Fen Survey Report
Bucks Lake Wilderness
Plumas National Forest

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2005 & 2006

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INTRODUCTION

The Sierra Nevada Framework has identified riparian and other water-dependent habitats as places of interest and concern on National Forest land, due to their uniqueness and vulnerability to disturbance. Fens are one type of wetland habitat, and the Plumas National Forest initiated surveys in 2003 to identify, characterize, and map the fens on the Forest. Fen surveys were conducted by Jim and Catie Bishop between July and October in both 2003 and 2004 on the Feather River Ranger District (FRRD) and in the Bucks Lake Wilderness (BLW) area in 2005 & 2006. We refer to this survey as the "Buck's Lake Wilderness" survey, however the survey includes adjacent areas that lie outside the Wilderness boundary. This report describes the Bucks Lake Wilderness fens, and makes some comparisons with the FRRD fens. The FRRD fens are described in the 2004 (which cumulatively include 2004 & 2003) and 2003 fen reports.

There are three currently accepted criteria for defining a fen. First of all it must be continuously saturated, and dry only minimally or not at all during the dry season. The continuous wetness encourages the formation of peat. Peat is incompletely decayed vegetation, the decay being retarded by water-saturated, cool, oxygen-deficient conditions. The second criteria for a wetland to be a fen is a peat depth of 40 centimeters or greater. Peat forms exceedingly slowly and deep peat layers indicate a stable environment lasting perhaps several thousand years. The peat builds up under the current year's vegetation, whose roots are contained within the peat layer and not in direct contact with mineral soil. So the third criteria is that the vegetation in a fen receives essentially all of its mineral nutrients from ground water (as it is not rooted in mineral soil). The fens encompass wetter and drier areas, as well as various depths of peat. So, not every square foot is technically a fen. However, in this report, the entire open area of perennially-saturated wetland, excluding forest and shrub border, is referred to as the fen opening. The fen perimeter follows the edge of the fen opening, as shown in Appendix D and on the GIS layer.

Fens are unique and important in the following ways:

- They contain a higher diversity, and a much higher diversity per unit area, of plant species than the surrounding forest
- They lack invasive non-native plant species.
- Fen imposes varied habitat structure that supports a higher diversity of wildlife than in the adjacent forest.
- They embody a biostratigraphic record that preserves plant and climate data over millennia.
- Fens are relatively rare on the landscape and represent outlying examples of higher-latitude ecosystems.

Further studies of the fens will be able to give us insights into important areas such as:

- Some of the fens may have begun to form at the end of the last ice age, and studying peat cores will help us understand the ecological history of the fen through post-glacial time.

- Pollen cores will enable us to know about changing plant community composition and abundance, both within and outside the fen.

- Isotope studies of the water in the fen could reveal when that water fell as rain, and how long it has been traveling underground. This will give us insight into the hydrologic framework that has formed and maintains the fens.

- Plant and water chemistry studies will show us how vegetation, especially mosses, interacts with water chemistry and influences nutrient availability.

- Studies of outside influences, such as cattle grazing and human impact, will help us better manage these unique wetlands.

Overview of this report:

I. Regional Setting

II. Scope and Methodology of This Study

III. Description of Fen Characteristics Observed in The Bucks Lake Wilderness Fens

IV. Hydrologic Changes Observed

V. Fen Comparisons and Correlations: Geographic, Botanical, Relative to Grazing Use, and to De/Re-Watering

VI. Discussion and Conclusions

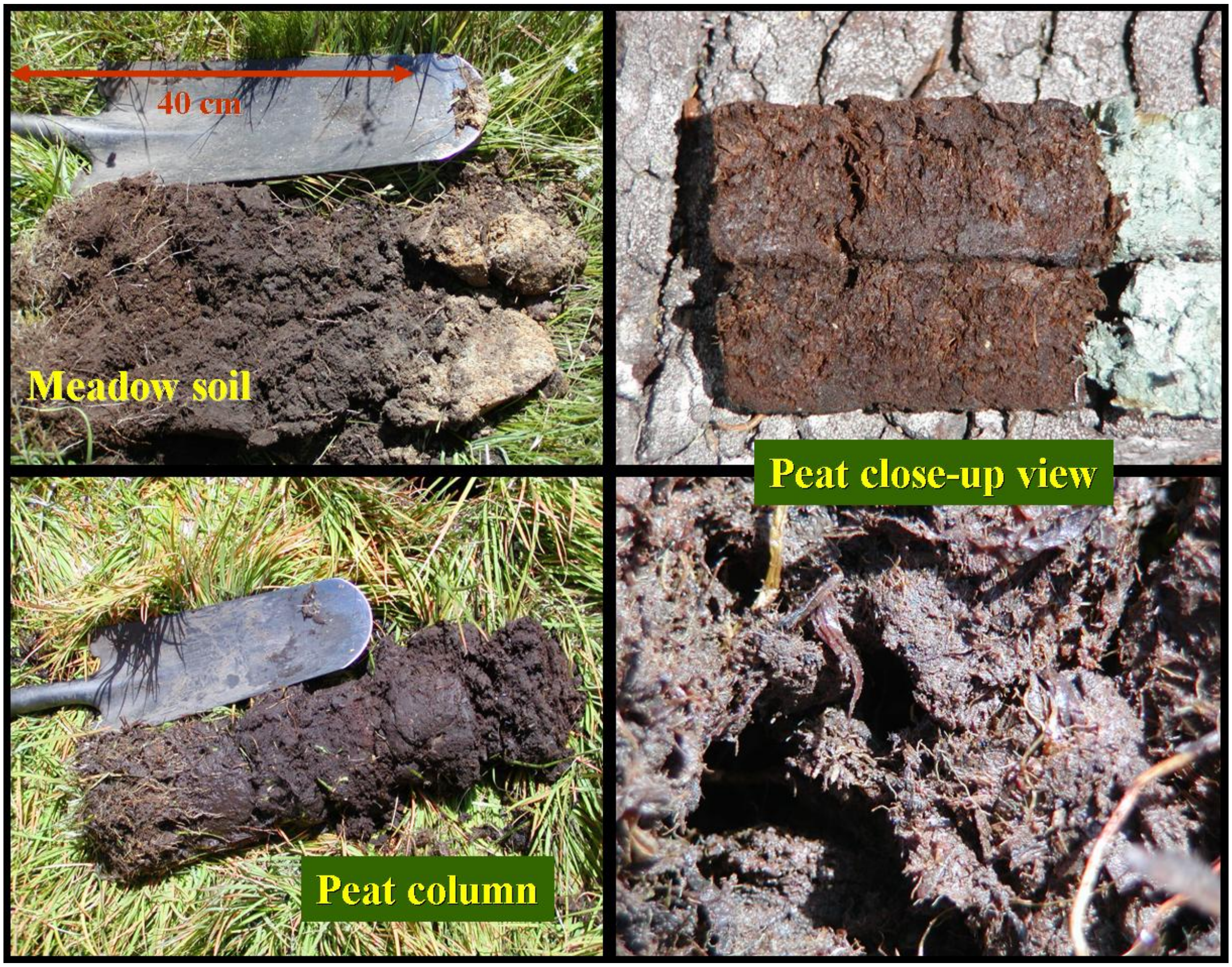

Figure 1. Peat, undecomposed vegetation, is an inherent feature of fens. Shown here are examples of peat, and a meadow soil for comparison. Sand (in granitic areas) and gray clay (in the metamorphic areas) constitute common substrates below the peat, shown in the upper right photo.

REGIONAL SETTING

An overview of the climate, geology, elevation, geography, and vegetation of the fens surveyed portrays their natural setting. The climate in which these fens exist reflects the typical Mediterranean pattern that dominates in California. There is a predictably hot and dry summer period and an unpredictably wet winter period. The heaviest rains fall during the winter months, with only occasional summer thunderstorms that deliver little if any water overall. Precipitation in the Bucks Lake Wilderness (BLW)totals about 200-230 cm (80-90 inches) annually, and winter snows are deep, often 3-4 meters. The fens surveyed in the Bucks Lake Wilderness and immediately adjacent areas lie between 5500 and 6800 feet in elevation, and so have a fairly short growing season and are covered by snow all winter. The fens are underlain predominantly by dioritic rock of the Bucks Lake pluton. While fens can have different water sources, all of ours were spring-fed. All sites were in openings of the red fir or white fir vegetation alliance (the former term for alliance was “series”, which is still used on the 2005 Wetland/Fen Survey

Records). The fen itself was considered sedge alliance and fen habitat, after the convention of the Manual of California Vegetation.

Figure 2. Examples of small fens and surroundings. Small fens are typically tenths of an acre in size. The bordering shrub zone can be broad, narrow, or non-existent, but usually is a transitional band between the fen opening and the forest, and is made up of water-dependent shrubs. Above examples include two from the Buck's Lake Wilderness and two from the Coldwater-Willow area south of Bucks Lake.

Figure 3. Some of the larger fens can reach several acres in size. The shrub border width can vary considerably from fen to fen. Above examples include two from the Coldwater-Willow area south of Bucks Lake.

Topographically most of the fens occur in the bottoms of drainages, where there were springs emerging and subsurface inflow at the toe of the adjacent slope. Smaller fens commonly lie within the smaller drainages, and often where the stream gradient is slightly sloping. Larger fens occupy larger/broader drainages where the stream gradient is nearly flat. A few small fens occur on steeper slopes where subsurface spring discharge is sufficient to keep the area saturated.

This summary of the regional setting also applies to fens on the FRRD. The FRRD fens lie in two separate areas:

1. **Coldwater-Willow (CWW)** for the main drainages holding the fens, which lies approximately 10 miles south of the center of the distribution of BLW fens

2. **LaPorte (LP)**, which lies roughly 20 miles southeast of the BLW area.

Comparisons between BLW and CWW/LP fens will be made later in the report. Illustrations in Figures 2 and 3 include small-fen and large-fen examples from both BLW and CWW fens.

