Lake Tahoe Basin Meadow Classification and Scorecards

Final Draft

For

The Tahoe Regional Planning Agency

And

The Lake Tahoe Basin Management Unit

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Introduction

The Lake Tahoe Basin Meadows classification is designed to provide an ecological classification (vegetative, soils, and hydrologic) and quantitative condition scorecards for meadows. These products are intended for use by wildlife biologists, range conservationists, hydrologists, soil scientists, and fisheries biologists in inventorying and assessing meadow conditions.

Methods

Sampling Design

One hundred and twenty-nine meadow sites were randomly chosen using an Arcview GIS database of meadow locations in the Lake Tahoe Basin. These sites were then plotted and used for locating meadow areas in the field. The overall approach in the field was based on sampling complexes of different ecological types occurring within each of the meadow areas. For example, a meadow location might include three separate ecological types: 1) along the active floodplain, on saturated soils, dominated by beaked sedge; 2) on an upper floodplain dominated by tufted hairgrass and Nebraska sedge; and 3) an upper terrace with seasonally dry soils dominated by tufted hairgrass. Each of the three types would be sampled in order to provide information on riparian complexes and environmental gradients, which influence riparian vegetation.

Site Data

Sketches were made of cross-sections of the meadow area and aerial views "overview" of the meadow mosaic. Sketches were made of the dominant vegetation physiognomy and relative positions of geomorphic features. Photos were taken of the entire mosaic and each of the individual ecological types sampled. The elevation, aspect, lateral slope perpendicular to the stream channel, and down valley slope were recorded for each ecological type sampled.

Vegetation data

A rectangular, fixed-area plot was placed in a representative location within each different "preliminary" ecological type identified by walking around the meadow. The size of the plot was 50 m^2, generally 5 X 10 m. More linear plots were used with the same area as necessary to fit the plot within a single type. All vascular plant species occurring within the plot were identified to species using nomenclature in The Jepson Manual, Higher Plants of California (Hickman 1993). Canopy cover for each species was ocularly estimated within the plot.

Within each 5 X 10 m vegetation plot, a soil profile was described using the standard NRCS protocol (USDA-NRCS 1975). A soil pit was dug to a depth of 1 m or to an impenetrable layer, whichever was first. Soil temperature was recorded at 20 and 50 cm depths. In addition, information on rooting depths and ground cover (total cover, litter cover, and cover of bare soil) was collected to provide additional indicators of the condition or ecological status of a site. Two root depth measurements were taken: the deepest depth to density of 10-100 roots dm^2, and the deepest depth to a density of > 100 roots dm^2.

Analysis

Classification

Constrained Indicator Species Analysis (COINSPAN)(Carleton 1993) was used to classify the 129 study sites into discrete ecological groups. COINSPAN is a divisive classification technique that allows for direct analysis of environmental gradients. COINSPAN uses canonical correspondence ordinations (CCA; ter Braak, 1986) to align plots along a gradient that reflects plant species gradients together with environmental gradients. These gradients are then grouped into similar species/environment classes using TWINSPAN (Hill 1979) sample-classification divisions. Because the COINSPAN classification is based on species groups together with environmental variables, it produces an ecological classification that reflects dominant gradients in the data. In the case of riparian areas, this is often a gradient that reflects soil moisture. From the CONSPAN classification, a dichotomous key to meadow types was developed.

Ecological Status

Ecological status was calculated for each plot sampled. In order to arrive at an ecological status the relative cover of three groups of plant species was calculated for each plot. The three groups of plant species were: 1) species indicating high seral conditions; 2) species indicating mid-seral conditions; and 3) species indicating low seral conditions. Plots were then classified as either fully functioning, functioning at-risk, or nonfunctioning depending on the relative amounts of the tree groups of plants (see scorecards). This gives the ecological status for vegetation. In addition, the ecological status for root depth and cover of bare soil were also calculated based on the scorecards. The scorecards developed by the Humboldt-Toiyabe National Forest Ecology Team (Weixelman et al. 1999) were used to guide the classification process. In order to arrive at an overall score for ecological status for a site, the scores for vegetation, rooting, and bare soil were combined and a preponderance of evidence concept was used. For example, if the vegetation score was fully functioning, and the root and bare soil score was functioning at-risk, then the overall score would be functioning at-risk. For the purposes of this report, ecological status was also summarized by riparian complex. For a given riparian complex, the plots within that complex were combined and a weighted average score was used to arrive at an ecological status for the complex.

Results

Ecological Type Classification

COINSPAN classification of the 129 meadow sites using vegetation and soil-site characteristics delineated 6 basic types (Table 1). A number of sites with willow cover were sampled (> 10% canopy cover of willow). These sites are included in Table 1 and in the key to ecological types because these sites are often associated with meadow types. The names of each of the six ecological types represent the dominant vegetation on the site at the nondegraded state, followed by the dominant soil suborder, and finally the dominant landform of the type. Examination of depths to soil saturation in Table 1 shows a clear moisture gradient from the drier ecological types (dry meadow and moist meadow) to the wetter types (Nebraska sedge and *Carex utriculata*). *Achnatherum lemonii* and *Muhlenbergia richardsonis* were associated with deeper depths to soil saturation, while Nebraska sedge and beaked sedge were associated with shallower depths to soil saturation. Variables associated with landscape position--soil suborder, depth to soil saturation, and depth to coarse fragments—were discriminating factors among ecological types. Each ecological type was a characteristic combination of ecosystem components (physiography, landform, vegetation, and soil).

Table 1. Results of the Lake Tahoe Basin riparian classification. Summary of selected physiographic, soil, and vegetation variables (means) for the six ecological types produced by COINSPAN.

