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JAN 20 1999

Memorandum

To: Project Leaders for Ecological Services, Refuges and Wildlife, and Fish and Wildlife Management Assistance, Region 6

From: Acting Regional Director, Region 6

Subject: Regional Policy on the Protection of Fens, As Amended

This policy was originally approved by Acting RD Mary L. Gessner on June 8, 1998. As a result of input received from users, Region 6 decided to clarify some of the language regarding the soils aspect of fens. The modifications are minor from a policy standpoint.

One of the Fish and Wildlife Service's wetland priorities in Region 6 (the Mountain-Prairie Region) is the protection and conservation of fens. Fens are wetlands that are primarily made up of organic soil material (i.e., peat or muck). Because they take thousands of years to develop, they are essentially irreplaceable. Many fens occur in the Mountain-Prairie Region, particularly in the middle to higher elevations of the Rocky Mountains and in the Nebraska sandhills. However, most fens are small and occupy an extremely small percentage of the overall landscape. They probably occupy much less than 1 percent of the total area in Region 6 and comprise only a small percentage of the total acreage of wetlands.

Although fens only occupy a minor portion of the landscape, they perform important hydrological and water quality functions. For example, rare native cutthroat trout often benefit from the water cleansing action of fens in headwaters of streams. They also often possess unique biotic assemblages, especially fens that are high in pH and calcium. The definitions of various classes of fens, the scientific justification for special consideration for these habitats, the functions of fens, and literature references are described in the attachment.

Because of their uniqueness and importance, Region 6 decided that all its functioning fens, which were identified on U.S. Geological Survey, National Wetlands Inventory, or other maps, and for which location information has been provided to applicable regulatory agencies, fall within Resource Category 1 of the Service's "Mitigation Policy" (Federal Register, Vol. 46, No. 15, February 4, 1981). The mitigation goal for Resource Category 1 is *no loss of existing habitat value*. In other words, because of the irreplaceability of the type of habitat, every reasonable effort should be made to avoid impacting that habitat type.

Functioning fens are those that (a) continue to support native plant communities and perform the functions inherent to fens or (b) have the potential to rapidly recover those functions with the removal or rectification of drainage, grazing, or other impacts.

Maps and other readily available documentation, such as descriptions of the functions of the fens, will be provided to applicable regulatory agencies (e.g., Corps of Engineers and State departments of water quality). When practicable, this information will be provided by Ecological Services and other Region 6 field offices in advance of project development to assist project planners in accordance with the intent of the Mitigation Policy.

I also encourage other agencies to help gather this important documentation. For example, the locations of fens also should be obtained (a) when wetland delineations are conducted in conjunction with project planning and development of permit applications under section 404 of the Clean Water Act and (b) for analysis of mitigation requirements for "Swampbuster" and section 404 violations. These wetland delineations should identify any fens in the project impact area and distinguish them from other wetland types. Fens identified during those delineations should be added to the regulatory agencies' databases and considered to be categorized as Resource Category 1 habitats.

For the purposes of this policy, fens will be defined as wetlands with organic material accumulations that are ground water driven. In other words, they may receive water from rain, snow, and surface sources. However, the hydrology, minerals, and nutrients that support the wetland are derived principally from ground water sources. Fens in Region 6 also normally have pH's above 5.5 and are dominated by grasses, sedges, or willows.

Region 6's recommended definition of a fen also includes soil characteristics. To qualify for this policy, the wetland soils should meet the Natural Resources Conservation Service's definition of a Histic epipedon or a Histosol in at least some part of the contiguous wetland, unless justified otherwise on a functional basis by a scientist with substantial expertise in fens. Histosols are widely recognized as organic soils formed by slow accumulation of plant debris in waterlogged situations where growth exceeds decomposition and decomposition progresses very slowly. Fens in the Rocky Mountains have particularly slow decomposition rates because of the cold climate.

The 1998 USDA "Keys to Soil Taxonomy" require that Histosols have organic soil materials and meet one or more of four criteria, which are described in the attachment to this policy. One of the criteria requires that organic materials constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or para lithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less.

In accordance with those criteria, fen wetland complexes can have a significant presence of mineral soils in layers or mosaics, and they may support unique minerotrophic flora. Fens also are not required to have thick organic layers. Such fen wetlands are common in the Rocky Mountains. They meet the aforementioned hydrologic criteria, are saturated throughout most if not all of the year, and may occur on high gradients or in headwater systems.

Mitigation for losses of fen wetlands is problematic because, as mentioned above, the rate of organic material (e.g., peat) accumulation in fens is extremely slow. For example, many of the fens of Colorado are over 10,000 years old with organic soil accumulation rates ranging from 4.3 to 16.2 inches per thousand years. In consideration of this slow accumulation rate, such wetlands cannot seriously be considered a renewable resource. In addition, removal of organic material (e.g., for peat mining) results in alteration of site hydrology and the substrate in which fen plant species can grow. Therefore, onsite or in-kind replacement of peat wetlands is not thought to be possible. Furthermore, at present there are no known reliable methods to create a new, fully functional fen or to restore a severely degraded fen.

Because of their vulnerability, protection of all fens are a priority in this Region, including those which have not yet been mapped and officially designated as Resource Category 1. Accordingly, in a letter dated April 1, 1997, I requested the applicable Division and District Engineers of the U.S. Army Corps of Engineers to revoke the use of Regional and Nationwide Permits pursuant to section 404(e) of the Clean Water Act for projects involving fens. This position was reiterated when the Corps proposed modifying its Nationwide Permits in 1998. I am pleased to note that, as a result, the Corps is giving increased attention to fen protection during permit processing in this Region.

With regard to individual permit applications, Region 6 field offices will encourage the Corps to closely scrutinize all applications involving fens to ensure they meet the requirements of the Environmental Protection Agency's Section 404(b)(1) Guidelines. For example, the project sponsor must prove that, in accordance with section 230.10(a), every effort to avoid the impacts has been made through selection of the least damaging alternative, there is no practicable alternative for nonwater dependent activities, and the siting of a water-dependent project in a fen is essential to the project.

If those requirements are first met, every reasonable effort must be made to minimize potential adverse impacts through project modifications and project conditions then in accordance with Section 230.10(d) of the Guidelines. The ES Offices should encourage their counterparts in the Corps to require that projects with the potential to adversely affect fens strictly adhere to the mitigation sequencing requirements of the Memorandum of Understanding between the Department of the Army and the Environmental Protection Agency, dated February 6, 1990. Unavoidable impacts remaining after those steps have been satisfied must be fully compensated when practicable through restoration of nearby and in-kind fens that have been previously degraded but which are recoverable (e.g., through elimination of grazing or restoration of hydrology).

Similar steps should be required for other federally funded, licensed, or constructed projects affecting fens that are subject to the requirements of the Fish and Wildlife Coordination Act, Endangered Species Act, Migratory Bird Treaty Act, or National Environmental Policy Act. This type of increased scrutiny also should be applied to natural wetlands that surround or are immediately adjacent to fens because they may not easily be separable and their functions will often overlap.

Proposed in-kind restoration mitigation for unavoidable impacts to fens should be thoroughly evaluated for likelihood of success before a permit is issued. Because of the high degree of uncertainty associated with attempts to mitigate impacts, the success of proposed mitigation should be demonstrated prior to project initiation, and thorough postproject monitoring and reporting should be required. Furthermore, all such applications will be considered on a site-specific, case-by-case basis.

Because unavoidable impacts will rarely be satisfactorily compensated by replacement of in-kind habitat, Region 6 Ecological Services Field Offices will normally recommend denial of all permits for projects that may adversely affect functioning fens. However, they also will look for opportunities to restore degraded fens. Draining, mining, and filling of all fens will be strongly discouraged. In addition, concentrated efforts will be made to encourage relocation of proposed reservoirs and linear projects (e.g., roads, utility lines, and canals) that might impact fens, when practicable.

Furthermore, restoration and proper management of fens should be given high consideration during the development and implementation of management plans on refuges and other public lands. Opportunities for restoration of fens also should be an area of focus for partnership opportunities with other agencies, citizens' organizations, and private landowners.

Copies of this policy were provided to several Federal and State agencies for their consideration, and this information will be available to other applicable entities for use in project planning and decisionmaking. However, the policy does not have any legal authority over Government or private decisions, and it does not affect ongoing, authorized development. The purposes of this policy are to help ensure consistent and effective recommendations by Service personnel and to provide other Federal, State, and local government agencies advance notification of Region 6's position regarding fens.