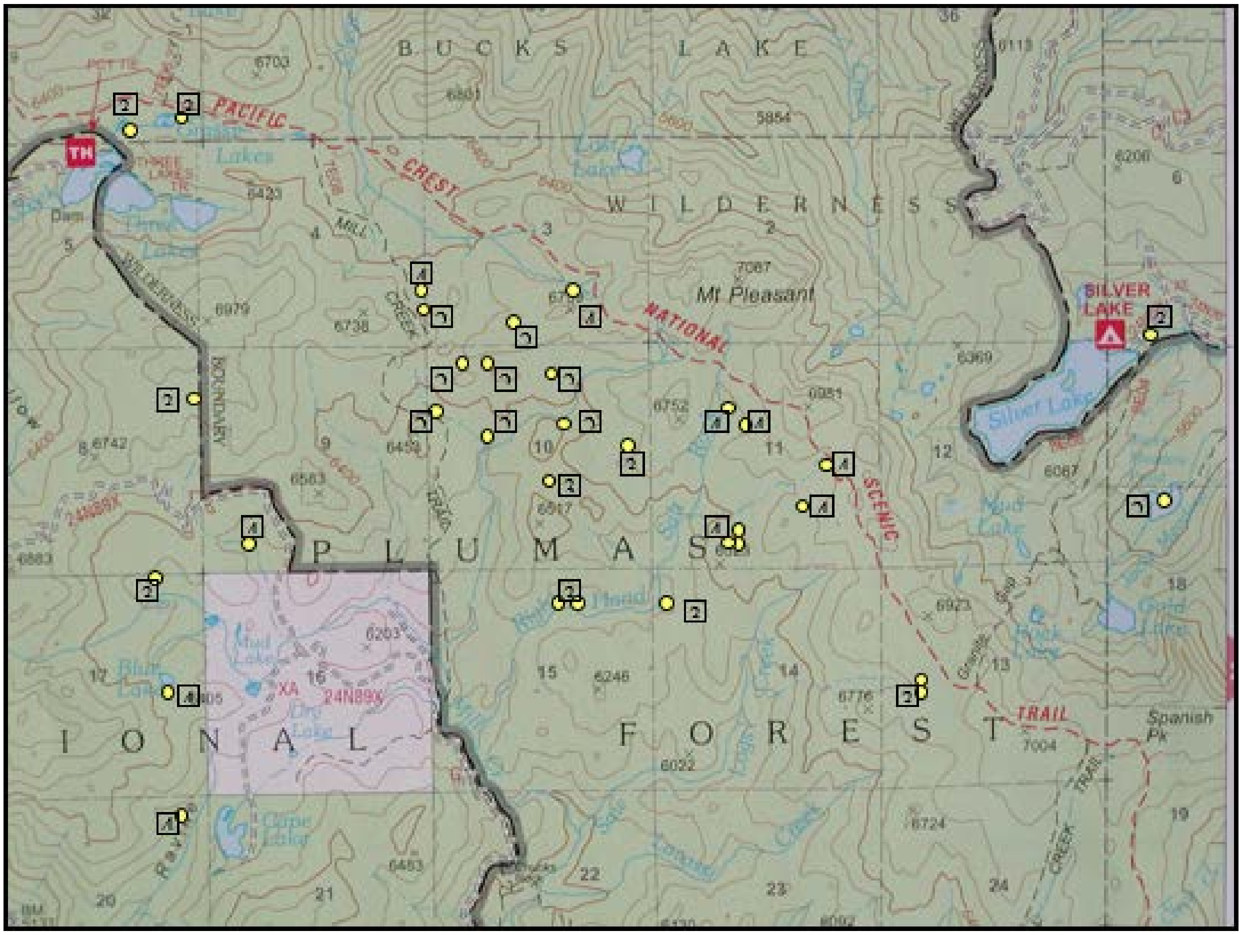

Figure 4. Geographic setting. The distribution of BLW fens is shown on a section of Bucks Lake Quadrangle map. Each named fen has a 2-digit identification number preceded by 11-0##. The ## is displayed above and corresponds to labels used throughout the report and accompanying forms and tables.

SCOPE AND METHODOLOGY

The goal of this project was to identify, characterize and map as many fens as we could within the Bucks Lake Wilderness and some immediately adjacent areas. Our survey area covered about 20,000 acres. Two strategies were used to locate possible fens: aerial-photo reconnaissance (primarily), and in a few cases occurrence records for *Drosera rotundifolia*. Most of the initial prospects had been previously identified by Mount Hough Ranger District personnel, and we added several from our own photo and field reconnaissance. We visited about 84 sites and found 33 of them to fit our working definition of a fen as outlined in this report's introduction. There are 29 numbered fens, three of which are complexes that include 2-3 separate fens each. At each targeted site surface wetness was checked, and sample holes were dug to evaluate subsurface wetness and the peat depth. We spent very little time in wet areas that we determined were not fens. The "non-qualifying" areas were usually meadows, sometimes with wet portions but often not saturated, and lacking sufficient peat depth.

In each fen Jim located one or more points that were clearly water sources supplying the fen to get an idea of the nature of the source water. These could often be recognized by their cold temperature (38-48 ^{o}F), having come directly from underground and not yet exposed to much solar heating. Many springs arise underneath the vegetation in the fen opening and cannot be directly sampled. The water temperature and pH were taken at each water source. Sample holes were dug at various locations out in the fen, with a narrow-bladed “sharpshooter” shovel, to at least 40 cm depth. Where it was practical a sample hole was dug in each of the major vegetation zones within the fen. Root-zone temperature (which is very close to the temperature of the soil and the water that saturates it) and pH were measured in sample holes at a depth typical of the rooting zone (~15-20 cm). The peat profiles removed from the holes were examined and sometimes photographed. Saturation depth was determined by measuring from the ground surface to a level on the side of the hole where water appeared to be seeping out (Figure 5) or by the level of standing water that eventually filled the hole. “Ground surface” is the average level of the vegetation mat at the rim of the hole. Not all of the holes had obvious seeps, and some holes refilled very slowly. More extensive work and documentation was done on three fens in the Right Hand Salt Rock Creek drainage, to detail observed hydrologic changes (see section Hydrologic Changes).

The basic accuracy of the pH meter is +/- 0.2 pH unit. It was calibrated to a pH 7.0 standard buffer each field day and was checked at the end of the day. Upon checking it would read pH 7.0 or 7.1. The thermometer was accurate to +/- 1 ^{o}F. Resampling in 2004 of fens sampled in 2003 suggests that the pH measurements are generally consistent to within about 0.2 pH units, the root-zone temperatures to within about 5 ^{o}F, and the water-source temperatures to within about 1^{o}F. The greater variability in root-zone water temperatures is expected, given the varying degrees of solar heating that influence it.

At each sample hole the following routine measurements were made (Figure 5).

- root-zone temperature (at 15-20 cm depth; typical of the rooting zone)
- pH of the root-zone-saturating water (by allowing sample hole to refill and taking its pH)
- peat depth (where peat depth exceeded 40 cm, the maximum depth was not determined)
- peat quality and special peat-column features such as charcoal or sediment lenses
- water saturation depth
- GPS location

For each recorded water source the GPS location, water temperature, and pH were observed.

The above measurements differ from the protocol utilized in the 2003 and 2004 surveys in two respects: separate “water” and “soil” temperatures are replaced in 2005 and 2006 by a single “root-zone” temperature (soil and sample-hole water temperatures do not differ significantly), and individual slopes are not taken at each sample hole.

Data were recorded the old fashioned way, in a field notebook. A sketch map was made of the fen, along with its notable features, and source and sample locations. With the aid of stereo-pair aerial photos and the sketch map, the fen perimeter was delineated on 4X-enlarged copies of aerial photos, and those perimeters and features are incorporated in the fen maps.

Catie conducted the plant surveys (Plant lists are in Appendix A). An attempt was made to identify all flowering plants in the fen opening and the major plants bordering the fen opening. For fens numbered 11-021 to 11-039 minor plants beneath the shrub border were included on the plant list; for fens numbered 11-040 to 11-049 those plants were not included. Special interest plants were actively looked for. In fens that were impacted by cattle grazing, many plants, especially grasses and grass-like plants, had lost the reproductive structures needed for identification. In the case of bryophytes, samples were collected and submitted for expert identification (see bryophyte plant list, Appendix A).

All supplementary information was recorded on a Wetland/Fen Survey Record form. The vegetation alliance (aka ‘series’) of the fen opening and the vegetation alliance of the surrounding forest was identified using the Manual of California Vegetation. The soil type of the surrounding forest was also recorded on the wetland forms. For most of the fens only a few hours were available for data gathering, and inevitably there were plants that were missed. Plant identification became more difficult and even impossible late in the field season because cattle had eaten off the reproductive structures of grasses and other grass-like plants. Along with plant species data, the fen features are described in a qualitative way.

Figure 5. Survey methodology. A sample hole was dug and allowed to fill with water typical of the rooting zone of the fen plants. Temperature of the rooting zone and pH of that water were measured, representing conditions at approximately 15 to 20 cm depth. As many plants as possible were identified in the fen opening. Peat depth was measured, to at least 40 cm depth.

DESCRIPTION OF FEN CHARACTERISTICS

Physical and Geographic Characteristics

The observed physical features of the fens are tabulated in the individual Wetland/Fen Survey Records and summarized here in Table 1. The pH data are summarized in Table 1 and in Figures 6 and 14.

Source water pH ranged from 5.1 to 6.6, and averaged 5.9 over all fens. Fen root zone-saturating water pH ranged from 4.6 to 6.4 and the average of all fens was 5.4, approximately 0.5 pH units more acidic than source water (presumably due to dissolved atmospheric CO_2 and organic acids). Source water temperature over all fens averaged 46°F, root-zone temperature (at 15 to 20 cm depth) averaged 53 °F.

Table 1. Bucks Lake Wilderness fen physical characteristics. Shown for each fen is the average value of all observations of saturation depth, pH (of fen root-zone and of source-water) and temperature (of root-zone soil and of source-water) made in that fen. NA means insufficient water for fen pH measurement, no good source-water location found, or slope not observed. Aspect and slope refer to the overall orientation of the fen. A range of slopes indicates that major portions of the fen had significantly different slopes. Averages over all fens were calculated using exact values for each fen average, but values shown on the table are rounded.

