen complex	Large size, basin at head of drainage, Unusual veg dominants	Unique species, floating mat, open water	Diverse fen habitat requires multiple samples
North Fork 191006	Sand Lake Rd Fen	Largest of kettle sites, unusual veg dominants	Unusual composition	Benchmark
North Fork 177302	Trail Creek Fen(s)	Mid drainage setting, typical shrub dominants	Extensive tree component	Small size, fen mosaic
Sheep Mountain 339001	Fence Creek Fen	Longest fen, head of drainage, multiple veg types	Unusual composition, unique species	Relatively time-consuming to access

This was not a study of livestock grazing, but signs of livestock grazing were noted in the course of survey. About 24% of field-verified peatland sites had signs of domestic stock use at the time of visit (38 of 154), including cattle or pack horse use. These included at least 11 of 17 Huston Park peatland sites, 15 of 50 Middle Fork peatland sites, and 12 of 79 North Fork peatland sites. Sheep Mountain had limited pack animal use. The pattern of use deserves mention. The only peatland settings in which livestock use was concentrated were in peatlands that are intermixed with extensive dry meadow habitat, i.e., in primary range, as in the case of

the Rock Creek Valley (North Fork study area), in broad grassy meadows along Douglas and Elk creeks (Middle Fork study area), and in much of the Huston Park study area. There were no peatland settings in 2003 study areas that had the same level and ubiquity of livestock use as observed earlier in a peatland site on the Laramie Range (Heidel and Laursen 2003).

Direct encounters with livestock were limited. In the Middle Fork study area, there were several encounters with a small number of cow-calf pairs or heifers, always fewer than five animals at a time in highly dispersed grazing. Their pattern of use is presumed to be concentrated elsewhere in the allotment, and they were observed in greater numbers on the Rob Roy Reservoir and contiguous meadows. In the relatively open Huston Park study area, the livestock remained in tight herds and the peatland habitat was intermixed with their primary range, making it more accessible than in the other three study areas. Even so, the best-developed peatland habitat of Huston Park, in basins at heads of drainages or on isolated seep slopes, had limited use because these particular peatland types and sites had limited forage, limited access, and there were much better water sources with easier access.

The affects of livestock use depended on site characteristics and history. In the North Fork Study Area, the head of Rock Creek has extensive peatland habitat and was the only site observed where deep hummocks were formed by livestock trampling. The confounding affects of beaver dams may have affected local susceptibility to trampling. This pasture also had the only livestock exclosure that was encountered during survey, but it is located above peatland and had a major *Salix geyeriana* component. The pasture also had “boggy” wooded seep-fed fringes that were set back from the water course. This portion of the pasture received light use and is in good condition.

The peatlands generally offer low forage. With the exception of the head of Rock Creek, there were no peatland sites that had widespread signs of grazing. There were usually no portions of the peatlands that received heavy use. An exception is at the upper end of a Mullan Creek peatland site. The pools in this peatland may be used for a water source. Locally, even low-productivity species like *Eleocharis quinqueflora* (few-flowered spikerush) had over 50% removal of vegetative growth in headwater patches where livestock watered and lingered, but graminoid peatlands in general have low productivity compared to other wetland types. Late-season grazing in this particular setting did not create hummocks, but the churning action of hoofprints and eutrophying effects of animal waste may still shift biotic and abiotic conditions.

There was no evidence that stock trail through or at borders of intact peatland sites. There were no salt block placements or stock dam developments in these settings, and evidently these were not warranted. The numerous timber harvest units in the area have apparently not been used to increase stocking rates. The limited season of use and the low stocking levels constrain grazing use of peatlands and accompanying affects.

In several areas, patches of peatland habitat were literally torn up. A place where peat was torn apart was observed in Libby Flats in 2002, a high-elevation setting where there is no livestock grazing. This pattern was most pronounced in the particular North Fork site that had the highest *Sphagnum* component and may have represented use by big game such as elk or moose. There is a latticework of peatland sites in some areas and they may provide wildlife travel

corridors. They are removed from traffic since peatlands are generally avoided in road construction. They may also provide browse and shelter. In addition, the stream courses that pass through peatland are insulated and receive groundwater discharge. Trout were noted in riffle/pool habitats of headwater peatlands in Standard Park in the Huston Park study area. Colorado cutthroat trout are documented in this watershed (Baxter and Simon 1970).

