DRAFT

Condition Checklist for Fens in the Montane and Subalpine Zones of the Sierra Nevada and Southern Cascade Ranges, CA

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Contents

Appendices

Figures

Sierra Nevada Fen Condition Draft Checklist (sloping fens) 12/14/200
Adapted from Prichard et al. 1999

Name of Fen-Wetland Area:	
Date:	
ID Team Observers:	

Potential:

Yes	No	N/A	HYDROLOGICAL
			1. Water table is at or near the surface (take into account precipitation for that year) Guideline for most fens: <20 cm from surface in July and August. Water Table Depth:____________________
			2. Potential extent of the fen, i.e. fen is enlarging or has achieved potential extent Current area:__________/Potential area:___________ x100 = ________%
			3. Upland watershed is not contributing to fen degradation
			4. Natural surface or subsurface flow patterns are unaltered (i.e. no flow pattern disturbance by dams, dikes, trails, hoof action, roads, rills, gullies, drilling activities, etc.) Flow pattern disturbance observed:______________________________________

Yes	No	N/A	VEGETATION
			5. Vegetation has a high percentage of native plant species by ocular cover estimate. native cover:_________ / total cover ____________ x 100 = ____________
			6. Vegetation has a high percentage of peat-forming plant species (either vascular or non-vascular plants) by ocular cover estimate. peat forming cover:_________ / total cover ____________ x 100 = _______
			7. Plant species present indicate maintenance of fen soil moisture characteristics.
			8. Fen indicator species present and well represented - generally applicable to poor fens, transitional fens, and rich fens. # of fen indicator spp:______________

Yes	No	N/A	EROSION DEPOSITION
			9. Amount of bare soil and bare peat is within guidelines for healthy fen systems. Guideline < 20% bare soil and bare peat. %bare peat and bare soil _______%
			10. Surface disturbance does not significantly expose peat or cause fragmentation of the vegetative (vascular and nonvascular) cover. (make notes as to significant disturbances)

				11. Fen–wetland is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Item Number	Remarks

SUMMARY DETERMINATION

___ Proper Functioning Condition

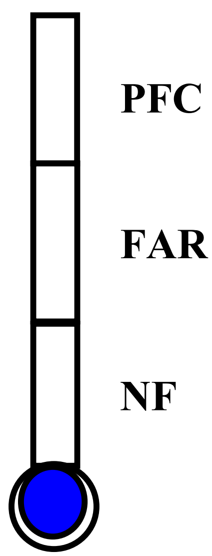
___ Functional - At Risk

___ Nonfunctional

___ Unknown

Trend for Functional - At Risk:

___ Upward
___ Downward
___ Not Apparent



Are factors contributing to unacceptable conditions outside the control of the manager?

Yes ___
No ___

If yes, what are those factors?

___ Flow regulations
___ Mining activities
___ Upstream channel conditions
___ Channelization
___ Road encroachment
___ Oil field water discharge
___ Augmented flows
___ Other (specify)

Purpose

The purpose of this document is to provide a checklist to help rate the condition of fens in the Sierra Nevada. This checklist is preliminary at this stage and should be considered as a starting point. The intention is to have this checklist reviewed by botanists, range conservationists, the National Riparian Service Team, and research (including Dr. David Cooper at Colorado State). The field assessment is designed to be done by an interdisciplinary (ID) team composed of botanists, range, and soils/hydrology expertise. The attributes in the checklist should be factors that can be estimated or measured directly in the field with a minimum of equipment. The design has similarities to a checklist prepared by Joe Rocchio of the Colorado Natural Heritage Program (Rocchio 2005) for fens. This checklist is similar to the Bureau of Land Management Proper Functioning Condition checklists for lentic areas (Prichard et al. 1999) -- but is tailored more for fens. Plant nomenclature follows the Jepson Manual (Hickman 1993).

Background

Definition of a fen
Fens are areas where there is at least 40 cm of organic soils in the upper 80 cm of the soil profile (Rocchio 2005). The organic soil consists of at least 12 – 18% organic-carbon content by weight (USDA 1994). This organic soil is commonly referred to as peat. Fens form where the rate of plant growth exceeds the rate of carbon decomposition of litter. Both saturated soils and cool temperatures slow decomposition to the point that productivity exceeds decomposition, resulting in an accumulation of organic matter (i.e. peat). Peat accumulates slowly, anywhere from 11 to 41 cm (4.3 to 16.2 inches) per thousand years in the Rocky Mountains (Cooper 1990, Chimner and Cooper 2002).

Types of fens
Fens are found in four major geomorphic settings in the Sierra Nevada (USFS 2006, Cooper et al. 2005a). The vegetation of fens varies widely and appears to be controlled by the hydrologic regime (water depth, water flow rates), as well as water chemistry (pH, cation and anion concentrations, nutrients) (Cooper et al. 2005a). The four major types are: sloping, basin, mound, and lava. In addition, Cooper et al. (2005a) identified a gradient of rich to poor fens based on pH and water chemistry within the sloping fen type.