The attachment to this policy further describes the characteristics of fens in general but only specifically discusses fens in Colorado. Therefore, I reiterate the request stated in the cover memorandum to the draft policy that was sent to Region 6 ES offices for review. Please continue to work with the Natural Heritage Programs and other sources of data in each State so we can broaden the base of our knowledge on fens in other States in Region 6 and further substantiate the position Region 6 has taken in this policy. Please keep my ES staff abreast of new data development in this subject area. Questions on this policy should be directed to Dennis Buechler, Senior Staff Specialist for Federal Activities, at (303) 236-7400, ext. 231.

Neil Hartman

Attachment

cc: See Distribution List

U.S. FISH AND WILDLIFE SERVICE
REGION 6

PEATLAND MITIGATION POLICY CONSIDERATIONS

Ecological Services
Colorado Field Office
Lakewood, Colorado

December 1997

Revised January 1999

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REGION 6
PEATLAND MITIGATION POLICY CONSIDERATIONS

Introduction

One of the highest wetland priorities in this Region is the protection and conservation of mountain and prairie fens. These peatlands are scarce in the West, and many have unique assemblages of plant and animal species. Fens are also known to perform important wetland functions, some possibly unique to peatlands. Fens are under imminent threat from peat mining, water development projects, and recreational development, and because of the slow rate of organic matter accumulation, they are essentially irreplaceable. Mountain and prairie fen habitats are important to the plant and animal species dependent on their unique characteristics. Considering the imminent threats to these uncommon and irreplacable habitats, it is the position of Region 6 that fens deserve special consideration by regulatory, construction, and land management agencies, and the public.

Region 6 Mitigation Policy

Region 6 has decided that all its functioning fens, which have been mapped, and for which that information has been provided to applicable regulatory agencies, fall within Resource Category 1 of the U.S. Fish and Wildlife Service's "Mitigation Policy" (Federal Register, Vol. 46., No. 15, February 4, 1981). Functioning fens are those that (a) continue to support native plant communities and perform the functions inherent to peat fens or (b) have the potential to rapidly recover those functions with the removal or reversal of human, livestock, or other impacts.

The mitigation goal for Resource Category 1 is *no loss of existing habitat value*. In other words, because of the irreplaceability of that type of habitat, every reasonable effort should be made to avoid impacting that habitat type. Therefore, because of their vulnerability, protection of all fens will continue to be a priority in this Region, including those which have not yet been mapped and officially categorized.

Definition of Peatlands

Peatlands are defined by the presence of organic soils, generally referred to as peat. Peat or muck is defined as organic soil material that is saturated with water for long periods (or artificially drained) and, excluding live roots, has an organic-carbon content (by weight) of: (a) 18 percent or more if the mineral fractions contains 60 percent or more clay; or

(b) 12 percent or more if the mineral fraction contains no clay; or (c) 12 + (clay percentage multiplied by 0.1) percent or more if the mineral fraction contains less than 60 percent clay (USDA 1996).

Organic soils form under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, July 13, 1994). Organic soils are classified by the USDA, Natural Resources Conservation Service, as the order Histosols, with three main suborders, fibric, sapric, and hemic (USDA 1996).

The 1998 USDA "Keys to Soil Taxonomy" require that Histosols have organic soil materials and meet one or more of the following criteria:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials, have a densic, lithic, or para lithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or para lithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more per year in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

   (1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

   (2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

Fibric soils contain three-fourths or more (by volume) fibers after rubbing, excluding rock fragments; or they contain two-fifths or more (by volume) fibers after rubbing, excluding rock fragments; and yield color values and chromas of 7/1, 7/2, 8/1, 8/2 or 8/3 (USDA 1996).

Fibers are pieces of plant tissue in organic soil (excluding live roots) which are: (1) large enough to be retained on a 100-mesh sieve (openings 0.15 mm in diameter) when the materials are screened after dispersion in sodium hexametaphosphate; and (2) show evidence of the cellular structure of the plants from which they are derived; and (3) are either 2 cm or less in their smallest dimension, or are decomposed enough so they can be crushed and shredded with the fingers (USDA 1996).

Hemic soil materials are intermediate in decomposition between the less decomposed fibric and more decomposed sapric materials. Sapric soils are the most highly decomposed of the organic soil materials. They have the smallest amount of plant fiber, the highest bulk density, and the lowest water-holding capacity. Their fiber content, after rubbing, is less than one-sixth (by volume), excluding coarse fragments; and their sodium-pyrophosphate-extract color on white chromatographic or filter paper is below or to the right of a line drawn to exclude Munsell color blocks 5/1, 6/2, and 7/3 (USDA 1996b).

Types of Peatlands

Peatlands can be classified based on a number of parameters, including water source and water chemistry (nutrient supply), floristics, and/or wetland functions. The following will outline some of the methods that are used to classify different types of peatlands.

Classification Based on Source of Water and Water Chemistry (Nutrient Supply)

Water sources for peatlands can be ground water, surface water, precipitation, or some combination. The following classifications have been used to define peatlands:

Bogs

Bogs are mineral-poor, acid peatlands that are raised above the influence of groundwater by the accumulation of peat. They generally have a pH of 3 to 4, and since they are no longer in contact with groundwater, the only water source for these peatlands is precipitation (Crum 1988). As a result of the mineral-poor water source, the nutrient supply to bog plants is solely from precipitation and dust. Because of the low pH and low nutrient availability, few plants can survive in bogs and they generally have low species diversity. Bogs are most often dominated by mosses, especially *Sphagnum*.

Bogs in Colorado

> No bogs have been identified in Colorado or in the Rocky Mountains south of Canada (Windell, et al. 1986). Low precipitation (Bierly 1972) and high evapotranspiration in the arid West limits the potential for bog development (Windell, et al. 1986).

Fens

Relative to bogs, fens are mineral-rich peatlands with a pH of 4.0 to 7.5 and are dominated by graminoids, particularly sedges. These peatlands are in contact with groundwater and derive their water and nutrients from groundwater, surface water, and precipitation (Crum 1988). Minerotrophic water is nutrient rich and more alkaline than the ombrotrophic water of bogs. The nutrients and pH of the ground and surface water supplying a fen significantly influence the type of vegetation that can grow on that fen. The higher pH, nutrient-rich water is reflected in the higher floristic diversity of fens. Fens have been classified based on their nutrient richness and pH. The most common fen divisions are poor, moderate, rich, and extreme-rich fens (Du Rietz 1949 and Sjors 1950).

In general, poor fens are fed by water low in nutrients, from granite or other hard rocks, while rich fens occur where the water has been in contact with rocks that have high salt content, such as limestone or dolomite. The nutrients that are abundant in rich fen waters are calcium, sodium, and magnesium (Cooper 1992). Although pH ranges are subject to seasonal and geographic variation, an approximation is that poor fens have a pH of 4-6, and richest fens 6-7.5 (Crum 1988). However, some rich fens in Colorado exhibit a pH of up to 8.3 (Cooper 1990).

Table 1 is a characterization of three of these fen types, poor, moderate, and rich/extreme-rich, based on pH, calcium, magnesium, sodium, and potassium.

Chee & Vitt did not discriminate between rich fens and extreme-rich fens, but Sjörs (1963) described an extreme-rich fen with high nutrients, especially calcium, and pH generally higher than recorded in rich fens.

Fens in Colorado

All of the peatlands in Colorado are considered to be fens (Cooper 1990). The proportion of these fens that are poor, moderate, rich and extreme-rich have not been determined. Cooper described three types of peat fens in Colorado: (1) extremely rich, (2) rich, and (3) transitional (moderate) fens (Cooper 1996).

No true poor fens have been identified in Colorado. However, Cooper has identified "iron or acid fens" in Colorado. These fens can contain moderate mineral nutrients, may have a pH in the range of 3.0 to 4.5, and contain poor fen species such as *Sphagnum angustifolium* or *S.fuscum*. The acidic conditions are influenced by the geochemistry of these fens which generally contain pyrite. The reduction of pyrite produces the acidic conditions (Cooper 1996).

Fens in South Park are rich and extreme-rich fens and are different from other peatlands in the state based their water chemistry and floristics. They are also very rare nationally, as well (Cooper 1990). Other than the South Park region of Colorado, inventories specifically addressing distribution of fen types have not been conducted in Colorado.