The objective of documenting floristics and surveying rare plant species was pushed back to the following year in order to complete the extensive work in one year. Despite the constraints, additional records of species of concern or of potential concern were documented (Table 6). One species that was known only from historic records in Wyoming was collected (*Potamogeton epihydrous*), and two species that were once known from fewer than five records in the state were shown to be widespread in the study areas. The two species, *Epilobium oregonense* (Oregon willow-herb) and *Carex paupercula* (bog sedge) were subsequently removed from the Wyoming plant species of concern list (Keinath et al. 2003) and the location records and specimens support this change. In this project, it was determined that the former species is not restricted to peatlands but is also found along spring-fed springs and seeps. The latter species is restricted to peatland and although it is neither as numerous or dense in its study area occurrences as *Epilobium oregonense*, it was documented in wetlands surrounded by clearcuts. In addition, there are at least three known or reported occurrences of *Carex paupercula* in the Medicine Bow Range subalpine zone where there are extremely large areas mapped as including a cryohemist component representing suitable habitat, providing an additional basis for reconsidering its status. Distribution maps for both species based on field verification are presented in Appendix D. Voucher specimens were collected at a subset of sites to represent the distribution across the study areas. In addition, a moss collected in 2002 from the Middle Fork study area was identified as *Scorpidium scorpidioides* (determination by Judith Harpel) that represents the second collection in Wyoming (first reported in Eckel 1996) and wood frogs (*Rana sylvatica*) were documented in at least one new location (Figure 11).

Table 6. Wyoming species of concern in Medicine Bow National Forest peatland study areas

Scientific name	Common name	Federal status / G&S ranks	Study area	No. of study area records prior to '02	No. of new study area records
<i>Carex limosa</i>	Mud sedge	G5 S2	North Fork, Huston Park	1	3
<i>Carex paupercula</i>	Bog sedge	G5 S1 ->S2	North Fork, Middle Fork	2	32
<i>Epilobium oregonense</i>	Oregon willow-herb	G5 S1 ->S2S3	Huston Park, North Fork, Middle Fork	2	53
<i>Eriophorum gracile</i>	Slender cottongrass	Sensitive/ G5 S1 ->S2	Sheep Mountain	-	1
<i>Potamogeton epihydrous</i>	Ribbon-leaf pondweed	G5 SH->S1	Huston Park	0	1
<i>Salix candida</i>	Hoary willow	Sensitive/ G5 S2	North Fork, Sheep Mountain	3	1
<i>Scorpidium scorpidioides</i>	A moss	G5 S1	Middle Fork	0	1
<i>Sparganium natans</i> ( <i>Sparganium minimum</i> )	Small bur-reed	G5 S1	North Fork	0	1
<i>Trichophorum pumilum</i> ( <i>Scirpus pumilus</i> )	Pygmy bulrush	G3Q S1	Sheep Mountain	0	1
<i>Utricularia minor</i>	Lesser bladderwort	Sensitive/ G5 S2	North Fork	0	2