> **Sloping fens**: Sloping fens also called soligeneous peatlands (Mitsch and Gosselink 2000); occur on or at the base of slopes where groundwater discharges due to a break in the topography or change in geology or in valley bottoms where alluvial groundwater supports peat formation (Cooper 1990, Rocchio 2005, Woods 2001). This type of fen is usually fed by a spring. This is probably the

most common type of fen in the Sierra Nevada and the fen condition checklist is probably most appropriate for sloping fens. Within this type, Cooper et al. (2005a) further differentiated types based on species composition and soil pH. These types were identified as poor fen, transitional fen, extreme rich fen, and rich fen.

Basin fens: Basin fens, also called topogeneous peatlands, develop in topographic depressions that typically have no inlet or outlet (Rocchio 2005). Their water source includes upwelling groundwater or surface runoff from the basin edges (Charman 2002). Some of these types develop a unique fen type, a floating fen or floating mat, on the margins of open water.

Mound fens: Mound fens are raised areas where peat has accumulated due to upwelling of water. This type often occurs at the base of slopes. In this fen type there is an outlet so they are not classified as basin fens. Mound fens are often associated with sloping fens.

Lava: Lava fens have been described by Cooper et al. (2005a). Lava fens appear to be restricted to the southern Cascades, primarily on the Lassen and Modoc National Forests. Lava fens are created when a lava discontinuity creates hillside groundwater flow systems. These fens are similar to the sloping fen type and differ due to their unique geology.

Threats

Groundwater alteration

The integrity of peatland systems is inherently tied to hydrologic conditions. Water diversions, ditches, and roads can have a substantial impact on the hydrology as well as the biotic integrity of fens (Johnson 1996, Woods 2001, Cooper et al. 1998). For example, roads placed above fens may divert runoff away from the fen and the result is a de-watering of the fen. Once the water table is lowered, peat oxidization and subsequent decomposition occurs quickly thereby reducing the peat depth, altering hydrologic patterns, and resulting in a change in plant species composition (Cooper 1990). In addition, roads can act as sources of sediment input into fens. As areas dry out, plant species often change to non peat-forming species such as forbs. Since this system is reliant on groundwater any disturbances that impact water quality or quantity are a threat. These threats include groundwater pumping, mining, improper placement of roads, water diversions, holes dug for water sources for livestock.

Land use

The types of land use occurring on near fens can threaten fens. Livestock management can impact peatlands by compacting peat, creating bare areas of soil and peat, and trampling. Cooper et al. (2005b) also found that more than 20% bare ground can result in a negative carbon budget and therefore a loss of peat. In some cases, cattle trails can lead to head cuts or channelization of water that alters the hydrology, lowers the water table, and dries out areas of the fen. As areas dry out or are overgrazed, plant species often change to non peat-forming species such as forbs and moss cover diminishes leaving exposed peat. Fens provide unique habitats for rare plant species. As compared to other habitats, the disproportionately large number of rare species of vascular and nonvascular plants associated with peatlands in the Sierra Nevada further underscores the importance of these habitats with respect to the biological diversity of the region. Off highway vehicle (OHV) use can negatively impact fens by exposing soil and bare peat, creating channels in fens, which acts as a water diversion, and compacting soil.

Exotics
Invasion by exotic species (nonnative plant species) is apparent in some peatlands in the Sierra Nevada. Such species include timothy (*Phleum pratense*) as well as exotic species common to other wetland types such as Canada thistle (*Cirsium arvense*) and dandelion (Taraxacum officinale). Native increasers (plants that increase after diturbance) such as *Phalacroseris bolanderi*, *Mimulus primuloides*, and tinker's penny (*Hypericum anagalloides*) often invade a fen that has been overgrazed or artificially drained. Although these species are native and commonly found in low abundance in undisturbed fens, they can be indicative of disturbance if they dominate areas previously occupied by sedges (Ratliffe 1985, Rocchio 2005).

Proper Functioning Condition (PFC)

Proper Functioning Condition (PFC) (from Prichard et al. 1999)

Proper functioning condition (PFC) is a qualitative method for assessing the condition of fen areas (Prichard et al. 1999). Some of the checklist items may be quantitatively measured to arrive at a condition rating. The term PFC is used to describe both the assessment process, and a defined, on-the-ground condition of a fen area.

The PFC assessment refers to a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of a fen. A checklist is used (pages 1 and 2 of this document), which synthesizes information that is fundamental to determining the overall health of a fen area.

Consideration of Capability and Potential

Each fen area has to be judged against its capability and potential (from Prichard et al. 1999). The capability and potential of natural fen-wetland areas are characterized by the interaction of three components: 1) hydrology; 2) vegetation, and 3) soil and erosion components.