FEN NAME AND #	FEN SOIL TEMP	FEN H2O TEMP.	FEN pH	SOURCE H2O TEMP	SOURCE pH	ASPECT	SLOPE %	Elevation
Jacks Meadow 11-021	0 cm	53 ºF	5.6	48 ºF	6.2	E	<2 %	5500
Snowbank 11-022	2 cm	60 ºF	5.4	50 ºF	6.0	E	8 %	6340
Afternoon 11-023	3 cm	59 ºF	5.4	45 ºF	6.0	SE	4 %	6260
Cowbell 11-024	3 cm	54 ºF	5.4	46 ºF	5.1	W	6 %	6380
Lone Tree 11-025	4 cm	58 ºF	NA	50 ºF	5.4	NNW	6 %	6500
Tadpole 11-026	2 cm	56 ºF	5.8	59 ºF	6.0	WSW	2 %	6520
Garden 11-027	2 cm	58 ºF	6.0	51 ºF	5.9	SSE	2-10%	6520
Rivulet 11-028	12 cm	59 ºF	5.0	44 ºF	5.7	WNW	6 %	6600
Pocket 11-029	3 cm	54 ºF	5.4	48 ºF	6.2	SE	8 %	6480
Boulder 11-030	8 cm	52 ºF	5.2	45 ºF	5.7	S	NA	6800
Bucks Lake 11-031	6 cm	54 ºF	5.6	44 ºF	6.2	SSW	2-4 %	6060
Granite Gap S. 11-032.1	3 cm	50 ºF	5.1	47 ºF	6.3	W	0 %	6750
Granite Gap N. 11-032.2	2 cm	56 ºF	NA	50 ºF	5.4	WSW	18 %	6750
Grassy Lake 11-033	4 cm	53 ºF	5.5	48 ºF	5.9	W	1-2 %	6220
Kneedeep 11-034	2 cm	54 ºF	NA	NA	NA	W	1 %	6210
Muck 11-035	0 cm	51 ºF	5.9	47 ºF	6.1	S	0-2 %	6220
Slope 11-036	6 cm	46 ºF	5.4	46 ºF	5.4	N	0-18 %	6520

FEN NAME AND #	FEN SOIL TEMP	FEN H2O TEMP.	FEN pH	SOURCE H2O TEMP	SOURCE pH	ASPECT	SLOPE %	Elevation
Quaking 11-037	5 cm	51 ^{o}F	5.4	40 ^{o}F	5.8	SW	4-8 %	6340
Rocky Knoll W. 11-038.1	7 cm	51 ^{o}F	5.5	39 ^{o}F	6.1	SW	0-2 %	6020
Rocky Knoll E. 11-038.2	12 cm	51 ^{o}F	5.5	NA	NA	SW	1 %	6020
Silver Lake 11-039	4 cm	47 ^{o}F	5.1	39 ^{o}F	5.8	NE	2%	5750
Lodgepole 11-040.1	4 cm	53 ^{o}F	5.2	NA	NA	W	8 %	6440
Lodgepole 11-040.2	6 cm	58 ^{o}F	NA	NA	NA	N	4 %	6440
Lodgepole 11-040.3	7 cm	49 ^{o}F	5.6	NA	NA	NNW	4%	6440
Snag 11-041	7 cm	50 ^{o}F	5.4	48 ^{o}F	6.4	SE	3 %	6220
Tigerlily 11-042	2 cm	51 ^{o}F	4.9	NA	NA	N	2 %	6460
Liverwort 11-043	4 cm	50 ^{o}F	NA	NA	NA	N	7%	6620
Aster 11-044	2 cm	55 ^{o}F	4.6	42^{o}F	6.0	S	8 %	6700
Line Springs 11-045	2 cm	51 ^{o}F	5.0	36 ^{o}F	5.1	NW	16 %	6620
Kalmia 11-046	4 cm	52 ^{o}F	4.8	43 ^{o}F	5.4	W	11 %	6540
Corner 11-047	2 cm	56 ^{o}F	5.1	NA	NA	SW	8 %	6520
Blue Lake 11-048	4 cm	47 ^{o}F	5.8	44 ^{o}F	6.6	N	4-6 %	6300
Cape Lake 11-049	3 cm	54 ^{o}F	6.4	39 ^{o}F	6.5	S	25 %	5940
AVERAGE OF BLW FENS	4 cm	53 ^{o}F	5.4	46	5. 9		6%	6200

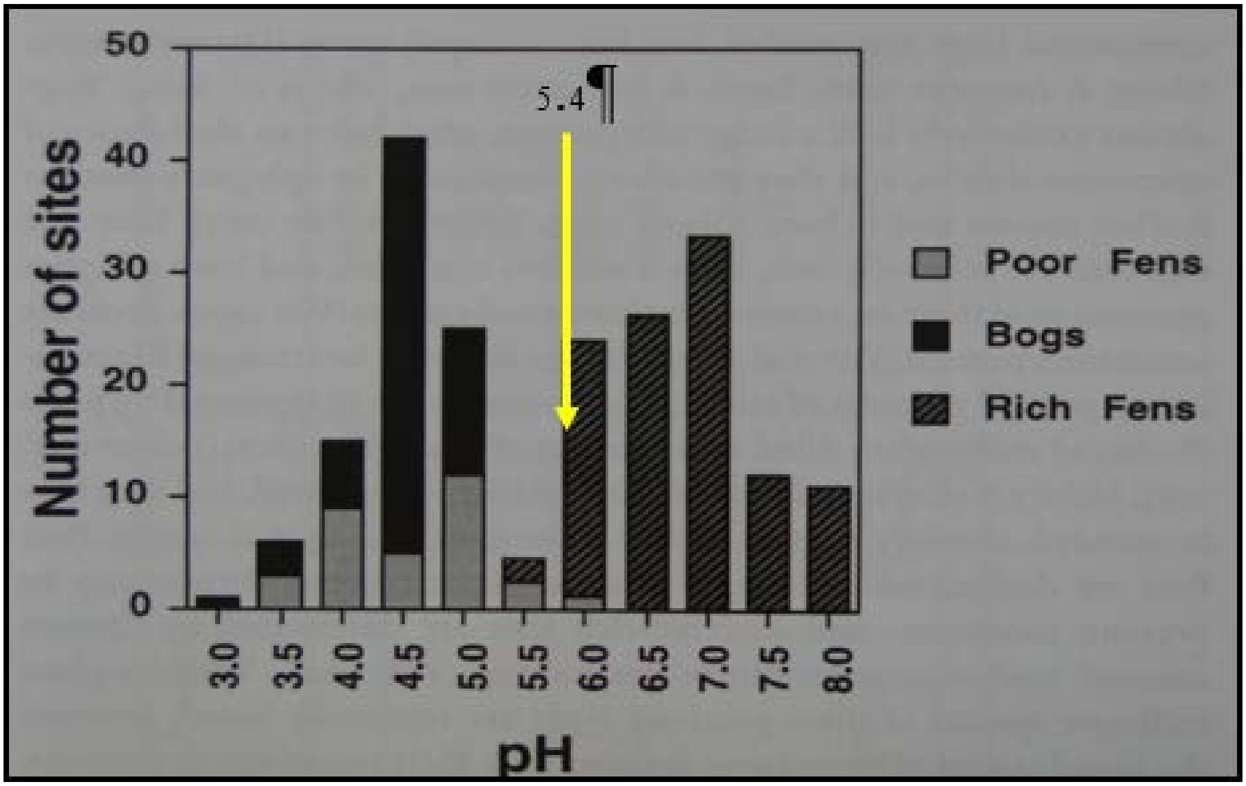

Figure 6. Distribution of fens as a function of pH for 100 western Canadian continental fens (Shaw and Goffinet, 2000) shown in gray. The pH average of BLW fens is shown superimposed in yellow. The BLW fen pH values cluster within the pronounced minimum in the bimodal pH distribution of Canadian fens.

The topographic position of the smaller fens would generally be described as “slope” position while the larger fens are best described as “stream” position. Fen slopes are primarily in the 0% to 8% range, with a couple of small fens on steeper slopes where they are fed by springs with high-discharge rates. Two thirds of the fen aspects fall in the southwest semicircle, probably reflecting the predominant regional slope to the SW. In addition, a significant group has north aspects, possibly due to greater potential for infiltration of water from late-season snow patches that lie above them on north slopes. Most of the fens would be described as of the “hanging” or perhaps sometimes “normal” hydrogeomorphic type, because they are maintained mainly by subsurface spring discharge, and by subsurface flow at the toe of adjacent slopes. The smaller fens are typically convex in longitudinal profile. The larger fens tend to be fairly flat, and often divided into terraces behind low berms that are oriented across the slope and along the contour. The fens range in size from less than a tenth of an acre to about 10 acres.

Fen Biotopography and Peat Characteristics

Topographic features of fen openings (Figure 7) with relief of order centimeters to decimeters are commonly observed. Although the reasons behind their formation are not all known, they are apparently the result of biological processes such as the differential growth and accumulation, and/or subsidence, of vegetation and are termed ‘biotopography’.

Springs emerging from beneath the fen vegetation can create spring holes, support floating vegetation mats, or can nourish greater plant productivity and therefore create spring mounds and spring berms (relief of order decimeters). Sample holes in the berms and mounds typically produced peat that was deep and well consolidated. The berm sample holes refilled with water quickly (commonly in minutes). Some berms formed over trees that fell from the surrounding forest into the fen opening, partially sank, and were colonized by vegetation. In several fens, upwelling springs spread out beneath and supported thick mats of floating vegetation capable of supporting our weight.

In the fen opening there are large areas of low-relief biotopography (relief of order centimeters) that contain a variety of low-stature plants. Fill rates in these sample holes is typically slow (tens of minutes to over an hour), the peat is not as deep as under the berms, and overlies silt or sand.

Some shallow pools form behind berms. The peat column underlying the pools, although sufficiently deep, is typically less solid and less competent than that under the berms, and would tend to settle and to form a shallow pool. Oddly enough, sample holes in shallow pool areas often refill very slowly from the subsurface. With increasing pool depth, the plant species change to a more sparsely distributed above-ground biomass that probably supports a lower rate of peat accumulation, given the limited photosynthetic output available for root growth.

These interesting biotopographic features certainly deserve more study to explain their origins and significance in the fen ecosystem.

Figure 7.Biotopographic features include: Spring mounds, where spring flow supports greater vegetative growth and accumulation resulting in a mound; Small elongate ponds impounded behind elongate low berms formed by vegetation create a "terrace" biotopography. Spring holes occurred where high-flow upwelling kept vegetation from closing over the hole.

Features within Peat Profiles

The peat profiles were very similar from one fen to the next, but sometimes contained anomalous features. Several charcoal layers were observed, generally in fens within the same area. In both BLW and CWW/LP fens we have observed sand lenses and layers of charcoal and carbonized sticks, pinecone scales, and bark at various depths in some profiles. Such features are yet-to-be-investigated evidence of episodic events in the life of the fen.

Botanical Characteristics

The biotopography helps to partition the fen into loose groupings of plants that prefer different microsites. Spring-fed mounds and berms which were raised above their surroundings (typically on the order of decimeters) were scattered throughout the fen and contained low (<1m) shrubs of blueberry (*Vaccinium uliginosum*), alpine laurel (*Kalmia polifolia var microphylla*) and sometimes stunted lodgepole pine (*Pinus contorta ssp. murrayana*), or rarely white fir (*Abies concolor*). They typically had scattered sedges, and occasionally sphagnum moss grew at the shrub base. In the shrub border at the edge of the fen grew alders (*Alnus incana var. tenuifolia*) and willows (*Salix eastwoodiae*) which typically exceeded 2 meters in height, along with herbs such as ragwort (*Senecio triangularis*), and marsh marigold (*Caltha leptosepala*).