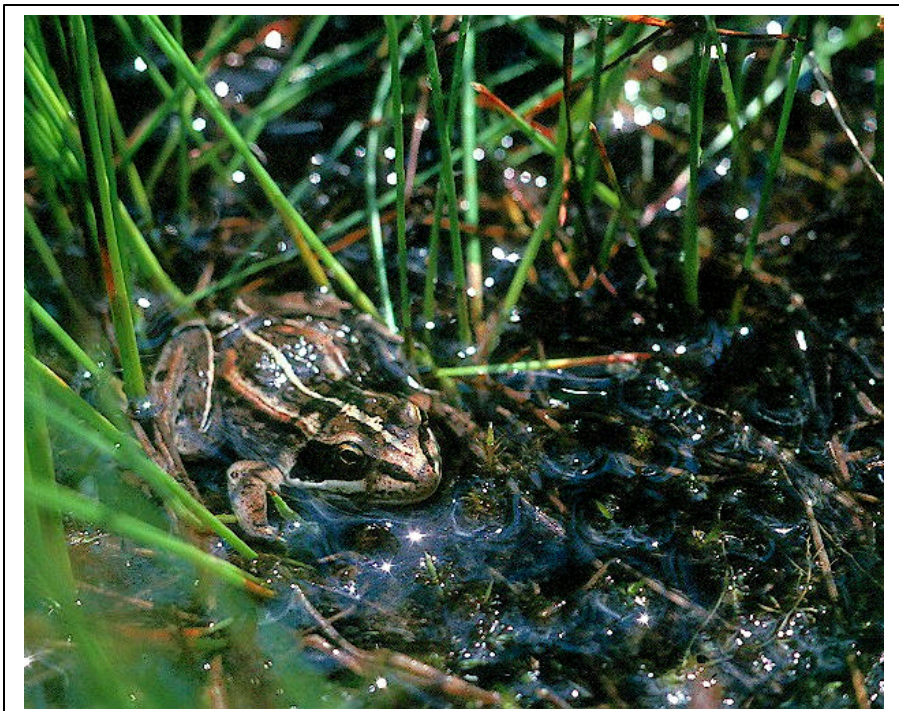


Figure 11.  
*Rana sylvatica*  
(wood frog)  
By B. Heidel



Figure 12.  
*Epilobium oregonense*  
(Oregon willow-herb),  
By B. Heidel

## DISCUSSION

The most surprising result of the inventory was the relative frequency and abundance of peatland habitat, particularly in the two large study areas on the Middle and North Forks of the Little Laramie River. The two large study areas have similar frequency and abundance of peatland habitat as the Huston Park study area, where extensive wetland community mosaics had already been mapped and reported in mosaics (Jankovsky-Jones et al. 1995). The relative peatland extent and frequency is higher in these three study areas than in the Sheep Mountain study area, though the latter has the longest peatland site known among the four the study areas.

Digitized soils data layers proved effective for locating peatland sites, corroborating the accuracy of the soils mapping. The peatland inventory work indicates that the Medicine Bow National Forest soils mapping has utility for locating peatland sites on the east slope of the Medicine Bow Range. The utility of soils mapping as part of peatland inventory methods depends greatly on the mapping conventions and scale, and the mapping may not have a consistent utility between different settings such as between the Medicine Bow Range and the Sierra Madre Range. The soils mapping did serve to identify all large peatlands (greater than 10 acres) and located the majority of them (10 of 12) in the Medicine Bow Range study areas. Soils mapping did not consistently identify peatlands below 2 acres in size in the same three study areas. A random comparison between wetlands inside and outside of the soils polygons would be needed to quantify soils mapping accuracy and scale relationships. The contrasting results between the Medicine Bow Range study areas and initial field reconnaissance in the Stillwater area, a glaciated area on the northwest side of the Medicine Bow Range outside the scope of study, indicated that the soils polygons that contain peatlands on the east side of the Medicine Bow Range did not contain peatlands on different landscapes of the same mountain range. Therefore, although the GIS methods applied in this study provide one example of successful application, the utility of the soils mapping and other natural resource data layers rests entirely on the unique terms of the mapping work and the unique landscapes.

An expanded GIS analysis would be needed to evaluate the merits of National Wetland Inventory (NWI) digital layer compared to the soils mapping digital layers for purposes of peatland inventory. The NWI data have the benefit of having statewide and nationwide coverage, though not yet complete in Wyoming. A third approach suggests itself in review of the study area maps (Figures 7-10), at least for montane habitat in the Medicine Bow Range. Many of the largest peatland sites are mapped as forest openings on the USGS topographic maps, and most of the forest openings with streams emanating from them are peatland sites. Finally, as a fourth option, the possibility of developing a remote sensing technique remains to be explored. It is likely that graminoid-dominated and shrub-dominated habitats have different signatures. In particular, the floating graminoid mat peatland habitats in particular could be discerned on color aerial photographs and would be expected to have different signatures than other graminoid-dominated peatland habitats. Regardless of the approach options, fieldwork is needed to document the distribution and abundance of peatland.

The digitized soil data in combination with two sets of aerial imagery were particularly effective in this study. Color aerial photographs were used to pinpoint sites with peatland habitat on the ground, as well as in discerning moisture levels and vegetation patterns within peatland

sites. Although color aerial photographs provided more detail than grey-scale digital ortho-photographs (DOQQs), they are not geo-referenced for GIS use. The grey-scale DOQQs were ideal for digitizing the peatland polygons because they are geo-referenced, and they provide fine resolution and tone contrasts. However, the use of DOQQs added significantly to the GIS work because the DOQQs use a different datum, NAD83, than the NAD27 datum used by the DRGs and other GIS layers. This required converting it back and forth for the different mapping purposes.

The fieldwork was intended to be systematic in covering all peatland sites greater than ca. 1 acre within the four study areas. That goal was not reached in full, in part because of the decision to square off study area boundaries for reporting purposes after the field season. The documentation to date can readily be expanded upon or this inventory project can be converted to exhaustive mapping if study area boundaries are made curvilinear, with the addition of fieldwork.