> **Potential** is defined as the highest ecological status a fen area can attain given no political, social, or economic constraints; it is often referred to as the "potential natural community" (PNC).
>
> **Capability** is defined as the highest ecological status a fen area can attain given political , social, or economic constraints. These constraints are often referred to as limiting factors.

If a fen area is not at PFC, it is placed into one of three other categories:

Functional- At risk – fen areas that are in functional condition, but that have an existing soil, water, or vegetation attribute that makes them susceptible to degradation.

Nonfunctional – fen areas that clearly are not providing adequate vegetation, soil and water characteristics, to maintain a healthy peat system.

Unknown – fen areas for which there is a lack of sufficient information to make any form of determination.

Determination of Potential for fen sites

When beginning the PFC process on a fen area, it is important for the ID team to discuss and determine the potential of the fen area. Fens vary in the type plant species that are established at potential and fens in the Sierra Nevada have been greatly impacted by grazing impacts, water diversions, and management in general. This disturbance has significantly altered the appearance and vegetation make-up of most fens. Yet, fens that are functioning properly have the following characteristics in common:

- Maintenance of a high water table and saturated soils during the summer months that limit decomposition rates
- Sufficiently low soil temperatures that limit microbial activity and higher CO^2 emissions
- Natural surface and subsurface flow patterns are not significantly affected by disturbance
- Good cover of vegetation (both vascular and nonvascular) and litter over the peat body with little exposed peat
- A high proportion of plant species that are peat forming plants
- Fen is in balance with the water and sediment being supplied by the watershed (i.e. no excessive erosion or deposition).

It is important for the ID team to address the potential of a fen using vegetation, hydrologic, and soil characteristics given the capability of the site. When discussing the potential of a site use the following points to guide the discussion process. This approach, outlined by Prichard et al. (1999), requires the team to:

- Look for relic areas (exclosures, preserves, etc.).
- Seek out historic photos and documentation that indicates historic condition
- Search out species lists (animals and plants – historic and present).
- Determine species habitat needs (animals and plants) related to species that are/were present.
- Examine the soils and determine if they were saturated at one time and are now well drained?
- Examine the hydrology; establish the likely water table depths and variation through the summer in different parts of the fen.

- Identify the vegetation that currently exists. Are they the same species that occurred historically and likely formed the peat layers?
- Determine the watershed's general condition.
- Look for limiting factors, both human-caused and natural, and determine if they can be corrected.

Once the team has discussed the vegetation, hydrologic, and soil and water characteristics using the points above, make a note of the potential for the site at the top of the condition checklist in the box labeled "Potential".

Note: the checklist should be used on areas that are already identified as fens according to the R5 fen Survey Form. The above attributes are not designed to determine if a site fits the criteria of a fen.

Functional Rating

The condition checklist has eleven attributes for assessing the functionality of the site. Previous inventories of Sierra Nevada fens and wetlands as well as the literature (Ratliffe 1985, Bartolomne et al. 1990, Allen-Diaz 1991, Chadde et al. 1998, Cooper et al. 1998, Prichard et al. 1999, Mitsch and Gosselink 2000. Cooper 2005, Cooper et al. 2005a, Cooper et al. 2005b, Rocchio 2005) suggests that the attributes in the checklist are important measures of the functional status of Sierra Nevada montane and subalpine fens and fens in general. These attributes were chosen because they can be observed in the field and do not require complex equipment. The checklist items can be broadly classified under: 1) hydrologic; 2) vegetation; and 3) and soil and erosion attributes.

Following completion of the checklist, a "functional rating" is determined based on an ID team's discussion (Prichard et al. 1999). When determining the functional rating, it is important for the ID team to understand the type of fen being assessed. The ID team must review the "yes" and "no" answers on the checklist and their respective comments about the severity of the situation, then collectively agree on a rating of proper functioning condition, functional-at risk, or nonfunctional. If an ID team agrees on a functional-at risk rating, a determination of trend is then made whenever possible.

There is no set number of "no" answers that dictate whether an area is at-risk or nonfunctional. This is due to the variability in kinds of fen-wetland areas (based on differences in climatic, geology, landform, vegetation, and substrate) and the variability in the severity of individual factors relative to an area's ability to maintain a functioning peat body.

If a fen area possesses the characteristics of a healthy fen described above, then it has a high probability of maintaining a functioning peat layer. If all the answers on the checklist are "yes", this area is in proper functioning condition. However, if some answers on the checklist are "no", the area may still meet the definition of PFC. The ID team reviews the "no" answers and determines if any of these answers make this fen area susceptible and cause a degradation of the peat body. If they do, the ID team would rate the area and explain why it is something less than PFC.