Soil-site and vegetation characteristics	Ecological types					
	Dry Meadow	Moist Meadow	Wet meadow Hairgrass	Wet meadow Nebraska Sedge	Wet meadow Beaked Sedge	Willow/ Graminoid
Elevation, ft.	6506	6552	6573	6733	6601	6400
Geomorphic surface /less common	floodplain	floodplain /terrace	terrace /drainway	floodplain	floodplain /terrace	floodplain /terrace
Soil suborder	Cryoll	Aquic Cryoll	Aquoll	Aquoll	Aquoll	Aquic Cryoll
Depth to saturation, cm[1]	99	69	99	65	33	61
Temperature @ 20 cm, °C	11	11	11	11	12	12
Temperature @ 50 cm, °C	10	10	11	11	11	10
Depth to 10% coarse fragments, cm	54	60	30	75	52	70
Percent clay, % [2]	14	17	18	20	13	14
Valley down-slope, %	1.45	1.54	1.48	1.50	1.59	1.71
Valley side-slope, %	1.36	1.63	1.30	1.17	1.55	2.00
Constancy (%)						
Achnatherum lemonii	27	2	0	0	0	0
Muhlenbergia richardsonis	45	10	23	17	0	0
Carex nebrascensis	30	23	41	89	70	8
Deschampsia cespitosa	0	12	76	80	4	3
Carex rostrata/vesicaria	0	2	8	28	98	41
Salix spp.	0	2	4	8	5	86

[1] at date of sampling
[2] A horizon

1. Sites dominated by herbaceous plants, willows less than 10% cover. Slopes generally 0-2% 2

1'. Willow species dominate the site with greater than 10% cover. Soils saturated generally within 100 cm of the surface during the growing season. Soil mottles typically occur within 100 cm of the surface. Valley gradients (measured down-valley) tend to be 2% or greater, though this is variable. Occurs on floodplains and terraces. Key indicator species are: *Salix lemonii*, **Salix geyeriana**, *Carex nebrascensis*, and *Carex lanuginosa*.
.... **Willow-graminoid/Cryoll/ floodplain**

2. Depth to soil saturation greater than 100 cm during mid-growing season. Soil mottles do not occur within 100 cm of the surface. Surface moisture air-dry to field capacity for most of the growing season. Occurs on floodplains and drainways. Key indicator species are: *Poa secunda*, *Achnatherum lemonii*, and *Muhlenbergia richardsonis*.
.... **Dry meadow/Cryoll/floodplain**

2'. Depth to soil saturation less than 100 cm. Surface moisture at field capacity or wetter for most of the growing season. Soil mottles typically occur within 100 cm of the soil surface... 3

3. Depth to soil saturation or mottling typically at a depth of 50 to 100 cm at mid-growing season. Soil surface at field capacity or wetter for most of the growing season. Occurs on floodplains, terraces, and drainways. Key indicator plant species are: *Poa pratensis*, *Juncus balticus*, and *Carex nebrascensis*.
.... **Moist meadow/Aquic Cryoll/floodplain**

3'. Depth to soil saturation or mottling typically within 50 cm of the soil surface at mid-growing season. Soil surface at field capacity or wetter for most of the growing season.. 4

4. Sites very wet, often saturated to the surface early in the growing season on most years. Sites dominated or co-dominated by *Carex utriculata* or *Carex vesicaria*.
.... **Beaked sedge/Aquoll/floodplain**

4'. Not as above. Other plant species dominating the site. 5

5. Depth to coarse fragments averages 30 cm (10% by volume or greater). Soils typically have a sandy loam or fine sandy loam texture in the A horizon. Occurs on terraces, drainways and occasionally on floodplains. Key indicator species are: *Deschampsia cespitosa*, *Carex nebrascensis*, or *Veratrum californicum*.
.... **Wet meadow-Tufted hairgrass/ Cryaquoll/drainway**

5'. Depth to coarse fragments averages 75 cm (10% by volume or greater). Soils typically have a silt loam or fine sandy loam texture in the A horizon. Most often occurs on floodplains, or less commonly on terraces or drainways. Key indicator species are: *Carex nebrascensis*, *Carex simulata*, *Deschampsia cespitosa*, and *Juncus balticus*................................. **Wet meadow-Nebraska sedge Cyraquoll/floodplain**

Dry Meadow—Cryoll—floodplain ecological type:

Setting: This type typically occurs on sites that are moist early in the growing season and dry as the season progresses. Soils typically have no mottles or other redoximorphic features within the soil profile (1 m). This type is found on floodplains or drainways (no defined water channel) and less commonly at the dry edges of stream terraces. Slope varies from 1 to 10 percent.

Dominant vegetation: Important indicator plant species in this type are: *Poa pratensis*, *Achnatherum nelsonii*, *Muhlenbergia richardsonis*, *Juncus balticus*, and *Agoseris glauca*. These are plant species, which require early season moisture but tolerate drying conditions as the season progresses and require soil moisture at or above field capacity in the rooting zone early in the season.

Successional pathways: Late successional plant communities in this type are dominated by perennial graminoid species such as *Elymus trachycaulus*, *Poa secunda ssp. juncifolia*, or *Carex praegracilis*. On sites that retain moisture late in the growing season, Carex *nebrascensis* may dominate. Disturbance species such as *Potentilla gracilis*, *Achillea millefolium*, *Poa pratensis*, and/or *Juncus balticus* are typically present on sites that are heavily grazed and/or compacted (Manning and Padgett 1995).

Management: This type has a moderate erosion control potential. Bunchgrasses in this type are less effective at stabilizing sites than rhizomatous graminoids with higher root densities. Heavy grazing or soil compacting activities cause a decline in perennial rhizomatous graminoid species and favor the establishment of early seral, shallow-rooted forb species. Because of dry soils, sites in this type are vulnerable and easily altered by disturbance, and once altered, are slow to recover.

Scorecard for assessing ecological function – Dry meadow

Ecological function	Species composition	Rooting depth (>10 roots dm^2)	Bare soil
Fully functioning	Late seral plant species greater than 50% relative cover	> 12 cm	< 8 %
Functioning at-risk	Late seral species less than or equal to 50% relative cover and low seral species less than 50% relative cover.	7 – 12 cm	8-19 %
Nonfunctioning	Low seral plant species greater than or equal to 50% relative cover	0 – 6 cm	> 19 %

Moist Meadow—Aquic Cryoll—floodplain ecological type:

Setting: This type typically occurs on sites that are wet to moist well into the growing season--having soil surface moistures near field capacity to the end of the growing season. Soils typically have mottles or other redoximorphic features at a depth of 50 to 100 cm in the soil profile. This type is found on floodplains or terraces and less commonly on drainways (no defined water channel). Slopes vary from 1 to 6 percent.

Dominant vegetation: Important indicator plant species in this type are: *Poa pratensis*, *Juncus balticus*, *Carex nebrascensis*, *Peryteridia* spp., and *Aster occidentalis*. These are plant species which require moist to wet conditions well into the growing season.