Table 1 **Water chemistry characteristics of several fens grouped into three minerotropic fen classes (Chee & Vitt 1989 and Cooper 1990)**

Reference	Study Area	pH	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)
POOR FENS						
Zoltai & Johnson (1987)	Alberta	4.7	2	0.8	4.0	0.9
Comeau & Bellamy (1986)	Eastern Canada	4.3	7	2.0	4.0	0.4
Karlin & Bliss (1984)	Alberta	3.5-6.1	2	1.0-3.0	-	-
Bellamy (1968)	Western Europe	4.5	20	5.0	7.0	2.0
Sjörs (1963)	Ontario	4.1-5.4	2	0.5	0.3	0.1
Sjörs (1948)	Sweden	4.3	6	2.0	2.0	0.4
RANGES		**3.5-5.4**	**2-20**	**0.5-5.0**	**0.3-4.0**	**0.1-2.0**
MODERATE FENS						
Zoltai & Johnson (1987)	Alberta	6.0	28	11.0	5.1	1.8
Comeau & Bellamy (1986)	Eastern Canada	5.5	15	6.0	7.0	1.0
Karlin & Bliss (1984)	Alberta	4.6-7.1	4-5	2.0-12.0	-	-
Schwintzer (1981)	Michigan	5.7-7.0	11-75	-	-	-
Yefimov & Yefimova (1971)	U.S.S.R.	6.1	18	8.0	1.0	0.3
Persson (1961)	Sweden	5.4-7.0	40-50	30.0	85.0-93.0	10.0
Sjörs (1948)	Sweden	6.0	68	12.0	2.0	0.4
Johnson (1996)	Colorado (RMNP)	5.9-6.8	1-4	0.7-1.8	1.9-2.9	<0.5-1.1
RANGES		**4.6-7.1**	**1-75**	**0.7-30.0**	**1.0-93.0**	**0.3-10.0**
RICH/EXTREME RICH FENS						
Zoltai & Johnson (1987)	Alberta	6.5	54	17	6	0.8
Karlin & Bliss (1984)	Alberta	7.2-8.2	31-120	10-53	-	-
Bellamy (1968)	Western Europe	6.6	183	19	11	2.0
Sjörs (1963)	Ontario	5.8-7.4	9	2	1	0.3
Sjörs (1961)	Ontario	7.9	32	7	3	0.6
Persson (1961)	Sweden	5.7-7.9	100-1380	50-1690	47-144	20.0
Cooper (1990)	Colorado (South Park)	7.4-8.3	15-95	2-9	2-10	-
Johnson (1996)	Colorado (High Creek Fen)	7.0-7.8	48-139	224-440	3-8	0.7-3.2
RANGES		**6.5-8.3**	**9-1380**	**2-1690**	**1-144**	**0.3-20.0**

USFWS Wetland Classification/The Cowardin System

The Cowardin (USFWS 1979) wetland classification system used in National Wetland Inventory (NWI) mapping can also be used to classify peatlands. Based on the Cowardin system, fens in Colorado would generally be classified as either; (1) palustrine, emergent, persistent, with a saturated water regime and organic soils, or (2) palustrine, scrub-shrub with a saturated water regime and organic soils. Peatlands can be further classified based on their dominance or dominant species composition and water chemistry, including salinity and pH. However, wetlands are rarely mapped to the detail which could distinguish specific types of fens.

Classification Based on Floristic Characteristics

In 1992, Cooper conducted ecological studies of the wetlands of South Park. The studies included a classification of wetlands, including 7 classes, 8 orders, 15 alliances and 40 associations according to the Braun-Blanquet system of vegetation classification.

The Mires (Fens or Peatlands) class includes all peatlands in the Rocky Mountain Region. These peatlands occur at high elevation (above 8,000 feet), usually have saturated soils for most of the summer, and usually occur where ground water is being discharged. This fen or peatland class, referred to as the *Carex aquatilis - Pedicularis groenlandica* has diagnostic species which include:

Carex aquatilis,
Kobresia simpliciuscula
Trichophorum pumilum
Eriophorum caurinum
Drepanocladus aduncus
Scorpidium scorpiodes
Tomenthypnum nitens
Pedicularis groenlandicum
Thalictrum alpinum
Triglochin palustre

Within this class of wetlands, Cooper identified rich fens and extreme-rich fens.

Rich fens are in the order *Carex aquatilis - Pedicularis groenlandica*. This order includes the rich fens, those with circumneutral pH, low concentrations of dissolved calcium in the water and dominated by sedges or willows. These ecosystems occur at ground water discharge sites and are usually saturated for the entire growing season. Diagnostic species include:

Carex aquatilis
Carex simulata
Pedicularis groenlandica
Eleocharis quinqueflora
Salix planifolia
Salix wolfii
Drepanocladus aduncus

Within this order of rich fens, Cooper identified two alliances; *Carex aquatilis-Pedicularis groenlandica* and *Salix planifolia - Carex aquatilis*. The following is a brief description of these alliances and their associations:

Alliance	*Carex aquatilis - Pedicularis groenlandica*
Association	*Carex aquatilis.*
Association	*Carex simulata*
Association	*Eleocharis quinqueflora*
Alliance	*Salix planifolia - Carex aquatilis*
Association	*Salix planifolia - Carex aquatilis*
Association	*Salix planifolia - Calamagrostis canadensis*

Extreme-rich fens are in the order *Kobresia simpliciuscula - Trichophorum pumilum* which is characterized by water with dissolved calcium concentrations exceeding 20 mg/l. In addition, free carbonates are usually seen on the soil surface and covering hummocks. Marl may be present in pools. The water source is always ground water and the stands may occur in a matrix of drier vegetation. Indicator species include *Kobresia simpliciuscula, Trichophorum pumilum, Carex scirpoidea, Salix myrtillifolia,* and *Salix candida.*

Within this extreme-rich fen order, Cooper identified 1 alliance with 5 associations:

Alliance	*Kobresia simpliciuscula - Trichoporum pumilum*
Association	*Kobresia simpliciuscula - Trichophurum pumilum*
Association	*Kobresia myosuroides*
Association	*Carex scirpoidea*
Association	*Juncus alpinus*
Association	*Triglochin maritimum - Salix candida*

Classification Based on Hydrogeomorphic Method (HGM)

The hydrogeomorphic classification is a wetland classification scheme that focuses on assessing the physical, chemical, and biological functions of wetlands. The classification is in the development stage and was presented by Brinson in 1993 in *A Hydrogeomorphic Classification for Wetlands* as a generic approach, not a specific approach that can be used in practice. It is intended that existing wetlands in different geographic regions can be assigned hydrogeomorphic classes that will better reveal their ecosystem functions. This approach emphasizes the importance of abiotic features of wetlands for functions such as the chemical characteristics of water, habitat maintenance, and water storage and transport.

The classification is based on three wetland hydrogeomorphic properties: (1) geomorphic setting, (2) water source, and (3) hydrodynamics (Brinson 1993). The following is a brief discussion of each of the HGM properties evaluated in the classification as they relate specifically to peatlands:

Geomorphic Setting

The geomorphic setting is a description of the location of a wetland in relation to surrounding landforms. This characteristic defines many wetland attributes as well as the hydrologic type of the wetland. Fens in Colorado are groundwater slope wetlands.

Table 2 is a summary of the characteristics of peatland geomorphic settings including qualitative evidence, quantitative evidence, functions, and ecological significance in Brinson's classification.

Water Source

The source of water to a wetland determines the water chemistry of the wetland, as well as flow paths and the energy required to transport the water to the wetland surface. For the purposes of classification, three hydrologic inputs are considered: (1) precipitation, (2) groundwater discharge (inflow usually into and through wetland sediments), and (3) surface or near surface inflow (Brinson 1993). **Figure A** illustrates the principal sources of water.

Precipitation, although important to all wetlands, by definition is not the primary source of water for fens. In Colorado, fens are primarily dependent on groundwater discharge and to a lesser degree on surface water for their water supply. **Figure B** illustrates the relative contribution of precipitation, groundwater discharge, and lateral surface flow with major wetland types within the triangle to show the relative importance of water sources (Brinson 1987). As shown in this diagram, fens and seeps are characterized by low contribution of surface water and a high contribution of groundwater.

The characters outlined in **Table 3** describe the wetland water sources as a property of the hydrogeomorphic classification including qualitative scale, quantitative estimates, functions, and ecological significance or characters maintained.

Table 2 Summary of the Characteristics of Groundwater Slope, Extensive Peatland, Geomorphic Settings as a Property of HGM Classification

Examples of Geomorphic Setting	Qualitative Evidence	Quantitative Evidence	Functions	Ecological Significance
EXTENSIVE PEATLAND				
Ombrotrophic Bog	Peat substrate; saturated most of time. Plant species indicate ombrotrophic bog; surface flows negligible.	Peat confirmed by organic content and thickness. Ombrotrophy evident from low pH and low ion content.	Surface storage may facilitate storm runoff; groundwater conservation occurs when water table is below surface. Peat deposits control topography and geomorphic surface.	Wetland-upland interactions minor relative to wetland-atmospheric exchanges. Upland habitats scarce. Species composition unique to bog conditions.
Rich Fens	Peat substrate; saturated most of time. Graminoid species indicative of groundwater supply.	Peat confirmed by organic content and thickness. Minerotrophy evident from circumneutral pH and high ion content.	Subsurface water supply maintains saturation to surface and hydraulic gradient to maintain flow.	Represents conduit for lateral water movement without channelized flow. Moderate levels of primary production and organic matter export.