The generally flatter areas contained a mix of low-stature plants. This is where the various mosses and the tiny sundew (Drosera rotundifolia) found a sunny patch away from the shrubby berms and the shallow pools. Small herbs such as primrose monkeyflower (Mimulus primuloides) and tinker's penny (Hypericum anagalloides) are commonly found here. Sphagnum is found in a variety of habitats.

The shallow pools were of various depths, from a few centimeters to a meter. The actual bottom of the pool is often obscured by a layer of algae. In the shallowest pools the spike rush (Eleocharis pauciflora) was usually dominant. With greater pool depth various sedges and grasses such as beaked sedge (Carex utriculata) and tall mannagrass (Glyceria elata) begin to appear. These give way to the mostly submerged buck-bean (Menyanthes trifoliata), and marsh cinquefoil (Potentilla palustris) in deeper pools, and finally the small bur reed (Sparganium natans), and floating-leaved pondweed (Potamogeton natans) in the deepest pools. (Figure 8)

We collected samples of mosses in most fens, representing the different habitats. The bryophytes make up a large fraction of the plants in the fens, and the total biomass. We didn't resample the mosses that were clearly the most common from one fen to another.The Sphagnum mosses can have a profound effect on the other plants in the fen ecosystem due to their ability to sequester nitrogen, and lower the pH of the surrounding water. They (as well as other types of mosses) can grow profusely during the summer, overgrowing small plants nearby. The mosses in turn have their own challenges. Not all moss species are widespread, some are very rare and may constitute a patch of a few square centimeters in an entire fen. These are especially susceptible to cattle trampling or "urine burning", a condition that results from a cow urinating in a single spot killing the moss in a patch which can cover up to half a square meter.

We were able to identify some mosses in the field. The rest were identified by David Toren, a moss expert working seasonally for the Plumas National Forest. In several fens David Toren collected his own samples. The Sphagnum mosses were sent to specialists at eastern universities for their identification. A list of the bryophyte species is included with the plant list in Appendix A.

There are obvious plant communities within the fens, often with quite sharp boundaries, and clearly associated with the microtopography and saturation. Currently the Manual of California Vegetation (MCV) does not define fen vegetation alliances, and we did not define and map any in our work. The MCV's coauthor, Todd Keeler-Wolf, visited several of the BLW fens with us and made a preliminary listing of vegetation alliances that he saw. The new alliances are presented in Appendix E. While those defined alliances are preliminary, they will be refined and incorporated into future editions of the MCV. And they do fit many of the plant communities that we perceived, but did not formally record.

Figure 8. Typical plants of shallow pools include Menyanthes trifoliata, Carex sp., and Eleocharis pauciflora., Sparganium natans, and Potemogeton natans.

The shrub border varied in width (from wide to non-existent), and also in its position around the fen opening. The border could be upslope of, downslope of, flanking, or surrounding the fen opening, or absent. Bordering shrubs were all greater than 1 meter in height (mostly >2 meters). In contrast, shrubs on berms and mounds in the fen opening itself were all less than 1 meter in height, and of mostly different shrub species. Occasionally there were islands of “border” shrubs out in the fen opening.

It has been noted from other regions, and from our previous surveys, that wetlands contain a high number of endemic plant species. We found that to be true during this survey as well. Importantly, we found no non-native plants in the fen opening. This was not something we looked for, but something we became increasingly aware of. In contrast, surveys done in non-fen habitats in the local area almost always reveal some non-native species.

Figure 9. An overview of typical fen plants. Variation in plant zonation of the fen offered the tiny Sundew (<u>Drosera rotundifolia</u>) and the low-growing bryophytes a refuge from the clump-forming and more vigorously growing tall Carex species.

Some Interesting Species

Sphagnum moss is a bryophyte found widely in the BLW fens (in contrast to occurring in only a couple of fens in the FRRD areas we investigated in 2003 and 2004). Several different species of sphagnum were collected in 2005 and 2006. Due to the fact that they have not been well studied in the western US, identifications may not be firm. See Bryophyte list in Appendix A. Sphagnum requires a sufficiently low pH to colonize an area, but once it becomes established, it tends to further lower the pH in its vicinity even more. It also prefers water with low levels of dissolved ions.

Two other mosses, one rare in California (*Bruchia bolanderi*) and one new discovery in California (*Amblestegia radicale*) were collected in the BLW fens.

The Sundew (*Drosera rotundifolia*) is an insectivorous plant that grows rooted in saturated substrates and is on the Plumas National Forest Special Interest plant list. Although it has been found in small numbers in wet areas not strictly considered fens (primarily because of their lack of 40 cm of peat), it is found in large numbers in the undisturbed fens we surveyed. The sundew is an obligate hydrophyte and can only maintain itself in a consistently wet habitat.

Another Special Interest plant found growing in this year’s fens is *Carex limosa*. This sedge has grass-like foliage, and grows in standing water.

Two sensitive mosses we found in BLW fens are *Meesia triquetra* (5 occurrences) and *Bruchia bolanderi* (3 occurrences).[note: *Meesia* and *Bruchia* were not as well recognized in our early surveys, and some occurrences may have simply gone unnoticed in the CWW and La Porte (together the FRRD area) fen areas].

The encroachment of conifers into the fens was minimal. The tree species we found trying to colonize drier spots in the fen was mainly the lodgepole pine, and to a lesser degree white fir . However the trees were always stunted and appeared not to live very long in that habitat, as there were many small, dead trees. Possibly that indicates episodic drier periods where the trees gain a foothold, followed by saturated conditions which kill them or until the trees develop a root zone that outgrows their small unsaturated site.

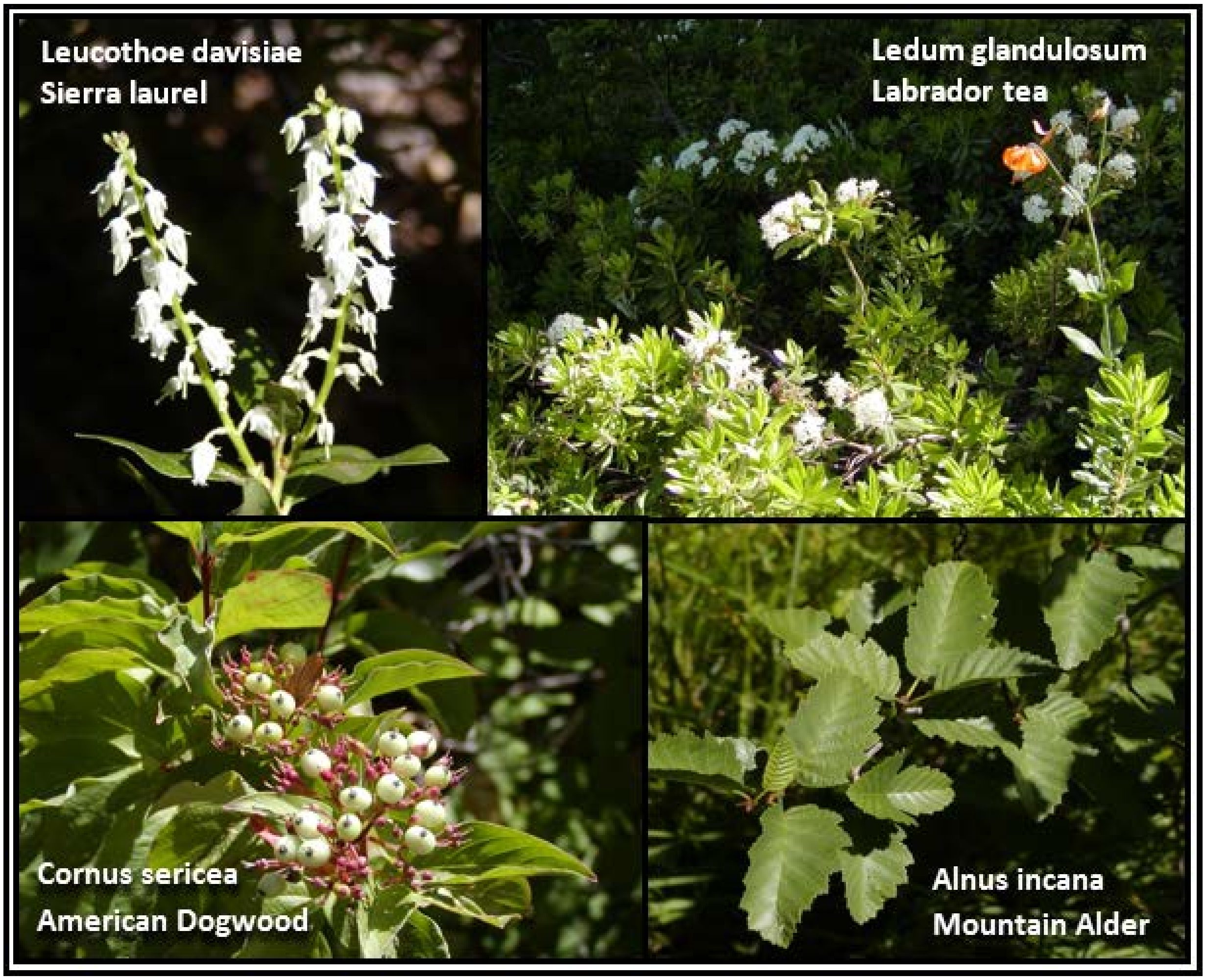

Figure 10. Some of the more common shrub border plants. There were also several willow species, but no photo available. In the border zone around the fen the plants were arranged in zones evidently related to water availability.

HYDROLOGIC CHANGES OBSERVED

Peat accumulates under perennially saturated and anaerobic conditions. The top of the "peat body" coincides closely with the top of the saturated zone. Sediment lenses occur within the peat column, and represent depositional events. The fen is the embodiment of processes of <u>accumulation</u>. The surface-water flow regime across the fen would be characterized as "sheet flow" (vs. channeled flow).

If water cuts a channel down into the peat it will lower the water table and dewater the peat. The new water level will slope upward and away from the water level in the stream to eventually reach the ambient level. Above that lowered water table the peat will begin to dry, and that portion of the peat body will no longer be a functional fen area, and will begin to decompose. Burrowing animals such as pocket gophers will move in, contributing to the decomposition process.