Successional pathways: Late successional plant communities in this type are dominated by perennial graminoid species such as *Carex nebrascensis*, *Elymus trachycaulus*, *Poa nevadensis,* or *Carex simulata*. Whether *Poa pratensis* is introduced or whether some varieties occurred naturally in North America is still under debate (Robert Soreng, Cornell University, pers. comm.) *Poa pratensis* can out compete many native species following disturbance. In these cases, *Poa pratensis* sites may represent late seral conditions or a disclimax stage in this type. Disturbance species such as *Iris missouriensis*, *Potentilla gracilis*, *Achillea millefolium*, *Poa pratensis*, and/or *Juncus balticus* are typically present on sites that are heavily grazed and/or compacted (Manning and Padgett 1995).

Management: This type has a high erosion control potential. Heavy grazing or soil compaction causes a decline in perennial rhizomatous graminoid species and favor the establishment of early seral, shallow-rooted forb species. This type is vulnerable to disturbance from grazing because these sites are a preferred area for livestock and provide high value forage. It is also one of the dominant meadow types in and around campgrounds. Soils are particularly susceptible to compaction due to soil moistures, which are moist but often not saturated.

Scorecard for assessing ecological function – moist meadow

Ecological function	**Species composition**	**Rooting depth (>100 roots dm^2)**	**Bare soil**
Fully functioning	Late seral plant species greater than 50% relative cover	> 12 cm	< 5 %
Functioning at-risk	Late seral species less than or equal to 50% relative cover and low seral species less than 50% relative cover.	7 – 12 cm	5 – 15 %
Nonfunctioning	Low seral plant species greater than or equal to 50% relative cover	0 – 6 cm	> 15 %

Wet Meadow, Hairgrass—Aquoll—floodplain ecological type:

Setting: This type typically occurs on sites that are wet to moist well into the growing season—with mottles or other redoximorphic features within 50 cm of the soil surface. There are typically coarse fragments (gravel or cobble size) within 30 cm of the surface (10% or greater by volume). This type is found on drainways (no defined water channel) or terraces. Slopes vary from 1 to 6 percent.

Dominant vegetation: Important indicator plant species in this type are: *Deschampsia cespitosa*, *Carex nebrascensis*, *Poa pratensis*, *Juncus balticus*, *Hordeum brachyantherum*, and *Veratrun californicum*. These are plant species, which require moist to wet conditions well into the growing season and tolerate the better-drained soils typical of these sites.

Successional pathways: Late successional plant communities in this type are dominated by perennial graminoid species such as *Deschampsia cespitosa*, *Carex nebrascensis*, *Carex lanuginosa* or *Carex simulata*. *Deschamspsia cespitosa* is an early seral colonizer on gravel bars, but can occupy sites away from the stream channel indefinitely given stable conditions. When these conditions are combined with coarse fragments in the soil profile, hairgrass probably represents a late seral community in this type. Disturbance species such as *Hordeum brachyantherum*, *Potentilla gracilis*, *Achillea millefolium*, and *Aster occidentalis* are typically present on sites that are heavily grazed and/or compacted (Manning and Padgett 1995).

Management: This type has an erosion control potential of moderate to high. *Deschampsia cespitosa* has a moderate to low erosion Control Potential and is less capable of stabilizing streambanks than strongly rhizomatous sedge species. *Deschampsia cespitosa* is a bunchgrass, which reproduces by seed, it has a competitive disadvantage compared to rhizomatous sedges and grasses, which spread vegetatively (Manning and Padgett 1995).

Scorecard for assessing ecological function – wet meadow hairgrass

Ecological function	Species composition	Rooting depth (>100 roots dm^2)	Bare soil
Fully functioning	Late seral plant species greater than 50% relative cover	> 12 cm	< 5 %
Functioning at-risk	Late seral species less than or equal to 50% relative cover and low seral species less than 50% relative cover.	6 – 12 cm	5 – 15 %
Nonfunctioning	Low seral plant species greater than or equal to 50% relative cover	0 – 6 cm	> 15 %

Wet Meadow, Nebraska sedge—Aquoll—floodplain ecological type:

Setting: This type typically occurs on sites that are wet to moist well into the growing season--having mottles or other redoximorphic features within 50 cm of the soil surface. This type is found on floodplains or terraces and less commonly on drainways (no defined water channel). Slopes vary from 1 to 4 percent.

Dominant vegetation: Important indicator plant species in this type are: *Carex nebrascensis*, *Poa pratensis*, *Deschampsia cespitosa*, and/or *Carex simulata*. These are plant species which require moist to wet conditions well into the growing season.

Successional pathways: Late successional plant communities in this type are dominated by perennial graminoid species such as *Carex nebrascensis*, *Carex simulata*. *Deschampsia cespitosa* may occur or codominate at late seral stages. Within this type, *Juncus balticus* can out compete many species following disturbance. In these cases, *Juncus balticus* may represent a disclimax stage in this type. Disturbance species such as *Hordeum brachyantherum*, *Poa pratensis*, *Juncus balticus*, *Potentilla gracilis*, or *Achillea millefolium*, are typically present on sites that are heavily grazed and/or compacted (Manning and Padgett 1995).

Management: This type has a high erosion control potential. Heavy grazing or soil compaction causes a decline in perennial rhizomatous graminoid species like *Carex nebrascensis* and favor the establishment of early seral, shallow-rooted forb species. This type is vulnerable to disturbance from grazing because these sites are a preferred area for livestock and provide high value forage value.

Scorecard for assessing ecological function – Nebraska sedge

Ecological function	**Species composition**	**Rooting depth (>100 roots dm^2)**	Bare soil
Fully functioning	Late seral plant species greater than 50% relative cover	> 20 cm	< 5 %
Functioning at-risk	Late seral species less than or equal to 50% relative cover and low seral species less than 50% relative cover.	9 – 20 cm	5 – 15 %
Nonfunctioning	Low seral plant species greater than or equal to 50% relative cover.	0 – 8 cm	> 15 %

Wet Meadow, Beaked Sedge—Aquoll—floodplain ecological type:

Setting: This type typically has standing water or saturated soils at the surface early in the growing season and has soil mottles or other redoximorphic features within 50 cm of the surface. This type often occurs as small inclusions in large meadow complexes, often occurring in depressions (e.g. silted-in pond or blown-out beaver dams). This type is found on floodplains and terraces, and less commonly on drainways (no defined water channel). Slopes vary from 1 to 6 percent.