A functional-at risk fen area will some or even most of the elements in the checklist, but have at least one attribute that gives it a high probability of degradation for any elements of the definition given above (Prichard et al. 1999). Most of the time, several "no" answers will be evident because of the interrelationships between items in the checklist. If the ID team thinks that these "no" answers collectively provide the probability for degradation from the definition elements above, then the rating is functional-at risk. If there is disagreement among the team members after all the comments have been discusses, it is probably advisable to be conservative in the rating (i.e. if the discussion is between PFC and functional-at risk, then the rating should be functional-at risk).

Trend must be determined, if possible, when a rating of functional-at risk is given. Preferably, trend is determined by comparing the present situation with previous photos (Prichard et al. 1996), trend studies, inventories, and any other documentation or personal knowledge. In the absence of information prior to the assessment, indicators of "apparent tend" may be deduced during the assessment process. Recruitment and establishment of wetland species (or absence thereof) that indicate an increase or decline in soil moisture characteristics can be especially useful. However, care must be taken to relate these indicators to recent climatic conditions as well as to management. If there is insufficient evidence to make a determination that there is a trend toward PFC (upward) or away from PFC (downward), then the trend is not apparent.

Nonfunctional fen areas clearly lack the elements listed in the definition above. Usually nonfunctional fen areas translate to a preponderance of "no" answers" on the checklist, but not necessarily all "no" answers. A fen area may still be dominated by peat forming plant species but be clearly nonfunctional because of a water diversion that is clearly lowering the water table and causing establishment of plant species that indicate drying conditions.

It is imperative for management interpretation of the checklist to document factors contributing to unacceptable conditions outside management's control for functional-at risk and nonfunctional ratings where achievement of PFC may be impaired (Prichard et al. 1999). It is desirable to document any of the factors listed if they occur, even if they don't appear to be affecting the achievement of PFC.

Checklist Attributes

Hydrologic attributes

Attribute 1. Water table depth (from Rocchio 2005)
This attribute measures water table depth based on a single site visit in July or August.
Rationale: The integrity of peatland systems is inherently tied to hydrologic conditions. In a study of fens in the Southern Rocky Mountains, only those areas with soil saturation or a water table within 30 cm of the soil surface through July and August accumulated

peat (Cooper 1990, Chimner and Cooper 2003). In many fens, the water table can drop in late-July and August so careful interpretation of this metric needs to be implemented (Cooper 1990).

Measurement – This metric is measured by augering several holes in the wetland and getting an average depth to water table. Allow at least 30 minutes to pass before measuring the water level in the soil auger holes. The distance between the soil surface and the water level equals the depth to water table. This metric should only be used during site visits made in mid-July through August. When making these measurements, disturb the fen as minimally as possible. Consideration of annual precipitation and annual snowpack are needed to assess the reliability of this metric (Rocchio 2005). During years of average precipitation (or average snowpack) this metric, taken together with the other metrics, is a reliable rapid method of assessing the integrity of the groundwater levels in the wetland. In order to make a determination of "yes" or "no" on this attribute, the ID team uses the average depth to water table as a general guideline considering the potential and capability of the site. As a general guideline, if the average water table depth in the fen is greater than (>)20 cm during the site visit the answer to item 1 would be "no".

Attribute 2. Has the wetland achieved potential extent? (from Prichard et al. 1999, Rocchio 2005)
This attribute is an estimate of whether the fen has achieved its potential extent. This metric is calculated by dividing the current size of the wetland by the total potential size of the wetland multiplied by 100 (from Rocchio 2005).

Rationale: Relative size is an indication of the amount of the wetland lost due to human-induced disturbances. For example, if field observation indicates that the historic or potential size of the wetland was 1 hectare, and field validation indicates that the extent of the fen is now only 0.5 hectare, the relative size is 50%.

Measurement: Relative size can be measured on aerial photographs, orthophoto quads, or inventory maps. However, field calibration is required to discern more accurately the potential and existing extent of the fen. Determining the potential extent of the fen often requires hydrologic and soil expertise. Evidence that a wetland is narrowing may include an increase in upland and/or non-hydric vegetation at the margins, or lowered water tables. If the ID team finds that a significant reduction in area of the fen has occurred, due to changes in vegetation, hydrology, or soils due to roads, impoundments, development, and human-induced drainage the answer to item 2 would be "no".

Attribute 3. Upland watershed is not contributing to fen degradation. (adapted from Prichard 1999, Rocchio 2005)
This attribute is an estimate of the degree to which adjacent land uses and human activities have altered hydrologic processes.
Rationale: Land uses near the wetland can reduce soil permeability, affect surface water inflows, impede subsurface flow, and lower water tables. The purpose of this item is to address whether there has been a change in the water or sediment being supplied to the

wetland area and whether it is resulting in degradation (Prichard et al. 1999). This item pertains to whether uplands are contributing to the degradation of a fen – wetland area; it does not pertain to the condition of the uplands.