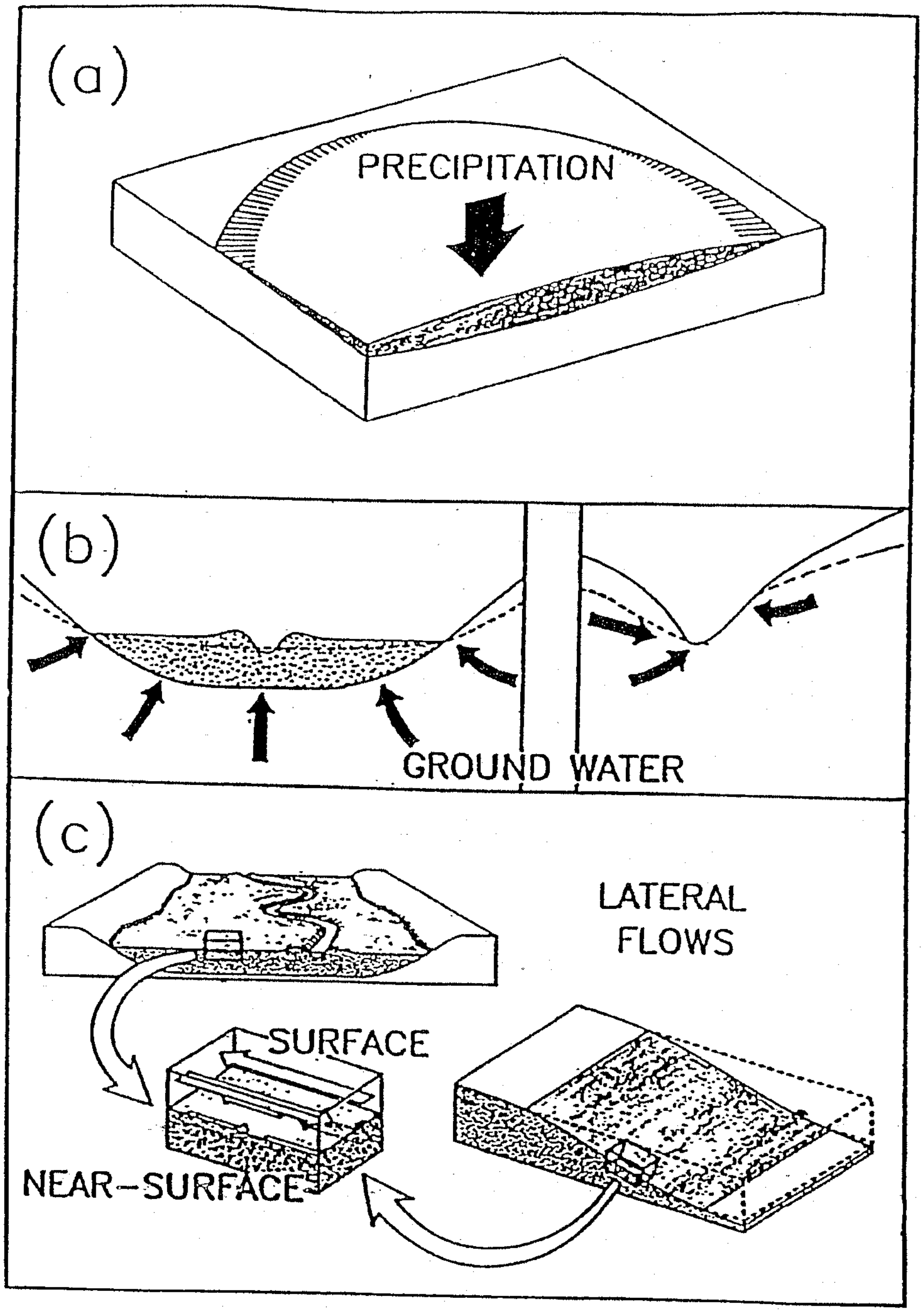

Figure A **Principal Sources of Water to Wetlands (Brinson, 1993)**

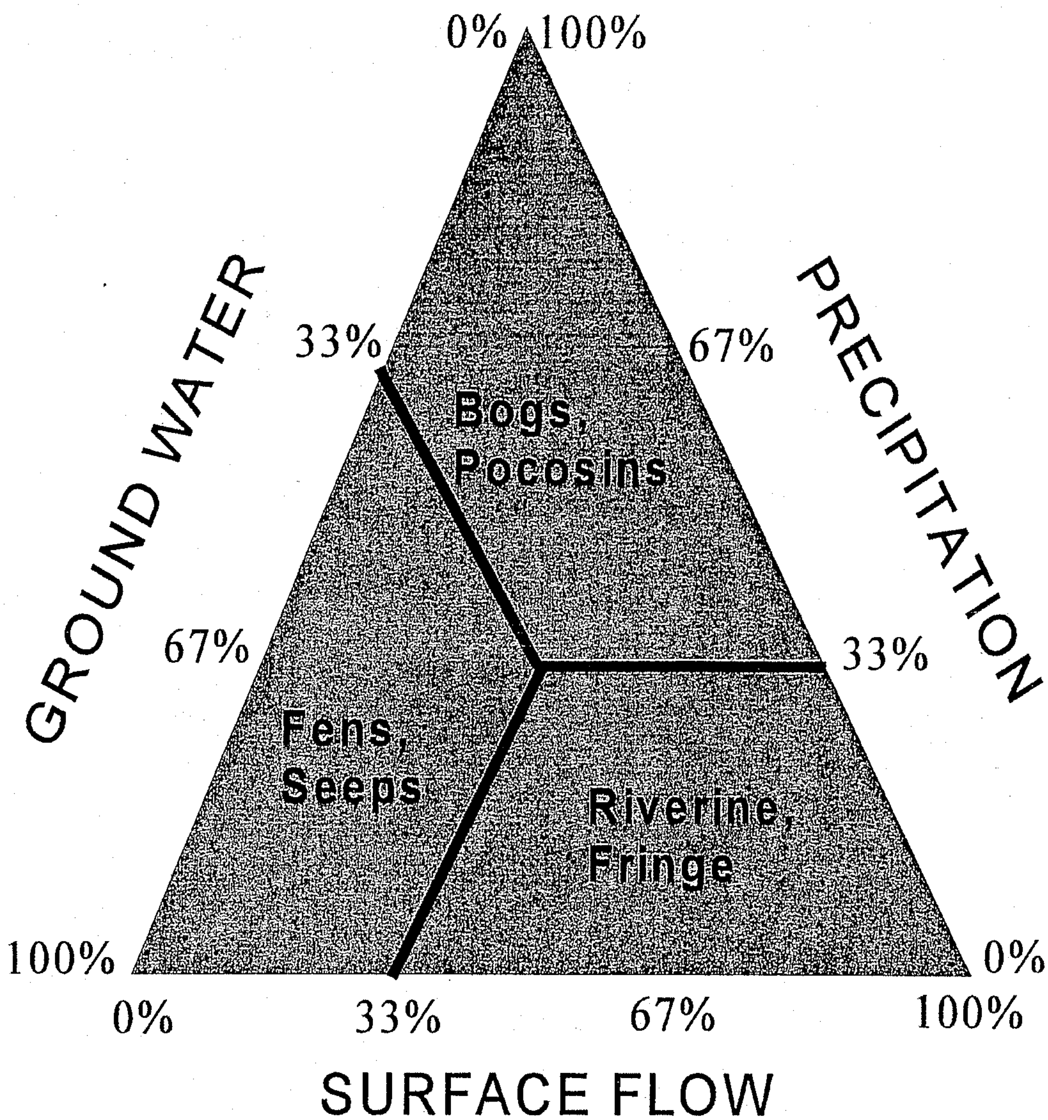

Figure B Relative Contribution of Precipitation, Ground Water Discharge, and Lateral Surface Flow with Major Wetland Types (Brinson, 1987)