The banks of streams incised in the peat body will be made of peat. Such stream banks were observed at several locations, most notably in fens in the Right Hand Salt Rock Creek drainage. Peat, in place in the peat body and not just washed in, is often visible also on the bottoms of such streams (Figure 11). Stream incision depths of a meter or so are common, and in Bucks Lake fen reached approximately 3 meters (to the bottom of a plunge pool in the stream, Fig. 12). In a peat body, stream incision and channeled flows (vs. sheet flow) represents a departure from normal fen processes, and a transition from accumulation to erosion.

The surface adjoining incised streams, on dewatered peat, often hosts plant cover distinct from that in the saturated fen (see FEN COMPARISONS). Sample holes on those dewatered areas are commonly silty in their upper 20 or 30 cm, and encounter peat at depths of 30 to 50 cm, sometimes as detached chunks and sometimes as continuous peat. The soil-peat profile in such holes is damp but unsaturated.

Figure 11a. ***Left panel:*** *Section of peat streambank adjacent to incised stream channel. This stream channel is a small tributary to the nearby main stream and was not actually flowing at the time. The material in this cut is largely fibrous, compressed peat. Faint blackish zones contain charcoal. Shovel blade is 40 cm long, and section depth is approximately 50 cm. The water table in the channel of the adjacent stream was approximately another 30 cm down or about 80 cm below the surface of this cut. Earlier in the season this channel contains water.*

Figure 11b. ***Right panel:*** *Peat visible on the bottom of a stream channel, still in place and partially covered by sand deposited by the stream.*

Figure 12. Peat section exposed in streambank in Bucks Lake fen. Vegetation on top is dominated by one or two densely-growing Carex species.

Not all fens we surveyed are associated with incised streams that flow through the fen area. Such channels were observed only in the Rocky Knoll and Bucks Lake fens (as noted above) and alongside several smaller fens in the Mill Creek drainage. However, other large fens, including Grassy Lake and Silver Lake fens did not have through-flowing streams, nor exposed peat streambanks. In these fens the saturated zone extends from one side of the fen basin to the other. There are deeper areas within those fens, but they are truncated/discontinuous and do not drain water from the peat body. There are also spring channels emerging around the edge of the fen opening flowing into the fen, but the flow is quickly absorbed and dissipated in the vegetation.

FEN COMPARISONS & CORRELATIONS

The Bucks Lake Wilderness fens showed significant geographic/physical and biological differences from the fens in the Coldwater-Willow area to the south. In addition, there were evident differences between fens currently grazed by cattle and those that are ungrazed. And there are some characteristic contrasts that accompany the dewatering and rewatering of fens, compared to hydrologically undisturbed fens. Basic data on which the comparisons described below are based is in Table 2.

Summary of Characteristics

Semi-quantitative, quantitative and qualitative data on all fens we have surveyed (including the BLW fens, the CWW fens, and LP fens) for several botanical and physical-geographical parameters, and grazing status, are summarized in Table 2.

Table 2. Summary of basic data for all Buck's Lake Wilderness, Coldwater-Willow, and La Porte fens. Ratings for Drosera rotundifolia populations are: 0 = "not observed"; 1 = "present but sparse"; 2 = "good in limited areas, but lacking in seemingly available, suitable habitat"; 3 = "robust/widespread". In the case of Carex limosa, Narthecium californicum, Meesia triquetra, and Sphagnum mosses 0 = "not observed" and + = "present". "Anom" means hydrologically anomalous and not necessarily comparable to grazed vs. ungrazed status. S, M, L are subjective estimates of fen size, reflecting the overall dimensions and shape (see sketch maps in Appendix D for more detail; see Figures 2 & 3 for examples).

Fen ID#	Dros	Mees	C. lim	Narth	Sphag	rt zn pH	rt zn T	geo sub	elev	size	slope	grazing
11-001	3	0	0	+	0	6.1	61	interm	5840	M	10	N
11-002	3	0	0	+	0	5.7	72	int-sil	5500	L	4	N
11-003	3	0	0	+	0	5.7	68	int-sil	5500	M	9	N
11-004	3	0	0	+	0	5.9	68	interm	5800	S	10	N
11-005	3	0	0	+	0	5.8	52	int-sil	5840	M	12	N
11-006	3	0	0	+	0	5.9	61	silicic	5600	M	9	N
11-007	3	0	0	+	+	6.0	58	interm	5000	M	8	N
11-008	2	0	0	+	0	5.8	61	interm	6000	M	5	N
11-009	0	0	0	+	0	6.4	51	ult maf	5800	S	7	Y
11-010	1	0	0	+	0	ND	ND	mafic	5700	S	2	N
11-011	0	0	0	0	0	6.3	52	ult maf	5400	L	3	Y
11-012	0	0	0	0	0	6.4	45	ult maf	5140	M	2	Y
11-013	3	0	0	0	0	6.2	58	int-sil	5360	M	10	N
11-014	3	0	0	0	+	5.3	66	int-sil	5350	M	4	N
11-015	0	0	0	0	0	6.0	61	?	5840	M	16	N
11-016	0	0	0	0	0	5.8	59	int-sil	5700	S	5	Y

Fen ID#	Dros	Mees	C. lim	Narth	Sphag	rt zn pH	rt zn T	geo sub	elev	size	slope	grazing
11-017	0	0	0	0	0	6.0	58	int-sil	5700	S	10	Y
11-018	0	0	0	0	0	5.9	57	int-sil	5300	M	8	Y
11-019	0	0	0	0	0	5.5	58	?	6920	M	4	N
11-020	3	0	0	+	0	6.0	62	int-sil	5500	M	2	N
11-021	0	0	0	0	+	5.6	53	interm	5500	L	<2	Anom
11-022	0	0	0	0	+	5.4	60	interm	6340	S	8	Y
11-023	0	0	0	0	+	5.4	60	interm	6260	M	4	Y
11-024	0	0	0	0	0	5.4	54	interm	6380	S	6	Y
11-025	1	0	0	0	+	ND	58	interm	6500	S	6	Y
11-026	0	0	0	0	0	5.8	56	interm	6520	SM	2	Y
11-027	0	0	0	0	0	6.0	58	interm	6520	S	6	Y
11-028	0	0	0	0	+	5.0	59	interm	6600	M	6	Y
11-029	0	0	0	0	+	5.4	54	interm	6480	S	8	Y
11-030	0	0	0	0	+	5.2	52	interm	6800	S	ND	Y
11-031	1	0	0	0	+	5.6	54	interm	6060	L	3	Y
11-032	1	0	0	0	+	5.1	53	interm	6750	S	0-18	Y
11-033	3	+	+	0	+	5.5	53	interm	6220	L	1-2	N
11-034	0	0	0	0	+	ND	54	interm	6210	M	1	Anom
11-035	0	0	0	0	0	5.9	51	interm	6220	M	1	Y
11-036	0	0	0	0	+	5.4	46	interm	6520	M	10	Y
11-037	1	0	+	0	+	5.4	51	interm	6340	L	6	Y
11-038	1	+	+	0	+	5.5	51	interm	6020	L	1	Y
11-039	3	+	+	0	+	5.1	47	interm	5750	L	2	N
11-040	2	0	0	0	+	5.4	53	interm	6440	L	4-8	Y
11-041	0	0	+	0	+	5.4	50	interm	6220	M	3	Y

Fen ID#	Dros	Mees	C. lim	Nart h	Sphag	rt zn pH	rt zn T	geo sub	elev	size	slope	grazing
11-042	0	0	0	0	+	4.9	51	interm	6460	S	2	Y
11-043	0	0	0	0	0	NA	50	interm	6620	SM	7	Y
11-044	2	0	0	0	+	4.6	55	interm	6700	ML	8	Y
11-045	1	0	0	0	0	5.0	51	interm	6620	ML	16	Y
11-046	1	0	0	0	+	4.8	52	interm	6540	M	11	Y
11-047	0	0	0	0	+	5.1	56	interm	6520	S	8	Y
11-048	0	+	0	0	+	5.8	47	interm	6300	M	5	Y
11-049	1	+	+	0	+	6.4	54	interm	5940	M	25	Y

Bucks Lake Wilderness vs. Coldwater-Willow Fens [and Several La Porte Area Fens Where Noted]

Geographic/Physical Contrasts

These two groups of fens, BLW vs. CWW/LP, occupy geographically different settings. The average elevation of the BLW fens is 6200 feet, and they range from 5500 to 6800 feet. The average elevation of the CWW/LP fens is 5560 feet and they range from 5000 to 6000 feet. The BLW fens are on granitic (predominately diorite) rocks of the Bucks Lake Pluton, while the CWW fens occupy a geologically varied area of metamorphic rocks that range in geochemical affinity from silicic to ultramafic. ‘Silicic’ rocks are relatively high in silica (SiO_2), Na, & K; ‘mafic’ rocks are relatively low in silica, and higher in Fe, Mg, and Ca. ‘Intermediate’ rocks fall in between, and ‘ultramafic’ rocks are extreme in their low silica and high Fe, Mg content.