Indicator species: Important indicator plant species in this type are: *Carex utriculata*, *Carex vesicaria, Carex nebrascensis*, *Juncus nevadensis*, and *Epilobium ciliata*.

Successional pathways: Late successional plant communities in this type are dominated by perennial graminoid species such as *Carex utriculata*, *Carex vesicaria*, or *Carex nebrascensis*. Disturbance species such as *Senecio hydrophyllus*, *Hordeum brachyantherum*, *Eleocharis pauciflora*, and/or *Mimulus primuloides* are typically present on sites that are heavily grazed and/or compacted.

Management: The potential for erosion control on this type is high. *Carex utriculata* and *C. vesicaria* are deep-rooted perennial rhizomatous species are important for stabilizing streambanks. Beaked sedge typically colonizes recently formed ponds, and/or sites adjacent to stream channels. Sjoberb and Danell (1983) noted that shoot density of *Carex utriculata* had higher cover on sites that were only seasonally flooded; continually inundated sites had decreased shoot density. *Carex utriculata* colonizes permanently flooded sites and often does so from the outside edge. As soil and litter build up, these sites are more conducive to *C. utriculata* dominance. As soil moisture decreases, other species such *as Carex nebrascensis*, *Carex simulata*, and/or *Deschampsia cespitosa* may replace *C. utriculata*.

Scorecard for assessing ecological function – beaked sedge

Ecological function	Species composition	Rooting depth (>100 roots dm^2)	Bare soil
Fully functioning	Late seral plant species greater than 50% relative cover	> 18 cm	< 5 %
Functioning at-risk	Late seral species less than or equal to 50% relative cover and low seral species less than 50% relative cover.	7 – 18 cm	5 – 15 %
Nonfunctioning	Low seral plant species greater than or equal to 50% relative cover	0 – 6 cm	> 15 %

Summary of Ecological Status

Figure 1 shows the number of samples in each category of ecological status. Overall, 65 of the 129 total plots were in fully functioning, 47 were functioning but at risk, and 17 plots were nonfunctioning. Functioning and not functioning sites were not rated for trend. In order to arrive at these scores, the vegetation, root depth, and bare soil scores were combined an a preponderance of evidence concept was used to arrive at an ecological status. Therefore, only about 50% of the plots sampled were in fully functioning condition.

Table 2 shows the number of plots in each category of ecological function by ecological variables that were measured in the field. Vegetation composition reflects the amount of cover of late seral species on each site that promote soil stability, nutrient cycling and hydrologic function. Forty-six percent of the 129 total plots were in fully functioning condition based on vegetative composition. Rooting dept is an indicator of plant vigor and the amount of soil that is being utilized by plants. Table 2 shows that rooting depth was fully functioning on only 22% of the plots. The amount of bare soil indicates the amount of soil left uncovered by vegetation and litter and therefore the amount exposed to wind and water erosion. Table 2 shows that soil cover was fully functioning on 89% of the plots. These data summarizing the vegetation composition, rooting depth, and bare soil cover indicate potential problems associated with vegetation composition and rooting depth condition on meadows in the Lake Tahoe Basin. The rooting depth information indicates a potential lack of plant vigor on the sites sampled. This may be due to livestock grazing, recreation impacts, or drying of the meadow due to lowering of the water table. The information on vegetative composition indicates a general lack of dominance of late seral plant species on the sites sampled.

Figure 2 shows the number of plots within each category ecological status grouped by ecological type. The most meadow type had the lowest proportion of plots within the nonfunctioning category. Tufted hairgrass sites had the highest proportion of sites within the nonfunctioning category.

Plots were grouped into riparian complexes and a weighted score was calculated for each complex. Figure 3 shows the number of plots in each category of ecological status for all complexes combined. The graph shows that a relatively high proportion of plots fell in the functioning-at-risk category for the complexes sampled in this study.

Functional, but at risk, riparian systems is where managers have the greatest likelihood of restoration in the foreseeable future, thusly, they are of the greatest interest. It is the recommendation of the report that these sites be located and potential strategies for restoration of individual sites is identified.

Figure 1. Bar graph of the number of samples within each category of ecological status for all plots combined for the Lake Tahoe Basin Management Unit.