Table 3 Wetland Water Sources as a Property of the HGM Classification

Examples of Water Source and (Climate Setting)	Qualitative Scale	Quantitative Estimate	Functions	Ecological Significance or Characters Maintained
Precipitation (moist climate)	Precipitation dominates site water balance and water supply to plant community.	Precipitation > PET during growing season.	Rarity of water table drawdown promotes organic matter accumulation, which further retards drainage: paludification is promoted.	Biogenic landscape isolates mineral soil from access by plants; low primary production eventually results.
Lateral surface or near-surface transport from overbank flow (moist climate).	Discharge commonly exceeds bankfull-channel capacity.	Duration and frequency of overbank flow to floodplain can be inferred from hydrographs and floodplain elevation.	Overbank flow contributes to both flashy hydroperiod and vertical accretion of sediments. This creates rapid biogeochemical cycling and supplies nutrients.	Conditions maintained for high primary productivity and complex habitat structure.
Groundwater (GW) discharge to wetland (mesic climate)	Seeps occur at bases of hillslopes or below breaks in slope, and along edges of streams and lakes.	Hydraulic gradient of groundwater increases with distance from wetland. Substrate permeable enough to allow flows.	GW supplies nutrients, renews water, and flushes potential plant growth inhibitors.	Conditions conducive for stable plant community of high productivity. Peat accumulation possible.
Both GW discharge and, during flood flows, lateral surface transport from upstream (arid climate).	Non-atmospheric sources greatly exceed supply from precipitation.	Precipitation << PET during growing season.	High water tables are maintained by catchment supplies from upstream and from GW sources.	Water supplies support vegetative complexity and habitat structure not found in uplands because of water stress in arid climate.
	All 3 sources, but precipitation is minor (subhumid to semiarid)	Alternate drought and wet periods produce decade-long cycles of water table fluctuations.	Precipitation <PET	High water levels induced by precipitation; GW discharge prevents extreme drawdowns; wetland may recharge GW when water table is high; conserves/reduces GW discharge when water levels are normal.

Hydrodynamics

The term hydrodynamics, as used in the HGM classification, refers to the motion of water and the capacity of that water to do work (Brinson 1993). **Figure C** illustrates the three qualitative categories of hydrodynamics: (1) vertical fluctuation of the water table that result from evapotranspiration and subsequent replacement by precipitation or groundwater discharge in the wetland, (2) unidirectional flows that range from strong channel-contained currents to sluggish sheet flow across a floodplain, and (3) bidirectional, surface or near-surface flows resulting from tides or seiches. These prevalent directions of water movement correspond, respectively, to the geomorphic setting categories. **Table 4** Are examples of hydrodynamic properties of the HGM classification.

In general, fens in Colorado have hydrodynamic properties of two kinds; unidirectional flow and vertical fluctuations. Unidirectional flow results from topographical gradients. Significant fluctuations may or may not occur on a fen, or they may occur in some areas of a fen, but not others (Johnson 1996).

HGM Classification of an Extreme Rich Fen in South Park, Colorado

In 1996, Johnson conducted an HGM classification of High Creek Fen. **Table 5** is a summary of the HGM characterization of High Creek Fen, and is likely to be representative of other extreme rich fens in Colorado. In summary, Johnson's classification included the following:

- Geomorphic Setting
  - Groundwater Slope Wetland
  - Wetland with Water Tracks
- Water Source
  - Groundwater Discharge
- Hydrodynamics
  - Consistently High Water Table
  - Unidirectional Flow -- Low Gradient

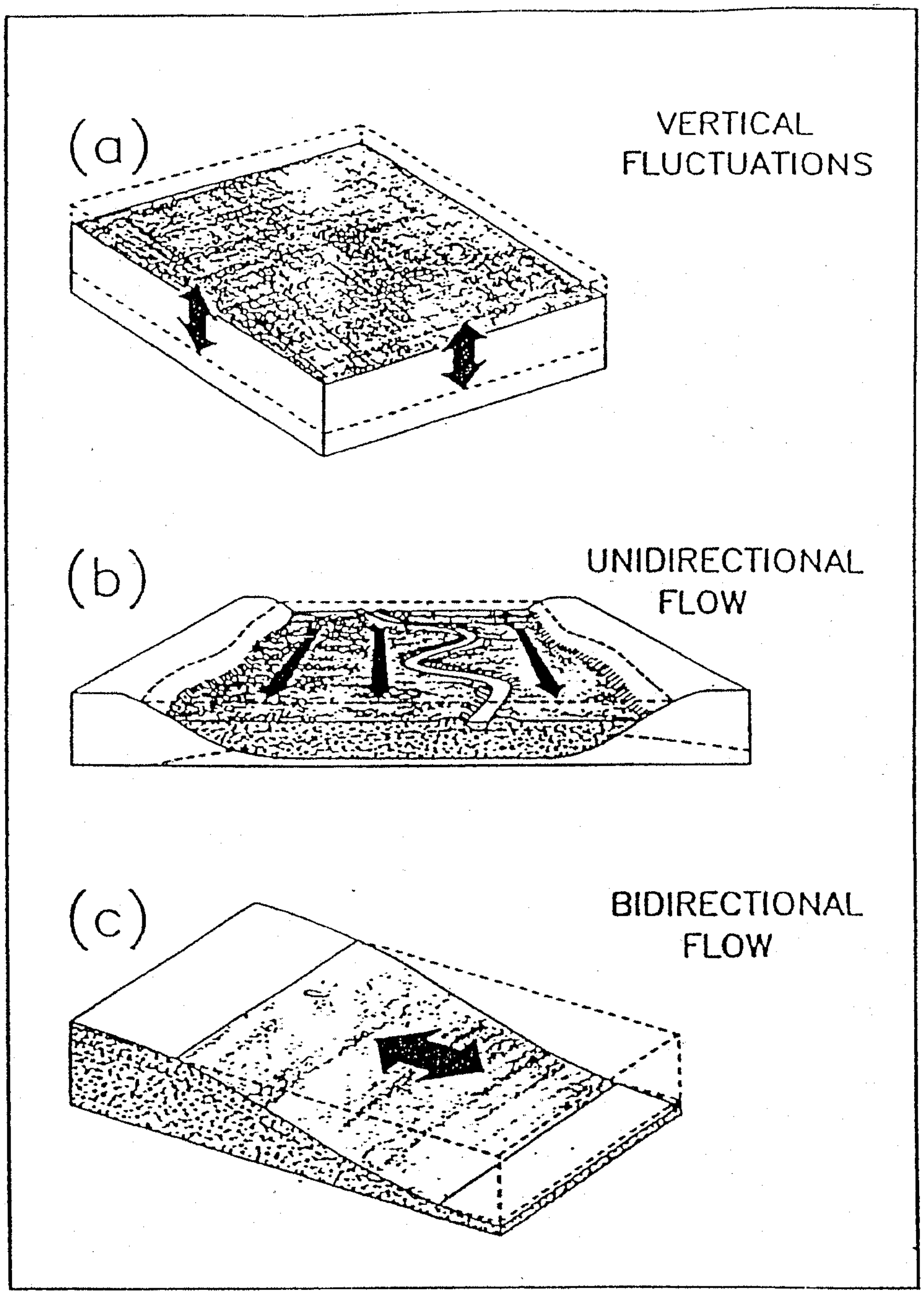

Figure C **Illustration of the Three Qualitative Categories of Hydrodynamics. Categories of hydrodynamics based on dominant flow patterns: (a) vertical fluctuations normally are caused by evapotranspiration and precipitation, (b) unidirectional flows are horizontal surface and subsurface, and bidirectional flows are horizontal across the surface (Brinson, 1993).**

Table 4 Examples of Hydrodynamic Properties Applicable to Peatlands in the HGM Classification System

Examples of Hydrodynamics	Qualitative Evidence	Quantitative Evidence	Functions	Ecological Significance
VERTICAL FLUCTUATION OF WATER TABLE				
Nearly constant water table at or near surface.	Relatively constant WT position suggest low ET because of cool, moist climate; if ET is high, strong groundwater discharge required.	Water table hydrographs have little fluctuation and are at or near surface. A cool, moist climate may suggest low ET; otherwise, strong GW discharge must be assumed.	Stable WT encourage peat accumulation. Where ET is low, ombrotrophic conditions promote bog formation. Strong groundwater sources encourage development of fens or maintain seepage slopes.	Landscape patterns dominated by biogenic process of peat accumulation that is vulnerable to changes in drainage and climate. For seepage slopes, species composition reflects waterlogged soils that are nevertheless well flushed and not strongly reduced.
UNIDIRECTIONAL FLOW				
Flow velocities correspond with low-gradient landforms.	Fine sediments (silt-clay and high organic content); barely perceptible flow during flooding.	Slope, flows, and particle size distribution all confirm low-energy system.	Residence time of water allows long contact between water and sediment; low-suspended load allows light penetration	Good conditions for trapping sediment and altering water quality. As nutrient trp, food web support is strong. Reducing conditions favor strongly obligate wetland species.