Measurement: Evidence that a wetland area is being degraded would include ditches or channels that are impeding or altering surface or groundwater inflows, and fan deposits showing excess sediment being deposited into the wetland. If any of these items are present, the answer to item 3 would be "no".

Attribute 4. Natural surface or subsurface flow patterns are not altered by disturbance (i.e., hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities) (adapted from Prichard 1999, Rocchio 2005).

Rationale: Land uses within the wetland can reduce soil permeability, affect surface water inflows, impede subsurface flow, and lower water tables. The purpose of this item is to address whether the natural surface or subsurface flow patterns have been altered resulting in degradation to the fen (Prichard et al. 1999).

Measurement: Evidence that the natural surface or subsurface flow patterns have been altered would include hummocking from hoof action of grazing animals, dams, dikes, trails, roads, gullies or any disturbance that impedes or alters surface or groundwater flows and in the judgment of the team is causing degradation to the fen. If any of these items are present, the answer to item 4 would be "no".

Figure 1. Photo of ditch that has been dug in a fen on the Tahoe National Forest. This ditch is approximately 6 inches (15 cm) deep and runs along the contour of the fen and is dewatering this general area of the fen.

Vegetation attributes

Attribute 5. Percentage of native plant species (from Rocchio 2005)
The percentage of native plant species is based on the cover of native species relative to total cover of all plant species.

Rationale: Native plant species dominate Sierra Nevada wetlands that have excellent ecological integrity (Cooper 2005b). This metric is a measure of the degree to which native plant communities have been altered by human disturbance. With increasing human-disturbance, non-native species invade and can dominate the wetland (Rocchio 2005).
Measurement: The objective is to determine the relative percent cover of native plant species growing in the fen. An ocular estimate of cover is used to calculate the relative cover. The entire fen area should be walked and an ocular estimate of the cover of the dominant plant species growing in the wetland should be made using the form in Appendix 3. Record the cover in cover classes and then convert to a cover class midpoint on the form (see Appendix 3). The suggested cover classes are:

Cover class	Cover	Midpoint
1	< 5 %	2.5
2	5 – 25%	15
3	25 – 50%	37.5
4	50 – 75%	62.5
5	75 – 95%	85
6	95 – 100%	97.5

To arrive at the relative percent cover of native species divide the total cover of native species by the total cover of all species and multiply by 100. The ID team can use the relative percent of native species as a reference point while discussing whether this attribute should be rated as “yes” or “no”. The ID team should consider the relative percent cover of native species vs. all species, the types of nonnative species that may be present, and the possible cause(s) of establishment of nonnative species when rating this attribute.

Attribute 6. Percentage of peat-forming plant species
This attribute measures the ratio of the cover of peat-forming plants relative to the total cover of all plant species.
Rationale: Peat-forming plant species dominate Sierra fens (Cooper et al. 2005b). Peat-forming plants, especially clonal sedges such as beaked sedge (*Carex* utriculata), Nebraska sedge (*Carex nebrascensis*), Water sedge (*C. aquatilis*), and short-beaked sedge (*Carex simulata*), are important functional components of fens. These species, due to their dense, deep root masses are critical for the development and stability of the peat layer (Cooper 2005). In addition, plants such as sundew (*Drosera rotundifolia*), *Narthecium californicum*, and mosses such as *Sphagnum* spp., *Drepanocladus* spp, and

Philonotis spp. are important in peat formation. Appendix 2 has a draft list of the important peat-forming plants in montane and subalpine regions of the Sierra Nevada. Cover of native, peat-forming graminoids tends to be higher in rich fens. In poor fens, plant cover may be dominated by mosses with little cover of native graminoid species. Yet, even in poor fens that are functioning properly, the ratio of cover for peat-forming species to the total cover all species is high. In general, with increasing human-caused disturbance, peat-forming cover decreases relative to the cover of non peat-forming species. Non peat-forming species common in fens in the Sierra Nevada include primrose monkeyflower (*Mimulus primuloides*), alpine aster (*Aster alpigenus*), mountain dandelion (*Phalacroseris bolanderi*), and tinker's penny (*Hypericum anagalloides*).

Measurement: A qualitative, ocular estimate of cover is used to calculate and score the metric. The entire fen area should be walked and an ocular estimate of the total cover of peat-forming species growing in the wetland should be made. Record the cover of the dominant species in the fen using the field form in Appendix 3. Record the cover in cover classes and then convert to a cover class midpoint on the form (see Appendix 3). To calculate the relative percent cover of peat forming species divide the total cover of peat forming species by the total cover of all species and multiply by 100. The ID team can use the relative percent of peat forming species as a reference point while discussing whether this attribute should be rated as "yes" or "no".

Attribute 7. Species present indicate maintenance of fen soil moisture characteristics. (adapted from Prichard et al. 1999)

The intent of this attribute is to look for those species that indicate the presence of a shallow water table, which maintains fen-wetland species over time (Prichard et al. 1999).