The fieldwork was not intended to evaluate peatland trends or the affects of land management practices, though the presence or absence of livestock-use was noted. No evidence of large-scale peat-digging or mining was observed, as has been documented in Colorado (Cooper 1990). There was one second-hand report of a couple people scooping buckets of peat in the Firebox Lake area, gleaned in talking with a recreationist who had observed it. There was what appeared to be very widespread alteration of peatland habitat due to beaver activity. In narrow, confined valleys that were conducive to peatland formation, peatland habitat was absent below beaver dams, and the upstream influence of beaver dams on peatland varied with hydrology and resulting secondary succession. The 2003 field season marked the fourth year of drought conditions, and areas of dessicated *Eleocharis quinqueflora* swaths were noted in places. The drought may modify the affects of land management practices.

The Medicine Bow Range is relatively well-studied in a botanical sense, so the numerous new records of species that were previously considered rare (*Carex paupercula*, *Epilobium oregonense*) supports the interpretation that these particular wetland systems have not been studied to the same extent as uplands. There was one major species' range extension documented in 2003, the record of *Sparganium natans* (syn. *S. minimum*; small bur-reed) from the Medicine Bow Range, whereas it was only previously known from northwest Wyoming and "skipping" south to Colorado. In addition, the collection of *Potamogeton epihydrous* in the Sierra Madre Range represented a re-discovery of this species, last collected near Elk Mountain by C.L. Porter in 1963.

Field verification of peatland sites in 2003 was based on qualitative soil and vegetation characteristics that await quantification. The immediate sequel to the extensive inventory is a thorough documentation of peatland characteristics, i.e., their biotic and abiotic nature, at a representative array of sites. This intensive sampling of a stratified set of peatland sites is planned for 2004.

## LITERATURE CITED

- Alexander, R.R., G.R. Hoffman and J.M. Wirsing. 1986. Forest vegetation of the Medicine Bow National Forest in southeastern Wyoming: a habitat type classification. USDA Forest Service Research Paper No. RM-271.
- Bauer, A., M.R. Edwards, L. Hudnell. 1989. Soil survey of the Medicine Bow National Forest, Wyoming – Medicine Bow Mountains and Sierra Madre Mountains areas – DRAFT. Medicine Bow National Forest.
- Baxter, G.T. and J.R. Simon. 1970. Wyoming fishes. Bulletin Number 4. Wyoming Game and Fish Department. Cheyenne, WY.
- Carsey, K., G. Kittel, K. Decker, D. Cooper and D. Culver. 2003. Field Guide to the Wetland and Riparian Plant Associations of Colorado. Colorado Natural Heritage Program, Fort Collins, CO.
- Chadde, S. W., J.S. Shelly, R.J. Bursik, R.K. Moseley, A.G. Evenden, M. Mantas, F. Rabe and B. Heidel. 1998. Peatlands on national forests of the Northern Rocky Mountains: ecology and conservation. Gen. Tech. Rep. RMRS-GTR-11. Ogden, UYT: USDA Forest Service, Rocky Mountain Research Station.
- Cooper, D. J. 1990. An evaluation of the effects of peat mining on wetlands in Park County, Colorado. Unpublished report prepared for Park County, Colorado.
- Cooper, D.J. and R.E. Andrus. 1994. Patterns of vegetation and water chemistry in peatlands of the west-central Wind river Range, Wyoming, U.S.A. *Can. J. Bot.* 72: 1586-1597.
- Dorn, R. D. 1997. Rocky Mountain Region Willow Identification Field Guide. Publication R2-RR-97-01. USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO.
- Dorn, R.D. 2001. Vascular Plants of Wyoming, third edition. Mountain West Publishing, Cheyenne, WY.
- Eckel, P. 1996. Synopsis of the mosses of Wyoming. *Great Basin Naturalist* 56(3): 197-204.
- Fertig, W. 2000. State Species Abstract: *Carex paupercula*. Wyoming Natural Diversity Database. Available on the internet at [www.uwyo.edu/wyndd](http://www.uwyo.edu/wyndd)
- Fertig, W. and B. Heidel. 2002. Wyoming plant species of special concern. Wyoming Natural Diversity Database. University of Wyoming, Laramie.
- Grunig, A. 1994. Mires and Man – Mire Conservation in a Densely-populationd Country – the Swiss Experience. Symposium of the International Mire Conservation Group to Switzerland, 1992. Birmensdorf, Federal Institute of Forestry, Snow and Landscape Research.