Table 5 Summary of the HGM Characterization of High Creek Fen

Geomorphic Setting	Qualitative Evidence	Quantitative Evidence	Functions	Ecological Significance
Ground water slope wetland	Peat substrate with high water table relative to surrounding areas; position at hill toe.	Nutrient rich water supply; regions of positive hydraulic head.	Groundwater recharge sites; allows growth of fen species in semi-arid habitat.	Greatly increases species diversity; provides habitat for a large number of rare plants.
Water Source				
Primarily groundwater discharge	Geomorphological position at hill toe; saturated conditions without or with inlet stream; floating mats and water-tracks; indicator species.	Nutrient rich water supply; regions of positive hydraulic head; presence of indicator species; high soil electrical conductivity, uranium content and bulk density.	Provides continual source of nutrient rich water; allows peat accumulation to take place in semi-arid environment; maintains water supply during dry periods.	Single most important factor for the maintenance of fens and all ecological attributes, thereof.
Hydrodynamics				
Constantly high water table	Presence of peat; water-tracks and floating mats indicate perennial saturation; tall hummocks suggest larger seasonal fluctuations, but water table still within a meter or less of the surface.	Depth to water table readings in groundwater wells.	Maintains saturated, reducing conditions; allows peat accumulation; provides habitat for hydrophilic species.	High water table necessary to maintain fen ecosystem; provision of rare and other fen species habitat.
Unidirectional flow - low gradient	Perceptible, but slow surficial flow; single trend in topography grade.	Slope and flow measurements.	Provide flow-through system without channelization; slow subsurface water flow allows long water residence times for chemical filtration to take place; provides a delay in water release; low energy system allows peat to accumulate.	Peat ecosystem substrate not eroded by low energy flow; increased filtration efficiency; continually renewed source of nutrients.

Scarcity of Peatlands in Colorado

In Colorado, the conditions required for formation of peat is restricted to alpine, subalpine, and upper montane regions, usually between 8,000 and 12,000 feet in elevation (Cooper 1990). It is estimated that 1,000,000 acres of Colorado's 66,716,019 acres are occupied by wetlands; less than 1.5 percent of Colorado's total area. A very rough estimate of peatlands in Colorado is 100,000 acres, or 10 percent of Colorado's wetlands.

Species Endemic to, or Dependent, on Peatlands

Although biological inventories of peatlands have not been conducted on a large scale in Colorado, the extreme rich fens of South Park are known to support fourteen rare plant species, two important rare plant communities, and a number of rare invertebrates. These plants, plant communities, and invertebrates, including their Colorado Natural Heritage Program Ranks, are listed in **Table 6** (Sanderson and March 1996). **Table 7** includes the definition of each of the Natural Heritage rankings.

Porter's Feathergrass (*Ptilagrostis mongholica* ssp. *porteri*) and pale blue-eyed grass (*Sysrinchium pallidum*) are two globally rare plants found in the extreme rich fens of South Park. Porter's Feathergrass is endemic to South Park and occurs only on peat hummocks in fens. There are twenty-five known occurrences of this plant and all are in Colorado. Pale blue-eyed grass is restricted to the southern Rocky Mountains. The plant is found in southern Wyoming and northern Colorado, but the vast majority of its occurrences are in South Park. It is not restricted to extreme rich fens, but does occur in many of them. As a result of their distribution, protection of their habitats in South Park is essential to the long-term viability of these species (Sanderson and March 1996).

South Park's wetlands, especially the extreme rich fens, contain a number of state rare plants. Compound Kobresia (*Kobresia simpliciuscula*) occurs principally on peat hummocks that only occur in fens fed by a constant supply of carbonate rich ground water. Greenland Primrose (*Primula egaliksensis*) is known only from South Park peatlands; the only other known populations in the lower 48 occur in Wyoming. Hoary Willow (*Salix candida*) is a rare willow known only from rich fens in South Park, the San Juans, and northern Colorado. Low blueberry willow (*Salix myrtillifolia*), is known from only two areas in the western United States: South Park and northwest Wyoming. A number of the state rare plant species are extremely far removed from their core populations. The disjunct nature of the populations in South Park greatly increase the biodiversity significance of these occurrences (Sanderson and March 1996).

Table 6 **Globally and State Rare Plants, Plant Communities, and Invertebrates of South Park's Extreme Rich Fens (Sanderson and March 1996)**

Common Name	Scientific Name	Heritage Program Rank
Porter's feathergrass	*Ptilagrostis mongholica* ssp. *porteri*	G2T2S2
Pale blue-eyed grass	*Sisyrinchium palidum*	G2G3S2S3
Livid sedge	*Carex livida*	G5S1
Canadian single-spike sedge	*Carex scirpoidea*	G5S1
Green sedge	*Carex viridula*	G5?S1
Slender cottongrass	*Eriophorum gracile*	G5S2
Greenland primrose	*Primula egaliksensis*	G4S2
Hoary willow	*Salix candida*	G5S2
Low blueberry willow	*Salix myrtillifolia*	G5S1
Autumn willow	*Salix serissima*	G4S1
Pygmy bulrush	*Scirpus rollandii* (*Trichophorum pumilum*)	G2G3QS1
Few-flowered ragwort	*Senecio pauciflorus* (*Packera pauciflora*)	G4G5S1S2
Northern bladderwort	*Utricularia ochroleuca*	G4?S1
A moss	*Scorpidium scropoides*	G4G5S?
Extreme-Rich Fen	*Kobresia simpliciuscula-Scirpus rollandii* Plant Association	G2S1
Extreme-Rich Fen	*Kobresia myosuroides-Thalictrum alpinum* Plant Association	G1S1
An aquatic beetle	*Agabus bifarius*	G?S1?
An aquatic beetle	*Rhantus suturellus*	G?S1?
An aquatic beetle	*Hydropurus despectus*	G?S1?
An aquatic beetle	*Hydropurus notabilis*	G?S1?
An aquatic beetle	*Hydropurus paugus*	G?S1?
An aquatic beetle	*Hydropurus tenebrosus*	G?S1?
An aquatic beetle	*Helophorus sempervarians*	G?S1?
An aquatic beetle	*Helophorus angusticollis*	G?S1?

Common Name	Scientific Name	Heritage Program Rank
An aquatic beetle	*Haliplus salinarius*	G?S1?
A caddisfly	*Ochrotrichia susanae*	G1?S1?
Glass physa (snail)	*Physa skinneri*	G?S2

Table 7 Colorado Natural Heritage Program Ranks

Rarity Ranks (applied to an element only)	
S1(G1)	Extremely rare; usually 5 or fewer occurrences in the State (world); or simply a few remaining individuals, often especially vulnerable to extirpation.
S2(G2)	Very rare; usually between 5 and 20 occurrences in the state (world); or with many individuals in fewer occurrences; often susceptible to becoming endangered.
S3(G3)	Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.
S4(G4)	Common; usually > 100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.
S5(G5)	Very common; demonstrably secure under present conditions.
S?(G?)	Unranked; some evidence that element may be imperiled, but awaiting formal rarity ranking.
SU(GU)	Status uncertain, often because of low search effort or cryptic nature of the element.
T	Used to indicate the status of a subspecies or variety. These taxa are ranked using the same criteria as for G and S ranks.
Element Occurrence Ranks (applied to the site where an element occurs)	
A	The occurrence is relatively large, pristine, defensible, and viable.
B	The occurrence is small but in good condition, or large but removed from its natural condition and/or not viable and defensible.
C	The occurrence is small, in poor condition, and possibly of questionable viability.
D	The occurrence does not merit conservation efforts because it is too degraded or not viable.
Biodiversity Ranks (applies to the site where element(s) occurs)	
B1	Outstanding biodiversity significance, for example, the best occurrence of a G1 element.
B2	Very high biodiversity significance, such as the best occurrence of a G2 or G3 element.
B3	High biodiversity significance, such as C-ranked occurrences of G2 or G3 elements, or A-ranked occurrences of G3S1 elements.
B4	Moderate biodiversity significance
B5	Of general conservation interest

Little work has been done on the species composition and distribution of invertebrates in peatlands in Colorado. However, Durfee and Polonsky (1995) collected invertebrates at High Creek Fen in South Park and demonstrated that extreme rich fens provide habitat for state and potentially globally rare invertebrates. A snail (*Physa skinneri*) is a state rare snail known only from a few sites at High Creek Fen and is believed to be associated with extremely rich fens. Nine species of aquatic beetle and a predaceous diving beetle that had not been reported west of Wisconsin in the U.S. were recorded for the first time at High Creek Fen. They also collected a caddisfly previously known from only one other location in the world. There appears to be a pattern of global rarity and extreme population discontinuities associated with these rare invertebrates that also appears among terrestrial invertebrates (Sanderson and March 1996).