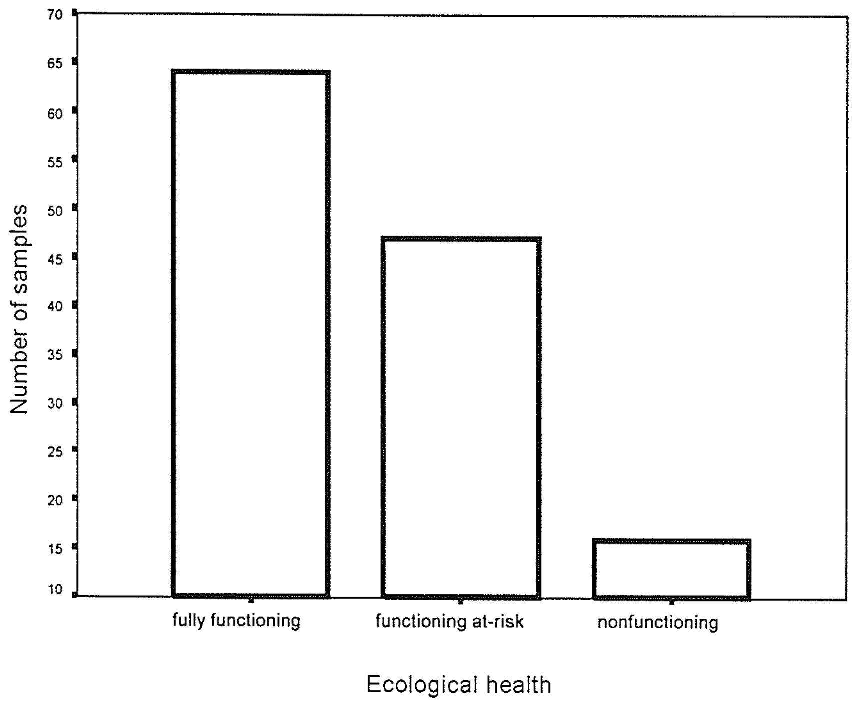
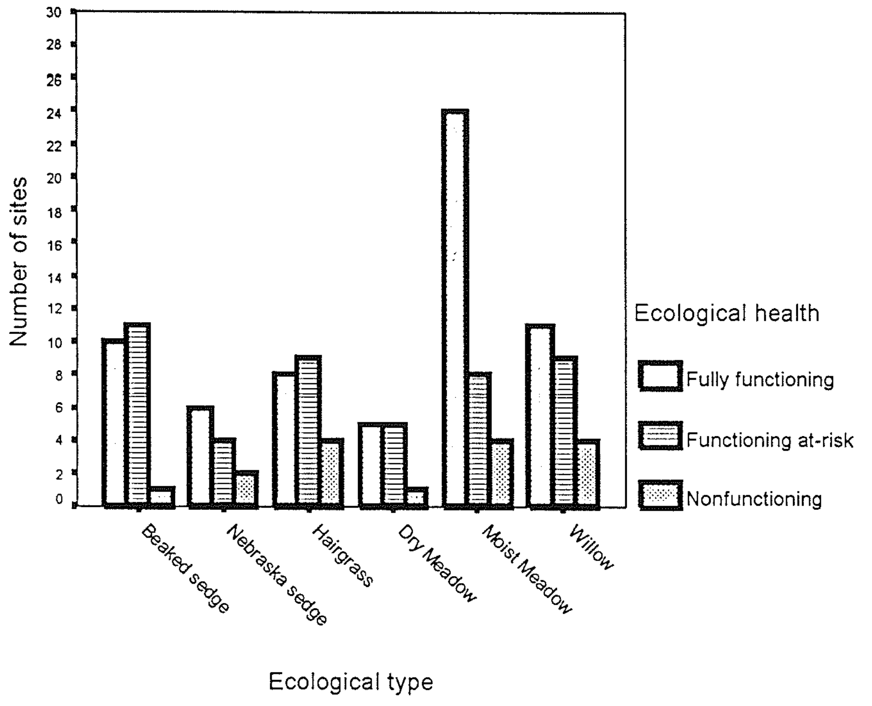


Table 2. The number of plots by ecological status by vegetation composition, rooting depth, and bare soil for all plots combined for the Lake Tahoe Basin Management Unit.

Variable	Fully functioning	Functioning at-risk	Nonfunctioning
Vegetation composition	60	48	19
Rooting depth	28	70	28
Bare soil cover	115	11	1

Figure 2. Bar graph of the number of samples within each category of ecological status by ecological type for the Lake Tahoe Basin Management Unit.



Desired future condition for meadows in the Lake Tahoe Basin

There is a need to define the desired future condition for vegetative and soil health of meadows in the Lake Tahoe Basin. The desired future condition should be based on a set of measurable attributes of meadows that help determine whether a site is healthy and functioning. Healthy, functioning sites are those sites where the hydrologic cycle and nutrient cycle are working properly. The scorecards in this report use plant species composition, rooting depth, and amount of bare soil as indicators of the ecological function of meadows. These indicators were chosen to provide measurable variables that indicate the ecological function of meadows.

Characteristics and Functions of Meadow Areas

Meadows often occupy transitional areas between upland and aquatic environments where surface, subsurface and atmospheric water meet. Due to this intermediate position, they are hydrologically linked to the upper and lower portions of the watershed. As a result, changes in wetlands often impact surrounding ecosystems and vice-versa. Because of this unique position in the watershed, meadows deserve special consideration in watershed management. Meadow areas are usually much more dynamic than uplands. While meadow plant communities may be especially susceptible to rapid change, it is not uncommon for hydro-geomorphological conditions to change dramatically, often in relatively short periods. These changes might include: flooding (either temporary or long-term, deposition of sediments across floodplains, accumulation of organic materials in areas such as wet meadows or bogs, dewatering of a site by a variety of means (e.g. irrigation diversions,) and changes in actual channel location. Each of these physical modifications can change the associated vegetation negatively or positively. Conversely, vegetation or the lack of it, may contribute to each of the above phenomena.

A healthy meadow provides several important ecological functions. These functions include water storage and aquifer recharge, filtering of chemical and organic wastes, sediment trapping, bank building and maintenance, flow energy dissipation, and primary biotic production.

Meadow areas provide for water storage and aquifer recharge. The soil underlying meadow areas act as a sponge to retain water. This stored water is released as subsurface water or groundwater over time, extending the availability of water in the watershed for a longer period in the summer or recharging the underground aquifer.

Riparian and meadow vegetation dissipates the energy of flowing water and stabilizes streambanks, thereby reducing erosion and the introduction of excessive sediment into the channel. Vegetation can also limit the movement of upland soil into the stream. These functions are particularly important during spring runoff periods and after major summer or fall rains.

Meadow vegetation traps sediments carried by the stream and by overland flow from the adjacent uplands. Trapping of sediment may lead to the development of new banks and bars, which become the location for new vegetation communities, further enhancing stability. Sediment retention is also important because excessive sediment loads reduce habitat quality

Healthy riparian systems enhance water quality by filtering out organic and chemical pollutants before they reach the channel and as they move downstream.

Appropriate meadow vegetation shields soil and water from wind, sunlight, and raindrop impact. This reduces erosion due to wind and the disruptive impact of rainfall as well as reducing evaporation. Vegetative canopy cover also provides shade, which reduces water temperatures and improves aquatic habitat. Although and increase in vegetation may increase evapotranspiration, in natural systems the overall benefits offset this loss.

Meadow areas are rich in biotic production. The presence of water and essential nutrients make these areas among the most productive parts of a landscape, especially in such regions as the arid and semi-arid western United States. This productivity enhances livestock use as well. Biomass on mountain meadows, for example, is 10 to 20 times higher than that of surrounding uplands.

At Lake Tahoe, watershed management concerns focus on preservation of the lake's exceptional clarity. Excessive input of nutrients and suspended solids has caused accelerated eutrophication, leading to national concern for the local environment and economy. Meadows mitigate eutrophication by immobilizing solutes and particles (Craft et al. 1988), an attribute that makes them a valuable ecological component of the Tahoe Basin.