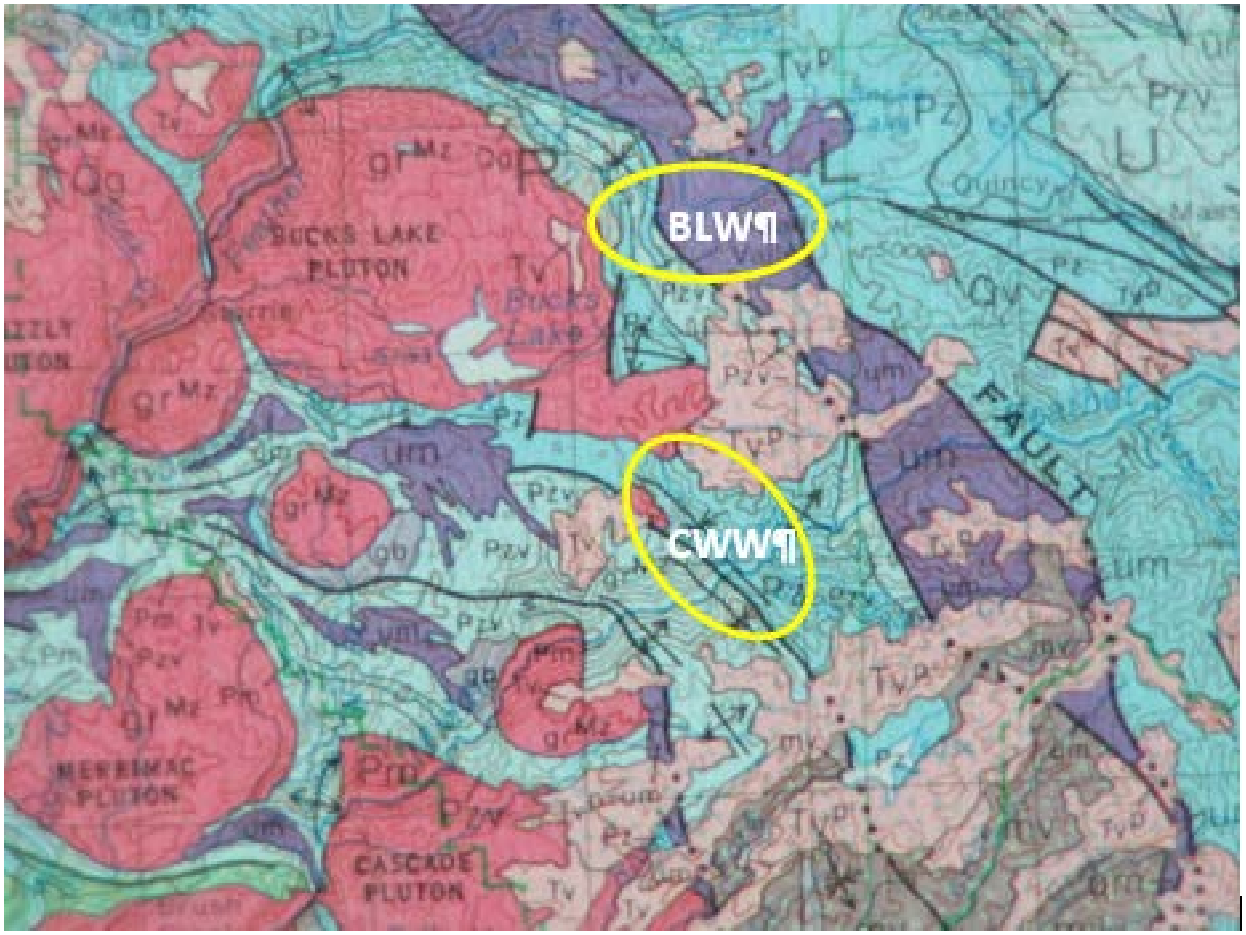

Figure 13. Geological map, with BLW and CWW areas indicated.

Fen pH in the BLW fens averaged 5.4 compared to 5.9 for the CWW/LP fens (Figure 14), and BLW source-water pH of 5.9 contrasts with CWW/LP source-water pH of 6.5. The lower pH of both root-zone waters and source waters in the BLW fens probably reflects the tendency of the BLW granitic geologic substrate to provide less buffering against lower pHs than do the CWW metamorphic substrates. In both areas the fen plant rooting zone pH is more acidic than the source-water pH by about 0.5 pH-points, due to the contribution of atmospheric dissolved CO_2 and organic acids in fen waters. In a couple of examples the root-zone pH was barely lower than source-water pH, and in those cases high flow rates and steeper slopes probably resulted in shorter residence times for the water and less pH lowering.

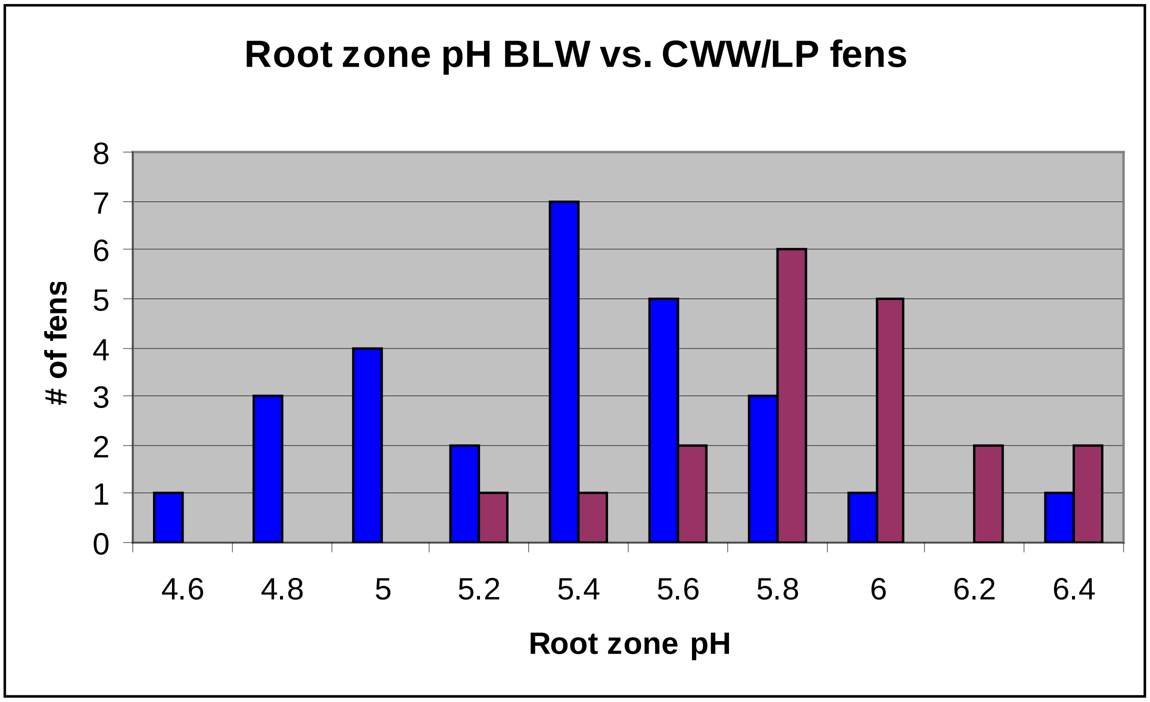

Figure 14: Frequency distribution of root-zone pH of BLW (blue) compared with that of CWW/LP fens (purple) shows consistent tendency of BLW fens to be more acidic.

Source-water temperatures in the BLW and the CWW/LP areas were very nearly the same at 46°F to 47°F. Root-zone temperatures were 53 °F in the BLW fens, compared to 58 °F in the CWW/LP fens. The 5°F cooler root-zone temperatures in the BLW may be due to its higher average elevation. [Note: even though individual root-zone temperatures varied by several °F in comparing repeated observations between the 2003 and 2004 fen surveys, the variations were not systematic. The averages cited here that characterize the BLW vs. the CWW/LP fens represent several dozen observations each, and the 5°F difference between those averages is considered to be significant.]

It is likely that ion concentrations in BLW fens are lower than in CWW/LP fens. Ion concentration was not measured, but the lower levels are hinted at by the long equilibration times of the pH meter and the abundance of *Sphagnum* mosses (which don't like high ion concentrations).

In summary, the BLW fens vs. the CW/LP fens are higher in elevation by about 640 feet, on granitic (typically sandy) vs. geochemically-varied metamorphic (typically fine-grained) substrates, lower in pH by about 0.5 pH-point, and cooler in the root zone by about 5°F.

Botanical Contrasts

Narthecium californicum is very common and a main peat-forming plant in the CWW fens, but it was completely absent in BLW and LP fens. The BLW fens lie mostly above the maximum elevation for *Narthecium californicum* reported by Oswald (2002), 5900 feet, in his flora of this area. Interestingly the plant does occur up to 6900 feet in elevation in the Northern Coast Range.

So perhaps it is deeper, longer-lasting winter snow cover that makes the difference in *Narthecium* occurrence between BLW and CWW fens. Substrate rock type may also play a part.

Sphagnum moss, an acid-loving bryophyte, was clearly a dominant plant in most of the BLW fens, and found in only two of the CWW fens, none of the LP fens. Possibly, the greater incidence of *Sphagnum* in the BLW is related to the generally lower root-zone pH, or perhaps to a lower ion concentration in the groundwater.Average pH in fens with Sphagnum is 5.2, and in fens without *Sphagnum* it is 5.9. Only 10% of the CWW/LP fens have sphagnum, and 83% of the BLW fens do.

All of the *Meesia* and *Carex limosa* occurrences noted were in several BLW fens and none were seen in the CWW or LP fens. Note: *Meesia* may have been overlooked in the earlier CWW/LP surveys simply due to our lack of familiarity with that plant when we worked there.

Species of sedges seemed to be slightly different in BLW vs. CWW/LP fens, but it is difficult to tell definitively because of the cattle grazing on BLW fens. In particular, populations of *Carex limosa* (a USFS Special Interest plant) in the BLW were hard to determine and are underestimated because grazing removes the reproductive parts.

Grazed Vs. Ungrazed Fens

Most of the fens within the BLW area are currently grazed, and grazing has occurred in the general area for at least a century. Most of the fens in the CWW area are not grazed, except a few that lie near a current grazing allotment. There are also some grazed fens east of the CWW area in the LP area (geographically very similar to the CWW fens), near Little Grass Valley reservoir, that are included in this discussion. These observations of correlations are presented without inference of cause-effect relationships.

In, and adjacent to, several currently-grazed BLW fens that occupy drainage bottoms are through-flowing stream channels with banks of exposed peat. Peat can only form in perennially saturated conditions. So the top of the peat banks represent a former stand of the water table. Stream incision has lowered the water table and dewatered some of the peat body. The deepest incision exposes approximately 3 meters of peat, with up to 2 meters standing above current stream water level (Figure 12). These dewatered areas extend from the channel to a natural berm and/or other discharge areas beyond which sufficient water is retained to maintain saturation of the peat body. The dewatered-peat areas are sometimes covered with thick *Carex* and sometimes dried to the point of having dryland vegetation or even bare ground. In contrast several medium and large fens in both the BLW and CW groups, where there is not evidence of stream incision, stretch from side-to-side in the drainage they occupy with no through-flowing stream channels (see top left photo in Figure 3). A developing channel in a grazed fen is shown in Figure 17.

The most notable difference in a plant occurrence correlating with the presence or absence of active grazing is for *Drosera rotundifolia*. *D. rotundifolia* was observed over a wide range of physical and geographical/geological conditions: elevations of 5000 to 6700 feet; fen root-zone pH of 4.6 to 6.4; fen root-zone temperature of 47 ^{o}F to 68 ^{o}F; and geologic substrates from mafic to silicic. Its population quality has its clearest correlation with the absence or presence of grazing. *Drosera rotundifolia* population quality was evaluated as follows: 0 = “not observed”;

1 = “present but sparse”; 2 = “good in limited areas, but lacking in seemingly available, suitable habitat”; 3 = “robust/widespread”.