- Hausel, W.D. 1993. Guide to the geology, mining districts, and ghost towns of the Medicine Bow Mountains and Snowy Range Scenic Byway. Wyoming Geological Survey. Public Inf. Circular No. 32. Cheyenne, WY.
- Heidel, B and S. Laursen. 2003. Botanical and ecological inventory of peatland sites on the Shoshone National Forest. Prepared for Shoshone National Forest. Wyoming Natural Diversity Database, Laramie.
- Hurd, E.G., N.L. Shaw, J. Mastroguiseppe, L.C. Smithman and S. Goodrich. 1998. Field Guide to Intermountain Sedges. Gen. Tech. Report RMRS-GTR-10. USDA Forest Service Rocky Mountain Research Station, Ogden, UT.
- Jankovsky-Jones, M., G. Jones, and W. Fertig. 1995. Ecological assessment for the potential Standard Park and Bogs Research Natural Area within the Medicine Bow National Forest, Carbon County, Wyoming. Unpublished report prepared by the Wyoming Natural Diversity Database, Laramie.
- Jankovsky-Jones, M., G. P. Jones, and W. Fertig. 1996. Ecological evaluation of the potential Sheep Mountain Research Natural Area within the Medicine Bow National Forest, Albany County, Wyoming. Unpublished report prepared for the Medicine Bow National Forest by the Wyoming Natural Diversity Database, Laramie WY. 103 pp.
- Johnson, J.B. and T.D. Gerhardt. 2003. Mapping and characterization of mires and fens in North Park, Jackson County, Colorado. Report prepared for Bureau of Land Management. Johnson Environmental Consulting, Fort Collins, Colorado.
- Johnston, B.C. 2001. Field Guide to Sedge Species of the Rocky Mountain Region. Publication R2-RR-01-03. USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO.
- Knight, D.H. 1994. Mountains and Plains – The Ecology of Wyoming Landscapes. Yale University Press, New Haven, Connecticut.
- Knight, S.H. 1990. Illustrated geologic history of the Medicine Bow Mountains and adjacent areas, Wyoming. Memoir 4, Geological Survey of Wyoming, Laramie.
- Love, J. D. and A. C. Christiansen. 1985. Geologic Map of Wyoming. U.S. Geological Survey, scale 1:500,000.
- Markow, S. and W. Fertig. 1999. State Species Abstract: *Epilobium oregonense*. Wyoming Natural Diversity Database. Available on the internet at: [www.uwyo.edu/wyndd](http://www.uwyo.edu/wyndd)
- Reider, R.G. 1977. Radiocarbon dates from carbonates of soils on Bull Lake and Pinedale tills of the Libby Creek area, Medicine Bow Range, Wyoming. Contributions to Geology, University of Wyoming, 15:67-62.



- Reider, R.G. 1983. A soil catena in the Medicine Bow Mountains, Wyoming, U.S.A., with reference to paleoenvironmental influences. *Arctic and Alpine Research*, Vol. 15(2): 181-192.
- Roberts, S. 1989. Map of Ice Age Features of Wyoming. *In: Wyoming Geomaps*. Education Series 1. Wyoming Geological Survey, Laramie.
- Selmants, P.C. and D.H. Knight. 2003. Understory plant species composition 30-50 years after clearcutting in southeastern Wyoming coniferous forests. *Forest Ecology and Management* 185 (2003):275-289. [www.elsevier.com/locate/foreco](http://www.elsevier.com/locate/foreco).
- Snoke, A. 1997. Geologic history of Wyoming within the tectonic framework of the North American Cordillera. Wyoming State Geological Survey Public Information Circular 38.
- Stohlgren, T.J., M. B. Falkner, and L. D. Schell. 1995. A Modified-Whittaker nested vegetation sampling method. *Vegetatio* 117:113-121.
- Sturges, D. L. 1967. Water quality as affected by a Wyoming mountain bog. *Water Resources Research* 3(4): 1085-1089.
- Sturges, D. L. 1968. Hydrologic properties of peat from a Wyoming mountain bog. *Soil Science* 106:262-264
- Sturges, D. L. and R. E. Sundin. 1968. Gross alpha and beta radiation in waters at a Wyoming mountain bog. *Water Resources Research* 4(1): 159-162.
- Windell, J. T., B. E. Willard, D. J. Cooper, S. Q. Foster, C. F. Knud-Hanson, L. P. Rink, and G. N. Kladis. 1986. An ecological characterization of Rocky Mountain montane and subalpine wetlands. U. S. Fish and Wildlife Service, Biological Report 86(11).
- USDA Soil Conservation Service. 1992. Keys to Soil Taxonomy. Soil Management Support Services Tech. Monograph No. 19. Pocahontas Press, Inc. Blacksburg, VA.
- USDI Fish and Wildlife Service. 1998. Regional policy on the protection of fens. Unpublished memo from Mary Gessner, Region 6 Director, sent to project leaders for ecological services, refuges and wildlife, and fish and wildlife management assistance in Region 6.