Peatland Functions

Peatlands, in general, perform many of the same functions as mineral wetlands. These include wildlife habitat, maintenance of water quality, ground water discharge sites, surface and ground water flow regulation, water storage, flood abatement and maintenance of groundwater table elevation both upstream and downstream of a peatland. A particularly important function performed by fens is the capacity of these wetlands to sequester heavy metals to a greater degree than mineral substrate wetlands. Mineral substrate wetland types also remove heavy metals from source waters through plant uptake and adsorbtion. However, fens, in addition to having plants with the ability to uptake heavy metals, also have soils with high organic content with the ability to adsorb high levels of heavy metals. Fens in Colorado have been shown to trap uranium and other heavy metals (Ref. USGS).

The following is a brief discussion of each of the wetland functions known to be performed by peatlands:

Ground Water Discharge Sites

Ground water discharge is the movement of ground water into the surface water. Wetlands with significant ground water discharge typically are saturated throughout much of the year and can perform vital water quality functions because their soils are anaerobic and reducing conditions exist. Generally, wetlands with the strongest and most constant springs can have organic soils.

Short-term Nutrient Retention

Wetlands performing short-term nutrient retention are typically anaerobic for long periods of time during the growing season and can convert, trap, and/or transform nutrients and heavy metals and remove them from the water column. Peatlands also provide short-term and long-term nutrient retention through bioaccumulation of nutrients in herbaceous tissues contained in peat soils.

Long-term Nutrient Retention

Wetlands that can retain nutrients on a long-term basis are generally found in stable systems that have been supporting the same or similar types of wetlands communities for long periods of time. Fens and willow carrs are the most common wetland types performing this function. Because of the slow decomposition rate of peat, nutrients are retained for long-term periods of time in peatlands. Wetlands that provide long-term nutrient retention also provide short-term nutrient retention

Plant and Wildlife Habitats

Based on biological inventories of rich and extreme-rich fens in South Park, they are important in providing habitats for both unique plants and animals. In additions, several of the extreme-rich fens in South Park have been identified as sites of biological significance. **Table 8** is a listing of these significant sites:

Table 8 Biological significant sites, arranged by Biodiversity Rank (B-rank) (Sanderson and March 1997)

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

Although a number of fens are known to support unique species, extensive data is not available on wildlife species that utilize Colorado peatlands. In 1990, Stevens researched the range of wildlife species likely to inhabit peatlands in Colorado. Much of the data he found were on northern peatlands. These northern wetlands may or may not be entirely applicable to Colorado peatlands, but in general, they provide important information in the absence of specific data on fauna in Colorado peatlands. The following summarizes Stevens' findings.

- Subalpine peatlands dominated by willows (carrs) are much more heavily used by breeding birds relative to the surrounding upland habitats.

- Minnesota peatlands were also found to be very important to a number of avian species (waterfowl and terrestrial birds) in at least two ways: (1) as a source of food needed at critical times of the year; and (2) as habitat for rare or threatened species which may be dependent on the peatland habitat (Wagner and Wells 1980)

- In Colorado, white-tailed ptarmigans are dependent on willow-dominated peatlands as a food source (Braun et al. 1976).

- In Minnesota, the following species are known to utilize or depend on peatland habitats (Marshall and Miquelle 1978).:

  moose (*Alces alces*)
  fisher (*Martes pennanti*)
  beaver (*Castor canadensis*)
  numerous small mammals (shrews, mice, moles, voles, squirrels, and chipmunks)
  numerous vertebrate and invertebrate aquatic organisms

Retention of Heavy Metals

In a study of more than 100 wetlands in Colorado, more than half showed uranium concentrations in the groundwater of greater than 20 ppm (Owen et al. 1992). The Environmental Protection Agency's proposed drinking water standard for uranium is a maximum contaminant level goal (MCLG) of 20 ppm. This is an non-enforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety (EPA 1991). Although undocumented, uranium concentrations retained in peatlands could represent an environmental concern. Wetlands are known to be efficient filters of metals dissolved in ground and surface waters. Peatlands can be particularly effective in this regard (Loparkina 1967).

Organic matter in wetlands is an effective sorber of uranium and other metals. Organic matter degradation greatly increases the surface area available for sorption and yields humic material, humic acids, and fulvic acids, all of which facilitate geochemical enrichment (Robbins,1990). In laboratory experiments with uranyl sulfate, it has been found that peat could remove as much as 98 percent of added uranium (U) from solution (Moore 1954).

Peat and peaty muck, because they have high organic contents, exhibit a large cation exchange capacity. Stednick (1988) pointed out that the pH of most riparian-wetland systems is near neutral, which helps limit metal solubility. Ibarra et al. (1979) concluded that humic acids produced from peat-forming processes, as well as those in existing peats, can exert a strong concentrating accumulating effect on heavy metals being transported by natural waters, even waters low in metal concentrations.

Tannins are water-soluble secondary plant products that can be observed as the "tea" or brown coloration in streams and peatland species. These tannins also form complexes with ions in solution (Crum 1988).

Bacteria and fungi also play a role in concentrating metals in wetlands. Bacteria are the prime degraders of vegetation in the peat-forming process (Waksman 1930; Moore and Bellamy 1974) and are partially responsible for formation of sorbents such as humic acids. Bacteria themselves may trap metals in or on their cell walls. A common fungus has also been reported to be very efficient in biosorption of uranium (Tsezos and Volesky 1981 and 1982).

Uniqueness of Peatlands in Colorado

Many of Colorado's peatlands are unique based on their assemblages of plant and animal species, as well as their water quality improvement function of retention of heavy metals. The unique plants and animals found in some Colorado peatlands are discussed in the Species Dependent on or Endemic to Peatlands section of this report. The metal retention characteristics of peatlands are discussed in the Functions of Peatlands section of this report.

Threats to Colorado Peatlands

Threats to Colorado peatlands include peat mining, ski and real estate development, water development projects, and draining and alterations associated with agriculture. The following is a brief overview of each of these threats to Colorado peat fens:

Peat Mining

It is estimated that historically, the total area directly affected by the extraction of peat has been approximately 200 to 500 acres. In 1989-1990 there were approximately 20 active peat operators in Colorado. The total estimated annual extraction of peat is 102,000 cu. yds. (51,000 tons). Colorado is fifth nationally in terms of peat tonnage extracted. Colorado's contribution to the national supply is estimated at 1.5 percent of the total. Approximately 80 to 90 percent of the peat extracted in Colorado is excavated in Park and Teller Counties. Peat is also mined to "dry up" land for use as pastureland and to create open water for recreation use (COE 1996).

Peat is marketed to gardeners and landscapers for increasing the soil's acidity and organic content, but the effectiveness of Colorado's peat as a soil amendment is questionable. The quality of Colorado peat is widely variable, but can contain as little as 21 percent organic matter, compared to 90 percent or more for sphagnum peat As much as 79 percent of the remaining volume consists of finely pulverized mountain rock and sand (Borland 1992).

Colorado's peat also usually has a high pH and a high calcium content. In a controlled study, Agut and Hartley (1981) found that plants grew worse in mountain peat mixtures than in other mixtures. Based on the soil characteristics of Colorado's peat, it appears it is most often ineffective as a soil amendment (Borland 1992). In 1992, Jim Borland, President of the *Colorado Native Plant Society said of Colorado mountain peat, " . . . I have concluded the best thing that can be said for the product is that it is dark brown in color." In addition, Denver Water Board, the Colorado Garden Club, and Permagreen, Inc., among others, have boycotted the use of Colorado mountain peat due to its low quality and the destructive nature of the mining practices (Johnson 1997).

The following is a list of some of the historic and operating peat mines in Colorado:

- Park County (South Park)
  - Universal Peat Mine -- 200 acres, mined for 25 years
  - Brinkerhoff Peat Mine -- historic mining
  - R&R Enterprises -- 200 acres, a peatland that has had the hydrology altered, very dry
  - High Creek Fen -- historically mined
- San Luis Valley
  - A large mining operation in an area similar to R&R Enterprises mine in Park County, altered hydrology, very dry, non-jurisdictional
- Teller County
  - Scotts Hyponex -- historically mined peat, but are not currently mining

Gilpin County

Eureka Gulch -- small scale mining north of Central City, U.S. Army Corps of Engineers issued a cease and desist order for excavation without a permit. They continued mining and the case is now with the Department of Justice for enforcement resolution

Impacts Associated with Peat Mining

Peat mining destroys many of the wetland functions associated peatlands. The primary impact is the destruction of plant and wildlife habitats. Alteration of hydrology also has major impacts to peatland ecosystems.