Desired Future Condition

This report recommends that the desired future condition of meadows be defined as **fully functioning or functioning but at risk**. The degree of ecological function-- fully functioning, functioning at-risk, or nonfunctioning, will be measured using the ecological scorecards outlined in this report. Three measurable indicators will be used to monitor ecological function: 1) plant species composition; 2) rooting depth; and 3) the amount of bare soil. The scorecard will be used to rate each of the indicators on a scale of ecological function, from fully functioning to nonfunctioning. The preponderance of evidence concept will be used to arrive at a score. For example, if the vegetative composition attribute is functioning at-risk, the rooting depth is fully functioning, and the bare soil attribute is functioning at-risk, the overall score is functioning at-risk. Further, each meadow scorecard will be specific to an ecological type.

Plant Species Composition

- The desired future condition on a meadow sites is defined as fully functioning or functioning at-risk. In terms of plant composition, this equates to having late seral species less than or equal to 50% relative cover and low seral species less than 50% relative cover (see individual scorecards).

Plant species composition is a particularly useful measure of ecological function in meadows because plant species composition reflects the overall health of a site. On sites with good infiltrating capabilities, late seral, deep-rooted plant species are able to grow vigorously. The deep, fibrous roots of these species promote water infiltration along preferential flow paths, species are long-lived perennial graminoid species that have deep, fibrous root systems. These root systems are effective soil binders and help protect streambanks from eroding. Early seral species are generally forbs or shallow rooted graminoid species that can quickly colonize a disturbed site. These species are not effective at protecting banks from erosion. The U.S. Forest Service, (USDA 1998), Region 5, has classified riparian plant species as late seral, mid seral, or early seral species. The relative cover of each of the seral classes gives an effective measure of the degree of disturbance and ecological function of a site.

Root Depth

- The desired future condition of meadows is to have the root depth at fully functioning or functioning at-risk (see individual scorecards).

Rooting depth is the depth to which roots penetrate the soil. The actual depth is measured as the deepest point in the soil profile where the density of roots is at least 10 roots or 100 roots per dm^2 (specified on the scorecard). This is area is about the size of your palm. This measurement is sometimes referred to as root-length density. This is effectively the sod depth. Root depth is a good indicator of the plant species composition because late seral plant species with fibrous roots have a deeper root depth than do early seral forb species. Root length density is also a good measure of plant vigor because vigorous plants have a deeper root-length density than do plants that are not vigorous. Rooting depth is a good overall indicator of the hydrologic function of a site. Sites with good infiltrating conditions are sites with deeper-rooted plant species. The degree to which the available root zone is occupied by plant roots suggests the degree to which nutrients are utilized and cycled (National Research Council 1994). Healthy sites with deep-rooted zones, result in a more complete utilization of the water and nutrients available throughout the entire soil profile. Often, when a site is disturbed, whether from physical disturbance or a change in the water table, a change in rooting depth will precede changes in plant composition. Likewise, when a site is recovering, changes in root depth may be the first obvious clue that the site is improving in ecological function.

Bare Soil

- The desired future condition of meadows is to have the amount of bare soil at fully functioning or functioning at-risk (see individual scorecards).

Bare soil is the percent coverage of exposed soil. The amount of bare soil is a good indicator of the erosion potential that exists on a site. In undisturbed meadows, a dense sod of perennial graminoid species helps keep the soil surface intact and prevents the loss of soil during rain or flooding events. The amount of bare soil provides a measure of the ability of a site to dissipate the energy of flood flows and captures sediment. This is important for meadows on floodplain landforms. The amount of bare soil is an indicator of the amount of disturbance on a site. Excessive soil disturbance due to livestock or human-caused disturbance causes breaks in the sod layer and eventually open areas of bare soil. These areas of bare soil are microsites that provide favorable seedling establishment for early seral pioneering plant species such as dandelion, yarrow, or cinquefoil species. Generally, dry meadows have a greater cover of bare soil than moist or wet meadows even under undisturbed conditions. These differences are evident in the scorecards.

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Appendix A. Ecological status of individual plots.

SAMPLE_ID	ECOTYPE	Overall Ecological Status
850	Moist Me	Proper functioning
851	Willow	Proper functioning
852	Willow	Proper functioning
853	Moist Me	Proper functioning
854	Willow	Proper functioning
855	Willow	Proper functioning
856	Willow	Proper functioning
857	Moist Me	Proper functioning
858	Beaked	functioning-at risk
859	Moist Me	Proper functioning
860	Willow	Proper functioning
861	Beaked	Proper functioning
862	Beaked	Proper functioning
863	Beaked	Proper functioning
864	Beaked	Proper functioning
865	Willow	Proper functioning
866	Willow	functioning-at risk
867	Cane	Proper functioning
868	Decal	Proper functioning
869	Decal	Proper functioning
870	Cane	Proper functioning
871	Willow	Proper functioning
872	Willow	functioning-at risk
873	Moist Me	Proper functioning
874	Cane	nonfunctioning
875	Moist Me	functioning-at risk
876	Moist Me	functioning-at risk
877	Moist Me	Proper functioning
878	Beaked	nonfunctioning
879	Dry Mead	functioning-at risk
880	Dry Mead	nonfunctioning
881	Decal	Proper functioning
882	Willow	nonfunctioning
883	Moist Me	functioning-at risk
884	Beaked	Proper functioning
885	Beaked	Proper functioning
886	Beaked	functioning-at risk
887	Moist Me	Proper functioning
888	Beaked	Proper functioning
889	Willow	functioning-at risk
890	Dry Mead	functioning-at risk
891	Moist Me	Proper functioning
892	Willow	functioning-at risk
893	Willow	nonfunctioning
894	Beaked	functioning-at risk
895	Moist Me	Proper functioning
896	Dry Mead	Proper functioning
897	Willow	functioning-at risk
898	Decal	functioning-at risk
899	Beaked	functioning-at risk
950	Moist Me	functioning-at risk