Rationale: a persistent, shallow water table is essential to the maintenance and recovery of a fen-wetland area. This characteristic is not asking the amount of the species, but rather if the presence of these species indicate the maintenance of fen moisture conditions. Even species which can increase with disturbance, such as needle spikerush (*Eleocharis acicularis*), an obligate wetland species (OBL), may indicate maintenance of the water table in the absence of deep-rooted perennial plant species. This depends on how degraded the area appears and the types of species present.

Measurement: The entire occurrence of the fen should be walked and the presence of obligate wetland plants (OBL) and facultative wetland plants (FACW) should be noted. If facultative (FAC), facultative upland (FACU), or upland (UPL) species are present, this item would be answered "no" since these species typically occur in drier settings. There is a relationship between checklist 7 and items 1 and 4 in the hydrology section of the checklist. Lowering of the water table as indicated by the hydrologic attributes will often lead to establishment of drier species on the site.

Attribute 8. Presence of fen indicator species (adapted from Rocchio 2005)

This attribute measures the whether the site has plant species indicative of fens in the Sierra Nevada. This attribute applies to sloping fens that are classified as either poor fens, transitional fens, or rich fens.

Rationale: Plants grow in habitats for which they are adapted. Some plants have a wide tolerance of ecological conditions, while others require specific environmental conditions (Rocchio 2005). Indicator species are a useful for unique wetlands such as fens. Plant indicators have been identified for fens in the Sierra Nevada (Cooper et al. 2005a) and their presence is indicative of unimpacted fens in the region. A draft list of fen indicator plant species is given in Appendix 1.

Measurement: The total number of indicator species present is used to rate this metric. See Appendix 1 for a draft list of indicator species for sloping fens in the Sierra Nevada. The entire occurrence of the fen should be walked and the presence of any of the indicator species listed in Appendix 1 should be noted. Using the field form in Appendix 3, note whether the species is a fen indicator or not. After noting the number of fen indictors, the ID team will make a rating for this attribute based on the number of fen indicators present, and the potential and capability of the fen.

Soil and Erosion Attributes

Attribute 9. Percent cover of bare soil/bare peat

This attribute measures the amount of bare soil/peat in the fen. The amount of bare soil is expressed in percent cover.

Rationale: In a study by Chimner and Cooper (2003), percent bare ground or bare peat was positively correlated with a net loss of carbon. Decreased carbon sequestration was likely caused by lower plant production and higher ecosystem respiration. Grazing intensity decreased carbon storage due to increased bare ground from trampling. Chimner and Cooper found that when bare ground exceeded 20% cover in fens there was a net loss of carbon, i.e. the fens were losing peat. Note that a small amount of bare ground can occur naturally in fens. A sloping fen, surveyed in Sagehen basin (Mason fen) on the Tahoe National Forest, had 8% bare peat and was considered to be in good condition. On this fen, bare peat was found in water tracks and hollows in the fen that remain permanently saturated or inundated with slow moving surface water.

Measurement: Recording the amount of bare peat and/or bare soil requires careful examination of the site. We suggest a step point method along a pace transect to determine the percent cover of bare peat and/or bare soil. This method uses a narrow diameter pin placed at systematic intervals along a pace transect.

The procedure involves selecting a random transect through a representative part of a fen. For most fens, it may be adequate to start the pace transect at one end of the fen and work toward the opposite side. In order to get 100 points, you may need to reverse direction at the opposite end. In either case, sample a representative portion of the fen. A transect consists of 100 paces, resulting in 100 points sampled. The observer establishes a step-point by lowering the sampling pin to the ground, guided by a definite notch or mark in the toe of the boot. At each step-point, the observer places the boot at a 30 degree angle to the ground to avoid disturbing plants or litter in the immediate area and lowers the pin perpendicularly to the sole of the boot until the pin hits a plant or the ground. Disregard elevated parts of vascular plants because we are recording ground cover. The pin is pushed to the ground and a hit on bare soil, bare peat, litter, rock, gravel, moss, liverwort, or lichen is recorded. Total percentage of bare peat and bare soil is determined by dividing the number of hits for these categories by the total number of points sampled. For monitoring purposes, a more detailed quantitative determination of the percent cover of bare peat and bare soil using permanently marked transect lines and quadrat frames can be used (Weixelman et al. 1996).

Bare peat is peat that is exposed and has the consistency of peat. If litter covers the peat and the litter does not have the consistency of peat and has not been incorporated into the peat then count as litter (see Figures 2 and 3). Standing water that covers bare soil and bare peat presents a special case. In a paper by Chimner and Cooper (2003), CO_2 emissions were significantly higher when the water table was +1 to +5 cm above the soil surface, compared to when it was between +10 and + 6 cm above the soil surface. If the depth of standing water is greater (>) than 5 cm, then do not count as bare peat or bare soil (see Figure 4). Conversely, if the depth of standing water is less than (< or =) 5 cm, then count as bare peat or bare soil. In order to quickly determine the depth of water, make a mark at 5 cm on the pin used for the step-point count. As a general guideline, if the cover of bare peat and bare soil is greater (>) than 20%, then the answer to item 8 would be "no".