Removal of peat affects the hydrology of a peatland in a number of ways. Drainage of the peatlands lowers the water table and results in oxidation of peat sediments. Peat extraction removes the more porous upper material which is the most active in water storage and pollutant trapping (EPA 1993). Water quality analysis conducted on South Park peatlands indicates that water quality standards can be exceeded after peat removal (Cooper 1990). The capacity of the peatland to store and slowly discharge storm water is known to decrease (Stevens et al. 1990; Johnson 1996) and removal of peat severely alters or destroys the hydrologic patterns of water flowing through fen areas. In addition to impacts to uses and quality of water in an area from which peat has been extracted, potential changes in evaporation rates could impact downstream and upstream water balance relations (Borland 1993; Johnson 1996).

Disturbance to metalliferous fens could substantially impact water quality. If a peatland is partly or completely drained, the subsequent oxidation of the organic-rich sediments may liberate metals that have been accumulating from very dilute solutions for thousands of year (Langmuir 1978). In a 1995 report on the geochemistry of Vassar Meadow in Eagle County, Colorado, the USGS recommended that any removal or draining of metalliferous wetland sediments should have safeguards in place to prevent escape of metals (particularly chromium and uranium) to ground or surface waters (Owen and Breit 1995).

Real Estate Development

Peatlands in Colorado are also threatened by development, particularly ski areas since they occur at higher altitudes. Vassar Meadows, a rich fen in Eagle County, has historically been threatened by the proposed Adam's Rib resort development. Although the resort development is no longer planned in the area, the future of Vassar Meadows is uncertain.

Impacts Associated with Real Estate Development

Because of the removal of peat for construction of buildings, ski lifts, etc., the impacts resulting from development in peatlands are similar to those associated with peat mining. In addition, water quality entering wetlands can also be degraded by adjacent development. Depending on type of development, projects upstream of a fen could result in increases in nitrate and phosphorous loading, as well as the possibility of the introduction of herbicides and pesticides to the water source.

Water Development Projects

Fens in Colorado are also threatened by proposed water development projects. As an example, in South Park, innovative water development projects have been proposed that include pumping groundwater, through a series of wells, from an occluded aquifer to satisfy depletions downstream. In addition to the wells, the proposed project would include a number of recharge reservoirs (possibly located in fens) to recharge and store water in the area vacated by water pumped from the wells. Although these types of projects are in preliminary stages of design and will not be finalized for several years, they are a threat to peatlands in South Park because of potential adverse impacts to groundwater.

Impacts Associated with Water Development Projects

Fens in Colorado, by definition, dependent on groundwater. Therefore, water development projects which could result in a reduction in groundwater could threaten, or perhaps even preclude, the existence and/or continued viability of associated fens.

Grazing and Haying

Drainage to accomplish grazing and haying mostly occurs on lower elevation fens, but can also occur at higher elevations. This practice is common in South Park fens in Colorado. However, no studies have been conducted to establish the extent of, or the impacts of, this practice in peatlands in Colorado.

Impacts Associated with Grazing and Haying

Studies of the impacts of grazing on peatlands have not been conducted in Colorado. However, significant impacts can result from attempts to drain peatlands for conversion to pasture or haying. These impacts are similar to those associated with peat mining, and real estate and water development. In addition, in agricultural areas, the introduction of carbonates, sulfates, or phosphates is common. These substances are constituents of lime, gypsum, and fertilizer that may be applied to a wetland being used for agriculture. In any wetland, including peatlands, these substances can complex and mobilize uranium (Langmuir 1978; Zielinski and Meier 1988).

Replaceability of Colorado Peatlands

In the 1996 404 permit denial of the Robert Wright Peat Mining project in South Park, the U.S. Army Corps of Engineers stated that they know of "no demonstrated or realistically means by which peatlands, and the unique combination of functions and values they provide, can be replaced" (Tri-Lakes Project Office 1996).

The following factors are considered to be the primary influences on the replaceability of peatlands:

Rate of Peat Accumulation

The rate of peat accumulation in Colorado fens is extremely slow. Most peatlands likely have peat accumulation rates of 8 to 11 inches per thousand years. With such slow rates of accumulation of peat, the fens of Colorado have been developing for many thousands of years. Cooper's 1990 study of South Park peatlands dated five peat cores using Carbon 14 dating. **Table 9** is a summary of these data. Some of Colorado's peatlands are more than 10,000 years old with peat accumulation rates ranging from 4.3 to 16.2 inches/thousand years. Considering the slow accumulation rate of peat, peatlands cannot seriously be considered as a renewable resource (Borland 1993, Cooper 1990).

Table 9 Ages and Peat Accumulation Rates for Five South Park, Colorado Peatlands (Cooper 1990)

Study Area	Date Before Present	Depth of Peat	Years/Inch (cm)	Inches(cm)/Thousand Years
Sacramento Creek	9,820 ± 150	7'0"-6'10"	117(297)	8.6 (21.8)
Carpenter's	9,280 ± 180 3,740 ± 90	10'3"-10'6" 4'11"-5'0.5"	61.8 (157) to 73.6 (186.9)	16.2 (41.1) to 13.6 (34.5)
McMasters	9,220 ± 110 3,710 ± 90 104.5 ± 0.8%	11'1:-10'11" 3'6"-3'7.5" 0-2"	69.3 (176.0) to 85.3 (216.7)	14.4 (36.6) to 11.7 (29.7)
Lost Park	10,080 ± 150 3,570 ± 100	8.54' 3.57'1.5"	98.4 (249.9) to 80.5 (204.5)	10.2 (25.9) to 12.5 (31.8)
High Creek-Windmill	8,270 ± 140	90 cm	233.4 (592.8)	4.3 (10.9)

Peat accumulates slowly in all southern Rocky Mountain peatlands, but the rate of accumulation in extreme rich fens, as low as 4 inches per thousand years (Cooper 1990b), is exceedingly slow. This slow rate is, in part, a result of the dry climate in South Park and low precipitation rates (Sanderson 1996). **Table 10** is a comparison of depth of peat, peat accumulation rates, pH, calcium content in water, and important plant species.

Table 10 Comparison of rich and extreme rich fens in and near South Park (based on Cooper (1990b) and Sanderson 1995 field work)

	Rich Fen	**Extreme Rich Fen**
Peat Depth	Moderate: up to 12 ft. (4 m)	Thin: typically less than 5 ft (1.5 m) in deepest spot, often 3 ft. (1 m) or less
Peat Accumulation Rate	Moderate: 10-16 in. (25-40 cm) per thousand years	Slow: 4.3 in. (11 cm) per thousand years at High Creek Fen
pH	Around neutral or slightly acidic (6.0-7.6)	Basic (7.4-8.6)
Calcium Content of Water	Moderate: 1.5-2.5 mg/l	High: 15-95 mg/l
Important Plants	*Salix planifolia, Carex utriculata, Carex aquatilis*	*Salix candida* (state rare), *Kobresia simpliciuscula, Kobresia bellardii* (typically alpine)

Mitigation for Wetland Losses from the Removal of Peat

Plant species present in fens are dependent on the peat substrate for hydrologic and nutrient support. Removal of peat results in alteration of the hydrology and the substrate in which fen plant species can grow. The alteration of hydrologic function in mined peatlands destroys the conditions necessary for natural revegetation (Borland 1993). Because of the slow rate of peat formation, after peat is removed, the conditions are no longer present for the formation of new peat or the support of most fen plant species. Therefore, on-site or in-kind replacement of peatlands is not possible.

Mitigation Policy Habitat Value

No evaluation species have been identified or designated for peatlands in Colorado. However, in a FWS 1995 memorandum on Region 6 policy on the use of the Mitigation Policy to Protect Unique Ecosystems, the primary author of the mitigation policy, who is now the Assistant Regional Director for Fisheries in Region 3, stated that, "There is nothing in the Mitigation Policy that indicates than an evaluation species cannot be stated as an ecological community and there is nothing in the Mitigation Policy that states that wildlife only refers to ducks and deer and excluded insects, mollusks, zoo plankton and, of course, fish . . . . " The author suggested that fens could be designated by the field supervisors as "unique and irreplaceable habitat, pursuant to Resource Category 1, and that the evaluation species are the very unique assemblage of both plants and animals that occupy the niche."

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