Montane and Subalpine Meadows of the Three Sisters Wilderness Area/Biosphere Reserve, Oregon: A Community Classification and Gradient Analysis.

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Introduction

Meadows occupy a small portion of the largely forested landscape of the Oregon Cascade Range. However, they support a significant portion of the regional flora and receive a disproportionate amount of public visitation. Despite their ecological and aesthetic value, there have been relatively few studies of the composition, structure, or environmental relationships of these physiognomically and biologically diverse communities.

I present a plant community classification and gradient analysis of the montane and subalpine meadow vegetation of the Three Sisters Wilderness Area in the central Cascade Range of Oregon (**Fig. 1**). Encompassing more than 100,000 ha of essentially undisturbed landscape, the Three Sisters was designated a UNESCO Biosphere Reserve in 1974—a "control" site for the nearby H. J. Andrews Biosphere Reserve. Baseline data on the composition, structure, and distribution of major plant communities was integral to the establishment of each Reserve, and is essential for monitoring both natural vegetation change and effects of human activities. The current work represents one component of a broader effort to describe the current conditions and long-term dynamics of the major ecosystems of the Three Sisters.

Study Area

The Three Sisters Wilderness straddles the crest of the central Cascade Range, encompassing two physiographic provinces:

Western Cascades.—steep, deeply dissected; volcanic flows and pyroclastic deposits of Oligocene/Miocene origin; soils derived from basalt, andesites, and pyroclastics (tuffs and breccias).

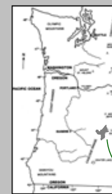
High Cascades.—gentle, rolling topography; geologically much younger, Quaternary shield/composite volcanoes; soils deep and well drained from recent deposits of pumice, ash, and cinders.

Climate.—varies markedly with elevation and topography:

- Precipitation: 1000-3300 mm (increases with elevation).
- Snow pack: >4 m in May (at elevations above 1000 m).
- Temperature (mean): Jan. 0.6°C, July 17.8°C (Andrews Forest).

Forest vegetation.—variously dominated by *Abies grandis*, *Pseudotsuga menziesii*, *A. amabilis*, and *Pinus contorta* in the montane zone (<1600 m) and by *Tsuga mertensiana*, *A. lasiocarpa*, and *Pinus albicaulis* in the subalpine (1600-2200 m).

Disturbance.—episodic forest fires, every100-150 yr at lower elevations but much less frequent in the subalpine; widespread sheep grazing (1870 to 1947), most intense from 1880 to 1910.



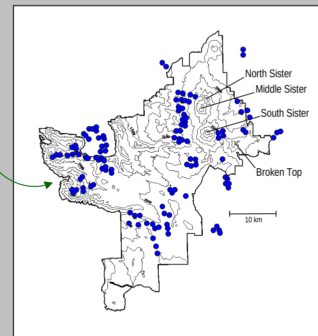


Figure 1. The Three Sisters Wilderness Area/Biosphere Reserve with locations of sample plots.

Methods

Sampling of meadow sites was conducted during summer 1982 using the reconnaissance method of Franklin et al. (1970). The term "meadow" is applied broadly to a diversity of non-forested vegetation types, including mires, lithosolic ridgetop communities, and pumice barrens characteristic of the High Cascade physiographic province.

Potential study sites were identified from topographic maps and aerial photographs. We sampled a total of 152 plots in montane and subalpine meadows within and adjacent to the Wilderness boundary (**Fig. 1**). At each location, a circular plot (500 m^2) was subjectively placed in visually homogenous vegetation. Cover of each vascular plant species was estimated and a series of environmental measurements was taken (**Table 1**).

Vegetation analysis involved two complementary approaches: classification using indicator species analysis (TWINSPAN) and indirect ordination (detrended correspondence analysis [DCA]). An initial ordination was conducted on the full data matrix; relationships of environmental variables with the principal ordination axes were then constructed using the overlay option in PCORD (ver. 3.2) (**Fig. 2**). Subsequent ordinations, including overlays of TWINSPAN communities and environmental characteristics of plots were conducted on subsets of the original data matrix (**Fig. 3**).

Table 1. Environmental variables used in correlation analyses and overlays of DCA ordinations (variables 4-6 treated as categorical).

1. Elevation
2. Slope
3. Aspect = 1 - sin (x + 45), range of 0 (NE) - 2 (SW)
4. Topographic position
   - flat or basin
   - lower slope
   - mid slope
   - upper slope
   - ridgetop
5. Hydrology
   - dry
   - sub-surface water table
   - ground-surface water table
   - standing water
6. Soil texture
   - coarse (sand - fine sandy loam)
   - medium (loam - silty clay loam)
   - fine (organic/peat)

Results and Discussion

Floristics

We recorded a total of 347 species representing 56 families and 186 genera. Families with the greatest floristic diversity were:

Family	No. species	No. genera
Cyperaceae	34	3
Gramineae	33	19
Compositae	32	18
Scrophulariaceae	23	7
Rosaceae	20	12

DCA and correlation analyses: all sample plots

Compositional trends among the full set of sample plots reflect broad gradients of slope, landform, and elevation:

- Axis 1 correlates strongly with slope (**Fig. 2**); it separates level landforms and basins from hillslopes and ridgetops.
- Axis 2 correlates strongly with elevation (**Fig. 2**) and separates montane from subalpine sites.