Figure 2. Photo of bare peat in fen. Note that surface litter (arrow) is decomposing and is in the process of being incorporated into the upper peat layer and has the consistency of peat.

Figure 3. Photo of litter cover in fen. Note that the litter layer is laying on the surface and is not incorporated into the peat layer and does not have the consistency of peat.

Figure 4. Photo of standing water in fen covering bare peat. Note that the standing water is less than (<) 5 cm deep and therefore would be marked as bare peat (see text).

Attribute 10. Surface disturbance does not significantly expose peat or cause fragmentation of the vegetative (vascular and nonvascular) cover.

The intent of this attribute is to determine whether there are significant impacts to the vegetative cover exposing the peat layer. This attribute is closely related to checklist item #9. However, item #9 measures the average amount of bare peat and bare soil only along the pace transect and may miss areas of impacts that are restricted in extent but significant.

Rationale: impacts due to hoof action from grazing animals can result in areas of bare peat and bare soil in wetlands and meadow areas in general. Excessive hoof action can alter natural surface or subsurface flow patterns in the fen and cause hummocking which in turn can cause drying in areas of the fen. Excessive hoof action can also weaken or destroy the rhizomatous root network of clonal peat-forming plants. Damage due to motorized or non motorized recreational vehicles can alter surface and subsurface flow patterns in fens and can result in areas of bare peat and bare soil. These areas of exposed peat will in turn dry out which can lead to a loss of peat. Damage from wheel tracks can also weaken or destroy the rhizomatous root network of clonal peat-forming plants.

Measurement: A qualitative, ocular estimate of the amount of surface disturbance is used score the metric. The entire fen area should be walked and an ocular estimate of the evidence of impacts which expose peat or cause fragmentation of the vegetative cover should be made. If the fen area shows no sign that its vegetative cover has been disturbed by management practices the answer to item 10 would be “yes”. If the ID team observes management activities that are causing significant breaks in the vegetative cover and exposing peat the answer to item 10 would be “no”. It is important to make notes on any management activities that cause this item to be checked as a “no”.

Figure 5. Photo of hoof prints and bare peat and mud in fen (from Cooper 2005a).

Attribute 11. Fen-wetland is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition) (adapted from Prichard et al.)

The intent of this attribute is to identify that water and sediment are being supplied at a natural rate and the fen can function properly.

Rationale: Increased flows into a fen or wetland area, and subsequent increased energy of water, may form headcuts, gullies, or channels. This process leads to dewatering of the entire fen or areas near the downcut. Small waterways or watertracks are natural in fens. However, road building, water diversions, grazing or other management activity can cause an increase in flows and energy into a fen causing excessive erosion leading to visible signs such as headcuts, rilles, gullies, or channels.

The type and amount of land use in the wetland and contributing watershed affects the amount of sediment that enters into a fen (Rocchio 2005). Excess sediment can change nutrient cycling, bury vegetation, suppress regeneration of plants, and carry pollutants into the fen.

Measurement: If a fen shows evidence of excessive deposition or if flow has been added and excessive erosion or deposition is taking place as a result of this increased flow, the answer to item 11 would be "no". Indicators of excessive erosion or deposition can include fans of sediment being deposited over the fen, headcuts, rilles, gullies, and channelization.

Figure. 6. Sediment being deposited (lower left corner of photo) directly from a road. The road is located immediately to the left of the fen in this photo.

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Appendix 1. Draft list of indicator plants for sloping fens in the montane and subalpine zones of the Sierra Nevada. NOTE: this list will be discussed at the R5 botany meeting in Feb. We plan to include whether the plants are obligate fen, facultative fen and so forth.