In grazed fens it is absent or sparse, and where it does occur it is usually in small pockets that are relatively unused by cows. Significant is the absence of *Drosera* in apparently suitable habitat in some grazed fens, even though it occurs in small concentrations in equivalent habitat in those same fens. In ungrazed fens we noted *Drosera* population densities of close to 400 plants per square meter, while in some grazed fens much of the apparently suitable habitat might have only a few plants per square meter (Figure 15). Of the 12 fens having robust/widespread populations of *D. rotundifolia* none are grazed; of the fens where *D. rotundifolia* is absent or sparse 29 are grazed and 3 are ungrazed. Viewed in another way, 75% of the ungrazed fens have robust/widespread populations of *Drosera*, while 0% of the grazed fens have robust/widespread populations, and only 6% have modest populations. Correlation of *Drosera* population quality with grazing is shown in Figure 16. While these statistics are for all fens, the same general trend exists within the data for the BLW fens.

Figure 15. Left panels: ungrazed vs Right panels: grazed. In grazed fens there was visible hoof damage to Drosera rotundifolia (compare top two panels). The left lower panel shows an extensive Drosera population numbering close to 400 plants per square meter in an ungrazed setting. The lower right panel illustrates a common observation in grazed fens in which some Drosera was present but large areas of adjacent good habitat lacked Drosera.

A healthy fen is essentially covered in a continuous layer of vegetation or open pools. Where organic soil of peat is exposed oxidation of the peat can take place. The amount of exposed soil is recognized as a gauge of the degree of degradation a fen has suffered. We noted various levels of soil exposure in the fens that are grazed, as illustrated in Figure 17.

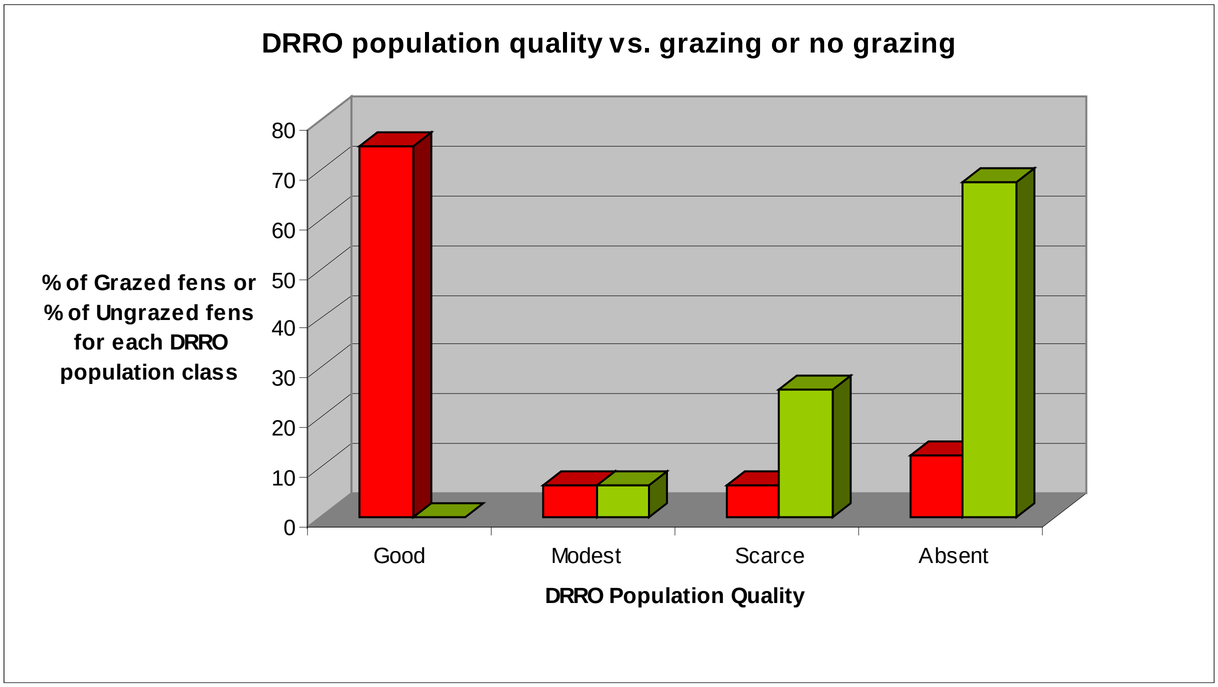

Figure 16. Quality of DRRO populations is correlated with the presence (green) or absence (red) of grazing. Ratings for Drosera rotundifolia populations"absent" through "good" correspond to 0, 1, 2, 3 in Table :, "not observed"; "present but sparse"; "good in limited areas, but lacking in seemingly available, suitable habitat"; "robust/widespread".

Figure 17. ***Left panel:*** *Surface of fen showing large areas of exposed soil, an indicator of degraded fen conditions. Right panel: Incision into fen vegetation cover, creating a channel for water flow. This is a cow path leading out of dry forest uphill from the fen, down across the center of the fen, and into a dry forest on the other side. Especially in the steeper-sloped fens this can be a serious problem.*

Dewatered/Rewatered Fens

Lowering of the water table can dewater a pre-existing wetland and its peat body. The fen plant community apparently becomes less diverse, and our observations suggest it commonly transitions to thick cover dominated by a couple of C*arex* species Figure 18). In some instances the dewatered area can become dry, dusty ground. One fen (Jack's Meadow 11-021) shows evidence of having been dewatered (as suggested by examining aerial photos that show exposed, dry stream channels), and is currently re-flooded by a dam at the outlet. The fen is now largely shallow-pool habitat. Even though it is now saturated, there is very limited plant diversity within the fen, and much of what is there is *Carex* (as is typical of dewatered peat).

Figure 18. ***Left panel:*** *A normally saturated and unimpacted fen, with extensive surface water and great diversity in vegetation community (related to small variations in surface elevation and saturation depth).* ***Right panel:*** *Dewatered peat body, now with a thick cover dominated by a couple of Carex species, no shallow pools, little or no shallow saturation depths, minimal diversity.*

DISCUSSION AND CONCLUSIONS

Some generalizations can be drawn from our reconnaissance regarding the likely habitat for fens on the Bucks Lake Wilderness. They tend to occur in, or on the lower slopes of, drainages, or on benches above the drainage bottoms. Most of the fens lie in the relatively low-gradient terrain in the drainages of Mill Creek and Right Hand Salt Rock Creek, below the Mount Pleasant crest. A few other fens, including some large ones, occupy basins near Three Lakes and near Blue Lake. The substrate rock is crystalline and not porous, leading to most of the subsurface flow being concentrated in fractures or toes of adjacent slopes. Where steady springs emerge on flats or modest slopes they can nourish vegetation growth, and in the saturated conditions the retarded decay of the vegetation results in peat accumulating. An equilibrium is established wherein the water flow maintains the fen, and the vegetation/peat blanket retains the water. There is a balance between inflow and drainage, and altering either could damage the fen.

There is useful information in the general nature of those prospects that we visited, but that did not turn out to meet the definition of a fen. In simple terms some prospects were too dry and others, while wet enough, did not have a deep peat layer. Two conditions commonly accompanied areas that turned out to be dry meadows:

1. Steep slopes and drainages, and/or what appeared to be an underlying base of rocky rubble (such as talus) that would allow free drainage of the water.

2. Very wet meadows that lacked peat seemed to be wetted by predominantly surface flows, vs. the infusion of groundwater from subsurface upwelling flows that is very characteristic of fens.

The few prospects that we were not able to visit in the BLW are very small and mostly in steep drainages—they hold rather small potential to be fens. The fens that are visible in aerial photos as an opening with hydrophilic vegetation are fairly well represented in our surveys. Fens that are overlain by woods and/or shrub patches are essentially impossible to identify in aerial photos—you almost have to walk into them. We certainly did not find all of those wooded fens, and much probably remains to be discovered by ground reconnaissance.

The spring-derived source waters of the BLW fens tend to be of slightly acidic pH, average 5.9, and probably of low ion concentration (one indication being the very long equilibration times for the pH meter). The waters saturating the fens are all slightly more acidic than their source waters, average pH 5.4. Source waters usually have temperatures in the 40s ^{o}F, average 46^{o}F.

Some plants, while they may not be strict "fen endemics", at least showed an occurrence strongly correlated with fens. Such fen plants include *Drosera rotundifolia, Carex limosa, Menyanthes trifoliata,* and *Sphagnum sp.* mosses. Where they occur outside of fens it was in very wet portions of meadows that were not fens primarily in lacking 40 cm of peat, but were fairly saturated and may have had sufficient peat to effectively contain the root zone. Very notable was the complete lack of any non-native plants in the fens.

Because of the continuous wetness and extreme age of the fens, plants which require these stable conditions have colonized and maintain the stable fen ecosystem. We hope to date some of our fens in the future; other fens in the Sierra Nevada have been dated to between 4000 and 8500 years old (personal communication, Sagehen Field Station staff). Fen pools are used by wildlife (such as frogs and toads for nurseries), and are often the only open water in the area. The shrub-dominated fen border provides good cover, diversity of structure, and is utilized by higher densities of wildlife, than in either the fen opening or the surrounding forest. This survey does not include invertebrates, however tiny clams (0.5-2mm), hydra, worms, and other water dependent animals were observed under the dissecting microscope during plant identification.

Wetlands of all kinds have been drained for agriculture, road building, grazing, OHV use and other uses, or polluted by agriculture or mining and logging runoff. This makes the remaining intact wetlands even rarer. And protecting the fens is important for reasons going beyond those associated with plant and wildlife habitat. These ecosystems have been stable for thousands of years and have been used as windows on the past. Their core samples can reveal the changes in plant types and abundances, and can suggest paleoclimates. It is well known that wetlands are excellent natural filters of water-born impurities, and they moderate peak water flows.

During this survey we noticed clear correlations between on-going cattle grazing and alteration/degradation of the fens. Also, historically higher stocking levels may have triggered progressively-amplifying hydrologic changes that are manifested today. It will take more study to quantify the effects, but cattle preferentially eat certain plants and trample others. Another question to be investigated in the future is if, or how much, the "fertilization" of a fen by cattle changes the nutrient input, and therefore the species composition, of an ecosystem that is defined by the special circumstance of the separation of its root system (and therefore its nutrition source) from mineral soil. It remains to be learned from further studies whether "urine burning" of fen mosses is a problem.