952	Moist Me	Proper functioning
953	Beaked	functioning-at risk
954	Dry Mead	functioning-at risk
955	Moist Me	Proper functioning
956	Beaked	Proper functioning
957	Cane	nonfunctioning
958	Moist Me	functioning-at risk
959	Moist Me	Proper functioning
960	Dry Mead	functioning-at risk
961	Moist Me	functioning-at risk
962	Moist Me	Proper functioning
963	Willow	functioning-at risk
964	Beaked	Proper functioning
965	Moist Me	Proper functioning
966	Willow	Proper functioning
967	Cane	Proper functioning
968	Beaked	functioning-at risk
969	Decal	functioning-at risk
970	Moist Me	Proper functioning
971	Cane	functioning-at risk
972	Beaked	Proper functioning
973	Moist Me	Proper functioning
974	Decal	nonfunctioning
975	Cane	Proper functioning
976	Dry Mead	Proper functioning
977	Beaked	functioning-at risk
978	Beaked	functioning-at risk
979	Moist Me	Proper functioning
980	Moist Me	functioning-at risk
981	Beaked	functioning-at risk
982	Willow	functioning-at risk
983	Moist Me	Proper functioning
984	Cane	functioning-at risk
985	Willow	Proper functioning
986	Cane	functioning-at risk
987	Willow	functioning-at risk
988	Decal	functioning-at risk
989	Moist Me	Proper functioning
1001	Dry Mead	Proper functioning
1002	Beaked	functioning-at risk
1003	Moist Me	functioning-at risk
1004	Willow	Proper functioning
1005	Willow	functioning-at risk
1006	Decal	functioning-at risk
1007	Moist Me	nonfunctioning
1008	Moist Me	nonfunctioning
1010	Decal	nonfunctioning
1011	Moist Me	nonfunctioning
1012	Moist Me	Proper functioning
1013	Cane	functioning-at risk
1014	Decal	Proper functioning
1015	Decal	Proper functioning
1016	Decal	Proper functioning
1017	Willow	nonfunctioning
1018	Decal	nonfunctioning
1019	Decal	functioning-at risk

1021	Decal	functioning-at risk
1022	Decal	functioning-at risk
1023	Decal	nonfunctioning
1024	Decal	Proper functioning
1025	Moist Me	Proper functioning
1026	Moist Me	Proper functioning
1027	Decal	functioning-at risk
1028	Moist Me	Proper functioning
1029	Decal	functioning-at risk
1030	Beaked	functioning-at risk
1032	Moist Me	nonfunctioning
1033	Cane	Proper functioning
1034	Dry Mead	Proper functioning
1035	Dry Mead	Proper functioning
1036	Decal	Proper functioning
1037	Moist Me	Proper functioning
1038	Cane	Proper functioning

RIPARIAN CLASSIFICATION/SCORECARD PROTOCOL SAMPLING

This protocol is designed to provide data for an ecological classification (vegetative, soils, and hydrologic) and quantitative ecological condition scorecard for meadows. Products will include an ecological classification guide, and scorecard for rating ecological condition of individual ecological units and mosaics. These products are intended for use by wildlife biologists, range conservationists, hydrologists, soil scientists, and fisheries biologists in inventorying and assessing meadow conditions.

OVERALL APPROACH

The approach is based upon sampling complexes of different ecological types occurring within meadow areas. For example, a meadow might include three separate types: 1) along the active floodplain, on saturated soils, dominated by beaked sedge; 2) on an upper floodplain, on saturated soils, with gravelly subsoil, dominated by Nebraska sedge and tufted hairgrass. Emphasis is placed on sampling a high proportion of meadows that have had little recent disturbance are included to provide information on reference conditions.

Classification information includes: complete floristic cover data, soil profile descriptions, and key hydrologic characteristics of associated channels. Condition information includes: soil infiltration rates (for moderate to dry types), rooting depth, soil structure, and vegetation structure (total cover, litter cover, hardwood age-classes).

SAMPLE SITE SELECTION

A statistical sampling approach is preferred but may not always be practical. A two-stage approach may be needed including subjective selection of key reference sites followed by a statistical sample of other sites.

For the first approach, Forest and District personnel that may be knowledgeable about meadow locations and conditions should be consulted including: botanists, range conservationists, wildlife biologists, hydrologists, soil scientists, and fisheries biologists. They should be especially queried for sites that may have had little recent disturbance and considered to be in "good condition". Information should be recorded on: location on a map; approximate elevation; surrounding forest or ecosystem type (i.e. red fire or mixed-conifer); dominant geologic substrate; grazing and recreation use history; and qualitative information on condition. In the second stages information can be gathered on additional meadow sites by querying potential natural vegetation layers for meadows as primary, secondary, or inclusions, and from examination of orthophotographs.

If possible, a combined map of potential sample sites from orthophotos, soil maps, and queries of knowledgeable personnel is then constructed and a unique identification number is assigned to each site. These can then be used to randomly select samples sites.

Since sites in undisturbed, "good condition" may be uncommon. These may all be subjectively included. A stratified sample may increase efficiency and representatives. Stratification can be achieved in several ways. One way would be to stratify by major soil types identified in soil surveys. A second way would be to construct a database with information on elevation, dominant soil type, major geologic substrate, grazing and recreation use history, and condition information and then conduct a query of the database. If an ecological unit inventory layer at the land type association scale is available, it may be selected in case some of the initial selections are not suitable for sampling or more time is available.

SITE DATA

Sketch a picture of a cross-section and aerial "over-view: of the meadow mosaic. Include diagrams of dominant vegetation physiognomy and relative positions of geomorphic surfaces. Record descriptive summary of dominant vegetation and site. Take a photo of the entire mosaic and each of the individual ecological types sampled using 64 35 mm slide film. Use a range pole to display a header plaque affixed with Forest Number code and Plot Number. The letters and numbers need to be large enough to be read from all photographs. Using a 35 mm wide-angle lens, take at least the following photographs:

- One photo 20 feet from pole for stand structure.
- One photo of typical shrub and ground layer species

Record the following location and overall environment data on the Cover card (I).

PLOT Plot identification number assigned by Forest, 4-digit numeric.

Record data on a site summary/location cover form (I). For every plot record the names of individuals on the sampling crew and plot collection date.

Classification

A rectangular, fixed-area plot is placed in a representative location within each different "preliminary ecological type" identified in walking around the meadow. The size of the plot is 50 meters squared, generally 5 x 10 m. More linear plots may be used with the same area as necessary to fit the plot within a single type.

All vascular plant species occurring within the plot are identified to species using nomenclature in Jepson (1993) unless a taxonomic expert is consulted as to a more accepted estimated within the plot and recorded on the R% data card III.