Plant scientific name (Hickman 1993)	**Common name (NRCS Plants Database)**	**Notes:**
Carex utriculata	Beaked sedge	Sedge
Carex alma	Sturdy sedge	Sedge
Carex amplifolia	Bigleaf sedge	Sedge
Carex canescens	Silvery sedge	Sedge
Carex capitata	Capitate sedge	Sedge
Carex echinata	Star sedge	Sedge
Carex illota	Sheep sedge	Sedge
Carex scirpoidea	Northern singlespike sedge	Sedge
Carex simulate	Analogue sedge	Sedge
Carex limosa	Mud sedge	Sedge
Eleocharis pauciflora	Fewflower spikerush	Rush
Scirpus microcarpus	Panicled bulrush	Bulrush
Scirpus pumilum	Bulrush	Bulrush
Rhynchospora alba	Beaked-rush	Cyperaceae
Rhynchospora capitellata	Brownish beaksedge	Cyperaceae
Eriophorum criniger	Fringed cottongrass	Cottongrass
Drosera rotundifolia	Round-leaved sundew	Forb
Drosera anglica	English sundew	Forb
Kobresia myosuroides	Bellardi bog sedge	Forb
Oxypolis occidentalis	Western cowbane	Forb
Thalictrum alpinum	Alpine meadow-rue	Forb
Tofieldia occidentalis	Western false asphodel	Forb
Darlingtonia californica	California pitcher plant	Forb
Drepanocladus spp.	Drepanocladus moss	Moss
Philonotis spp.	Philonotis moss	Moss
Meesia triquetra	Meesia moss	Moss
Meesia uliginosa	Meesia moss	Moss
Sphagnum spp.	Sphagnum moss	Moss
Aulocomnium palustre	Aulocomnium moss	Moss
Campylium stellatum	Campylium moss	Moss
Vaccinium uliginosum	Bog blueberry	Shrub
Ledum glandulosum	Western Labrador tea	Shrub
Kalmia polifolia	Bog laurel	Subshrub

Appendix 2. Draft list of peat forming plants for sloping fens in the montane and subalpine zones of the Sierra Nevada. NOTE: to be discussed at the R5 botany meeting.

Plant scientific name (Hickman 1993)	**Common name (NRCS Plants Database)**	**Notes:**
Carex utriculata	Beaked sedge	Sedge
Carex vesicaria	Blister sedge	Sedge
Carex aurea	Golden sedge	Sedge
Carex nebrascensis	Nebraska sedge	Sedge
Carex alma	Sturdy sedge	Sedge
Carex amplifolia	Bigleaf sedge	Sedge
Carex canescens	Silvery sedge	Sedge
Carex capitata	Capitate sedge	Sedge
Carex echinata	Star sedge	Sedge
Carex illota	Sheep sedge	Sedge
Carex scirpoidea	Northern singlespike sedge	Sedge
Carex simulate	Analogue sedge	Sedge
Carex limosa	Mud sedge	Sedge
Carex lemmonii	Lemmon's sedge	Sedge
Carex luzulina	Woodrush sedge	Sedge
Carex scopulorum	Mountain sedge	Sedge
Eleocharis pauciflora	Fewflower spikerush	Rush
Scirpus microcarpus	Panicled bulrush	Bulrush
Scirpus pumilum	Bulrush	Bulrush
Rhynchospora alba	Beaked-rush	Cyperaceae
Rhynchospora capitellata	Brownish beaksedge	Cyperaceae
Eriophorum criniger	Fringed cottongrass	Cottongrass
Drosera rotundifolia	Round-leaved sundew	Forb
Drosera anglica	English sundew	Forb
Kobresia myosuroides	Bellardi bog sedge	Forb
Oxypolis occidentalis	Western cowbane	Forb
Thalictrum alpinum	Alpine meadow-rue	Forb
Pedicularis groenlandica	Elephantshead	Forb
Pedicularis attolens	Little elephantshead	Forb
Tofieldia occidentalis	Western false asphodel	Forb
Darlingtonia californica	California pitcher plant	Forb
Drepanocladus spp.	Drepanocladus moss	Moss
Philonotis spp.	Philonotis moss	Moss
Meesia triquetra	Meesia moss	Moss
Meesia uliginosa	Meesia moss	Moss
Sphagnum spp.	Sphagnum moss	Moss
Aulocomnium palustre	Aulocomnium moss	Moss
Campylium stellatum	Campylium moss	Moss
Vaccinium uliginosum	Bog blueberry	Shrub
Ledum glandulosum	Western Labrador tea	Shrub

Appendix 2 continued. Draft list of peat forming plants for sloping fens in the montane and subalpine zones of the Sierra Nevada.

Kalmia polifolia	Bog laurel	Subshrub
Menyanthes trifoliate	Buckbean	Forb
Juncus oxymeris	Pointed rush	Rush
Juncus nevadensis	Sierra rush	Rush
Juncus phaeocephalus	Brownhead rush	Rush
Juncus balticus	Baltic rush	Rush
Glyceria borealis	Small floating mannagrass	Grass
Spiranthes romanzoffiana	Hooded ladies tresses	Orchid
Pinus contorta	Lodgepole pine	Tree
Carex lenticularis	Lakeshore sedge	Sedge

Appendix 3. Draft field form for recording plant species data.

Plant species	Cover class	Mid point	Peat forming (yes or no)	Native species (yes or no)	Fen indicator species (yes or no)	Wetland status
Total cover						
Relative cover peat forming species =						
Relative cover of native species =						

Cover class	Cover	Midpoint
1	< 5 %	2.5
2	5 – 25%	15
3	25 – 50%	37.5
4	50 – 75%	62.5
5	75 – 95%	85
6	95 – 100%	97.5