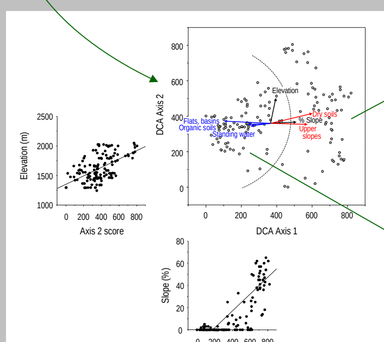


Figure 2. DCA ordination of the full set of sample plots. Correlations between environmental variables and DCA axes are represented by the length and direction of arrows.

Community classification

TWINSPAN yielded the following plant community types:

Montane zone

Hydric series
- *Carex sitchensis*
- *Eleocharis pauciflora*
- *Deschampsia caespitosa*
- *Deschampsia caespitosa - Trifolium longipes*

Mesic series
- *Veratrum* spp.- *Senecio triangularis*
- *Rudbeckia occidentalis*
- *Rubus parviflorus*
- *Pteridium aquilinum - Elymus glaucus*
- *Carex pensylvanica - Bromus* spp.

Xeric series
- *Festuca idahoensis - Agrostis diegoensis*
- *Eriophyllum lanatum - Gilia capitata*
- *Penstemon procerus - Sanicula graveolens*

Subalpine zone

- *Festuca viridula*
- *Deschampsia caespitosa - Carex spectabilis*
- *Carex spectabilis - Lupinus latifolius*
- *Polygonum newberryi*
- *Juncus parryi*
- *Luetkea pectinata*
- *Phyllodoce empetriformis - Cassiope mertensiana*
- *Carex scopulorum*
- *Carex nigricans*

Environmental correlates of plant communities

- Communities defined by TWINSPAN occupy fairly distinct regions in ordination space (**Fig. 3**), although some show greater variability in species composition than do others.
- For ordinations of both landform types, species turnover is high (beta diversity of 8 to ~10 standard deviations) along the elevational gradient defined by Axis 1 (**Fig. 3**). Pearson correlation coefficients for Axis 1 vs. elevation were 0.846 (sloping landforms) and 0.733 (level landforms).
- Climate changes dramatically across the elevational range sampled (1240-2200 m): temperature decreases, precipitation increases, and depth and duration of winter snowpack increase with elevation, leading to a decline in the length of the growing season.
- On sloping landforms, community composition also correlates with topographic position, particularly in the montane zone (**top panel, Fig. 3**). Soil moisture availability and soil depth decline from lower slopes to ridgetops.
- On level landforms and in basins, community composition varies with site hydrology (depth and seasonal movement of the water table) and with associated changes in soil texture (soils become finer textured and increasingly organic under more hydric conditions) (**bottom panel, Fig. 3**). In the montane zone, *Carex sitchensis* communities occur where water lies at, or well above, the ground surface, and *Deschampsia* types, where it is deeper or soil saturation more seasonal. In the subalpine zone, *Carex spectabilis* communities occur on well-drained soils, *Carex nigricans* types in areas of late snow melt, and *Carex scopulorum* types in hydric soils associated with surface flows, seeps, or lakeshores.

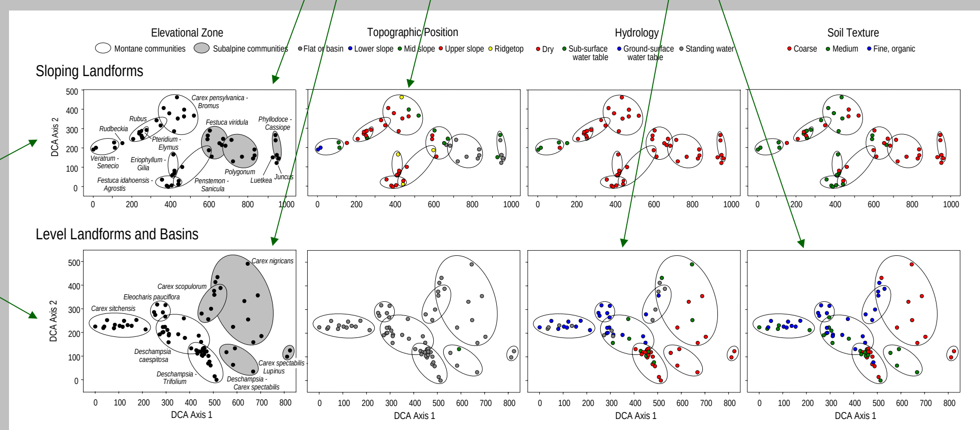


Figure 3. DCA ordinations of subsets of plots derived from the initial ordination of all sites (Fig. 2). Community types defined by TWINSPAN are superimposed on the first set of ordination axes. Topographic, hydrologic, and soil texture classes of sample plots are color coded. **Top panel:** plots representing sloping landforms. **Bottom panel:** plots representing level landforms and basins.