Fens appear to be very unique, stable, and relatively pristine ecosystems. On the Plumas NF they occur on a wide variety of geologic substrates (a potentially important determinant of a fen's character) which is unique compared to the widespread granitic substrate found elsewhere in the Sierra. They merit further study for many reasons: to locate fens in new areas; to add quantitative plant-frequency data; to characterize the chemistry of their groundwater; to get some absolute ages; and to analyze the embedded paleoecological and paleoclimate records. They have much they can tell us, once we know how to read them, and should be protected from direct impacts and from any impacts to the hydrologic systems on which they depend.

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Appendix A
Plant Lists

Master Plant List 2005 and 2006

MASTER PLANT LIST 2005 & 2006	FEN NUMBER 11-0##																												
DICOTS																													
*** = plants of concern**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Abies concolor	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x					x	x
Abies magnifica					x	x	x	x	x	x	x	x	x	x			x			x	x	x	x	x	x	x	x	x	x
Aconitum columbianum							x																				x		
Alnus incana var. tenuifolia	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Aster occidentalis var. occidentalis											x																		
Botrichium multifidum	x																				x								
Boykinia major		x									x										x							x	
Calocedrus decurrens	x																												
Caltha leptosepala			x	x	x		x	x	x	x		x	x	x		x		x		x	x	x	x	x	x	x	x	x	x
Castilleja miniata ssp. Miniata																									x				
Cornus stolonifera									x																				
Dodecatheon alpinum		x				x		x												x									
*Drosera rotundifolia**					x						x	x	x				x		x	x				x		x			x
Epilobium ciliatum ssp. glandulosum	x		x				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Gentiana newberryi var. tiogana															x														
Hypericum anagaloides			x	x	x		x	x		x	x	x	x	x	x		x	x		x	x	x	x	x	x			x	x
Kalmia polifolia	x		x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x
Ledum glandulosum																			x	x									
Leucothoe davisiae			x		x																							x	
Lotus oblongifolius	x																												
Lupinus latifolia										x											x		x						
Menyanthes trifoliata											x		x	x	x		x	x	x									x	
Mimulus guttatus	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x
Mimulus primuloides	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Nuphar luteum ssp.polysepalum		x	x					x	x		x	x	x			x	x	x										x	
Oreostema alpigenum											x		x				x	x		x	x	x	x	x	x	x	x		x
Pedicularis attollens						x	x		x	x	x	x			x	x	x	x		x				x	x				x
Perideridia parishii			x				x		x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x		x
Pinus contorta ssp. murrayana																			x	x	x		x	x	x	x	x	x	x
Pinus jeffreyi		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x										
Polygonum bistortoides		x			x		x	x		x		x						x		x	x	x	x	x	x	x	x		x
Populus tremuloides								x				x					x	x											
Potentilla palustris			x				x		x	x								x											
Ranunculus alismifolius var. alismellus			x						x	x										x	x		x	x					

MASTER PLANT LIST	FEN NUMBER 11-0##																												
DICOTS (cont.)																													
*** = plants of concern**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Ranunculus aquatilus																		x											
Salix eastwoodiae	x						x	x	x	x	x		x				x	x		x	x	x	x	x	x	x	x	x	
Salix sp.	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x		x	
Saxifraga oregana											x		x				x	x	x		x				x	x	x	x	x
Senecio triangularis		x	x	x	x	x	x	x	x		x	x	x			x		x		x	x	x	x	x	x	x	x		
*Sparganium natans**																		x											
Sphenosiadium capitulatum												x																	
Spiraea densiflora	x	x	x								x	x													x				
Spiraea douglasii			x						x	x	x		x		x			x		x	x			x				x	x
Stachys ajugoides var. rigida		x							x		x																	x	
Trifolium longipes		x	x																	x	x								
Vaccinium uliginosum	x		x		x	x	x	x	x	x	x		x		x			x		x	x	x		x	x			x	x
Veratrum californica		x			x		x	x	x			x				x	x												
Veronica americana																													
Viola macloskeyi		x	x		x			x							x	x		x			x			x				x	
MONOCOTS																													
Camassia quamash ssp.quamash	x		x			x	x	x		x		x					x			x	x	x		x	x	x		x	x
Carex angustata	x						x		x				x	x		x		x					x	x	x		x		x
Carex capitata																													x
Carex echinata			x	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x
Carex jonesii						x	x			x			x			x	x	x			x			x	x		x		x
Carex lenticulares var. impressa			x						x			x									x	x	x	x	x				
*Carex limosa**											x		x				x	x	x		x								x
Carex utriculata	x					x	x				x	x	x	x	x			x	x	x		x		x		x		x	
Danthonia californica var. americana											x																		
Deschampsia cespitosa ssp. Cespitosa																									x				
Eleocharis acicularis var. bella																					x								
Eleocharis pauciflora	x		x	x	x		x	x			x		x	x	x		x	x	x	x	x	x		x	x	x			x
Eriophorum criniger													x						x									x	
Glyceria borealis																													
Glyceria elata	x																		x		x			x	x	x			x
Juncus balticus	x									x			x	x	x								x						
Juncus covillei var. obtusas																	x				x			x					

MASTER PLANT LIST	FEN NUMBER 11-0##																												
MONOCOTS (cont.)																													
*** = plants of concern**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Juncus nevadensis							x						x					x		x									x
Lilium pardalinum ssp. shastense			x				x			x											x	x							
Luzula comosa								x		x										x									
Muhlenbergia richardsonis														x			x			x	x	x		x	x		x	x	
Plantanthera leucostachys						x																							
Platanthera sparsiflora																			x			x		x	x	x	x		x
Scirpus congdonii																x						x							
Scirpus diffusus					x		x	x		x		x				x				x	x	x		x	x	x	x	x	x
Spiranthes porrifolia											x	x	x				x	x	x					x		x			
Tofieldia occidentalis ssp. occidentalis			x								x	x	x				x		x	x				x	x				x
Veratrum californicum																				x	x		x	x	x	x		x	x

Bryophytes of the Buck's Lake Wilderness Fens
2005-2006

GENERAL MOSS DETERMINATION BY DAVID TOREN.

SPHAGNUM MOSS DETERMINATION BY: JAN JANSSENS (LAMBDA MAX ECOLOGICAL RESEARCH) AND RICHARD ANDRUS (BINGHAMTON UNIV. N.Y.)

* = Sensitive Species

Aulacomnium androgynum
Aulacomnium pa/ustre
Brachythecium frigidum
Brachythecium sp.
Bruchia bolanderi *
Bryum "robustum" (undescribed)
Bryum muehlenbeckii
Bryum pseudotriquetrum
Bryum weigelii
Ca!ypogela sp.
Cephalozia sp.
Cratoneuron filicinum
Dichodontium flavescens
Drepanocladus aduncus
Fissidens crispus
Fontinalis antipyretica
lsopterygiopsis pulchella
Marchantia polymorpha
Meesia triquetra *
Philonotis fontana
Philonotis fontana
Plagiomnium medium
Plagiothecium denticulatum
Pohlia camptotrachela
Pohlia drummondii
Pohlia nutans
Pohlia wahlenbergii
Polytrichum commune
Polytrichum juniperinum
Rhizomnium pseudopunctatum
Scapania undulata
Sphagnum angustifolium
Sphagnum capillifolium
Sphagnum contortum
Sphagnum sqarrosum
Sphagnum subsecundum
Sphagnum teres

Appendix B
Preliminary vegetation types observed in the fens

Fen Vegetation Types at Mt Pleasant RNA, Plumas National Forest

Based on Field Observation in Right-Hand Fork Salt Creek July 12-13, 2006

Todd Keeler-Wolf

1. *Eleocharis pauciflora-Carex limosa*: basin (central spring) with berm. Generally not sloping and sparsely to moderately covered with *Eleocharis pauciflora, Carex limosa, Drepanocladus*, *Meesia*, ; water depth only ca 2-4 inches in July. Usually has scattered *Carex utriculata*, either *Eleocharis or C. limosa* may dominate. may have scattered *Menyanthes*, but usually not a codominant as in #2

2. *Carex utriculata-Menyanthes (Sparganium minimum)* (dark green thick underwater moss), sometimes *Potamogeton natans*, *Torreyochloa pauciflora*, too. This is the deeper basin or spring hole type of fen community at Mt Pleasant. Potter's (2005) analog is *Carex utriculata*, but he does not mention *Menyanthes* or underwater mosses, so probably this does not describe the fen type of association.

3. Polygonum bistortoides - Carex echinata /Sphagnum (berms and flow areas into basin fens) often has Drosera rotundifolia, Mimulus primuloides, Saxifraga oregona, and Pedicularis attollens. Potter (2005) analog is Mimulus primuloides-Polygonum bistortoides. However, his description suggests he includes non-fen as well as fen types in good shape as well as in disturbed (grazed) conditions.

4. *Scirpus microcarpus* (sheet flow saturated fens); more low lying than #5 and possible the better condition model for #5. Potter's (2005) analog is *Scirpus* spp. (microcarpus lumped with congdoni) association. Potter notes that these stands are watered by moving water (sheet flow) and subsurface flow. Potter only lists moss at 14% constancy and low moss constancy appears to be generally true at Mt. Pleasant.

5. *Carex aquatilis – Carex lenticularis*; dewatered sheet flow peat or stream edges. Potter (2005) has the same name for his analog (he states either species can be dominant and both are ecologically analogous). *C. aquatilis* is highly rhizomatous.He does not mention a degraded (post fen destruction) form.

6. *Pinus contorta* ssp. *murrayana/Vaccinium uliginosum/Caltha / Polytrichum.* Wooded fen (edges of fen basins at base of slopes with springy flows) also includes *Kalmia microphylla*. This is an analog to Potter's (2005) *Pinus contorta murrayana/Vaccinium uliginosum-Ledum glandulosum* association, although he does not recognize it as a wooded fen and he does not note it occurring N of Yosemite.

7. *Vaccinium uliginosum-Kalmia/Drepanocladus* (may have *Alnus incana* and isolated *P. contorta murrayana*), similar to #3 but more stable and less saturated at surface. Forms along tops of fen berms separating basin and/or pool types of fens. Many species are shared with

the *P. bistortoides-C. echinata* type. Potter's (2005) analog is *Vaccinium uliginosum/Polygonum bistortoides* and he notes moss constancy at 90%.

8. Deflated fen top: mostly annuals: *Muhlenbergia filiformis-Spergularia rubra-Mimulus breweri, Rumex acetosella, Gilia capillaris, Lewisia nevadensis,* etc. Much pocket gopher activity, plus dry surface, this is not a fen but is the remains of one after peat is dewatered and bioturbated.