For plots wit woody vegetation (i.e. aspen or willows) that exceed 1" d.b.h. a fixed-area plot 10m x 10m is placed in conjunction with the understory plot. The d.b.h. of each stem is measured with a diameter tape and recorded along with species. Height of the first three trees recorded in 10" d.b.h. classes are measured with a range pole or with a clinometer and tape (if range pole is too short). Overstory canopy cover is measured using a spherical densiometer from the center and four corners of the plot.

SOILS

Classification and Scorecard

Within each 5 x 10 m vegetation classification plot, complete a soil profile description, using the standard NRCS protocol. Sample to 40 " or to impenetrable layer, whichever is first. An auger is generally sufficient to sample the soils.

Measure soil temperature at 20 and 50 cm depths. Measured with a thermometer probe penetrating at least 7.5 cm; recorded to the nearest degree Celsius.

I. Overall Meadow

PLOT — Unique number for each plot (one for each site within a meadow)
Tahoe start at 800
Eldorado start at 9f50

Location

FOREST — Two digit numeric code
03-Eldorado
17-Tahoe

DISTRICT — two-digit numeric code

STRMO — Stream Order. Determine from quad sheet. One digit numeric. See appendix for a graphic depiction.

VB — Valley Bottom. Four-digit numeric. Use Valley Bottom Classification, See diagram and codes in appendix.

ELEV — Elevation in feet. Record plot elevation from USGS topographic map Sheet or using an altimeter, which is, recalibrated daily. Record to the nearest 20 feet. 4-digit numeric value.

II. For each plot location

For each site sampled in the meadow measure/record the following:

DISTAQ — Distance to stream bankfull) from water source for the plot in horizontal Feet

ELABAQ — Elevation in feet above stream or water source, estimated or measured with appropriate instruments. A clinometer and range pole can be used to measure elevations. Record to nearest 0.1 foot. If plot is submerged, record a negative value.

1. inactive channel
2. lower terrace
3. upper terrace
4. cutbank
5. rock cliff (won't apply to meadows)
6. lower bank
7. upper bank
8. depositional bar
9. island
10. inside bend
11. outside bend
12. beaver pond
13. area of subsurface flow
14. active floodplain-immediately next to channel
15. active floodplain-not immediately next to channel

HMRLF/ VMRLF — Horizontal and vertical microrelief within confines of the plot (parallel and perpendicular to contours), 1- digit numeric code

1. convex
2. linear
3. concave
4. undulating
5. hummocky
6. mounded
7. other (explain)
8. terraced

WTRMV — Plot water movement, 1-digit numeric
1-stagnant. Velocity of water flow through the plot is very slow
2-water is entering and leaving the plot readily. Fresh aerated water is available to plants
3-dry

INPFLW — Input flow = water source for meadow site. 1-digit numeric
1-stream
2-seep/spring
3-snowmelt or neither 1 or 2

ASPECT — Azimuth (actual value) to the nearest degree. 3-digit numeric. A zero means flat with no aspect.

SLOPE — Slope of the plot in %, observed from one edge of the plot to the other edge and perpendicular to the contours. 3-digit numeric.

Vegetation Summary Data
With the fixed-area plot, measure/estimate and record the following summary data. If a layer is not present, it is missing. Record a blank (dash) for the absent layer to note that it was observed as not being present versus missing data.

TVEG% — Total Vegetation. Ocular estimate of total foliar canopy cover (always 100% or less). This is a vertical projection of canopy cover on the ground. 3-digit numeric value.

TFCOV% — Total Forb Cover. Record estimate of total for (herbs) cover on plot. 3-digit numeric value.

TGCOV% — Total graminoid cover. Record estimate of average height of graminoids cover on plot. 3-digit numeric value.

GRAMHT — Graminoid height. Record estimate of average height of graminoids on the plot, in inches (measure in 3 spots and average).

GRASS% — Total grass cover. Record estimate of total grass cover on plot. 3-digit numeric value.

GRSSLK% — Total grasslike cover. Record estimate of total cover of sedges, rushes, etc (all except grasses) for the plot. 3-digit numeric Value.

TSCOV% — Total shrub cover. Record estimate of total shrub cover on plot as vertical foliar projection (value less than 100%). 3-digit Numeric.

SHRBHT — Shrub height cover. Record average height of dominant shrubs on the plot to the nearest 1 ft.

TTCOV% — Total tree cover. Record estimate of vertical projection of tree Cover. Always 100% or less. 3-digit numeric value.

MOSS% — Moss cover. Record estimate of cover of mosses in the plot. 2-Digit numeric.

For each vascular plant species present, record the species and canopy cover.

SPECIES NAME	Write out complete scientific name for each species (if Jepson was not source, then note the source).
SPECIES CODE	5-digit Plant Code for each species
%CC	Estimate the % cover of each plant species. If less than 1% record as t (trace).

Shrub age-class/decadence/form and hedging

SHRAGE

Shrub Age and From Classes. Sampled along a transect, 6' wide, along the plant frequency transects. For each woody species rooted within the ends of the pole (3 feet on either side) are tallied based on the following categories.

Age Classes: S=Seedling/sprout -1 stem
Y=Young Plant - 2 to 10 stems
M=Mature Plant - > 10 stems, >1/2 alive
D=Decadent Plant - >10 stems, < ½ alive

Form Classes: 1 - all available, little or no hedging
2 – all available, moderate hedging
3 – all available, heavily hedged
4 – largely available, little or no hedging
5 – largely available, moderately hedged
6 – mostly unavailable
7 – unavailable

For smaller stature species such as *Salix wofii*, change the number of stems from ten to five. And, for single stemmed species such as *Salix exiqua*, *Betula* spp., and *Alnus* spp., count each stem that occurs 12 or more inches from each other as a separate plant.

Soil Profile Description

Using the standard SCS soil profile description procedures describe the soil profile.
Use the SCS soil profile description data sheet and fill in the following portions:

a) horizon depths (include O horizon)
b) color (for classification)
c) structure
d) course fragments
e) % clay, texture
f) depth to sod layer (instead of rooting information)
g) mottling/gleying (depth and describe)
h) depth to saturation (in pit)
i) drainage class
j) soil temperature at 20 and 50 cm depths
k) evidence of compaction (i.e. with structure)