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Forest and Meadow Communities of the Three Sister Biosphere Reserve

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The Three Sisters Biosphere Reserve encompasses nearly 100 square kilometers of virtually undisturbed land stradling the crest of the central Cascade Mountains of Oregon. Although coniferous forests dominate, an array of other ecosystems creates a diverse picturesque landscape (Figure 1). The Three Sisters Biosphere Reserve, established as a primitive area in 1933, was selected in 1974 to serve as a control for the nearby experimentally oriented H. J. Andrews Biosphere Reserve. Ecological information about the Three Sisters Biosphere Reserve was needed to establish a basis for future comparative research with the intensively managed H. J. Andrews Biosphere Reserve.

Objectives

The objectives of this study were to:

- Describe the composition, structure, and distribution of major forest and meadow communities, as well as their principal environmental controls.
- Establish a series of permanent sample plots for examining long-term changes in the composition and structure of these communities.



FIGURE 1. Forest and meadow ecosystems in the Three Sisters Biosphere Reserve in the central Cascade Mountains of Oregon.

Methods

Field sampling, conducted over a 3-year period starting in 1981, documented the composition, structure, and distribution of forest and meadow communities in the Three Sisters Biosphere Reserve. In the summer of 1983, a series of permanent transects were established to assess long-term changes in vegetative composition and structure across boundaries between these forest and meadow communities.

- Forest vegetation was sampled using a reconnaissance method, in which compositional characteristics of forest sample plots were assessed through estimates of canopy cover of each vascular plant species. Structural characteristics were examined through the identification of height and diameter size class distributions for all tree species.

The age of forest stands was estimated with increment cores taken from one or two dominant seral trees within each sample plot. Environmental features (elevation, slope and aspect, landform, and topography) were recorded and important soil characteristics (particle size distribution and litter composition) were described. Additional observations on fire and geomorphic disturbance, as well as other distinctive features not addressed in the reconnaissance data, were recorded.

- Meadow communities, comprised of bog, fen, pumice flat and "rock garden" communities, were examined using techniques similar to those employed for forests. Sample plots were characterized in terms of species composition and environmental features, with special attention given to the mosaic of vegetative types within each meadow.
- Baseline information for future examination of vegetative change, obtained from a series of permanently marked transects across the

boundaries between forest and meadow communities, was installed (Figure 2). Sites were selected to represent a diversity of types and to encompass the variety of tree invasion patterns observed.

- Along ecotone transects, four types of data were collected:
 - composition and structure, including in species frequency and canopy cover;
 - location, diameter, height, and age of all trees. Smaller trees that could not be cored were aged by counting terminal bud scars.
 - soil characteristics and environmental features;
 - photographs taken at permanently located points for future comparison.

Reconnaissance data were utilized to develop community classifications for forest and meadow vegetation, and to identify environmental features influencing the composition and distribution of these communities. Cluster analysis and ordination techniques were used for this purpose.

Analyses of ecotone transect data focused on the spatial distribution of tree species by size and age classes, and the composition of the corresponding forest understory and meadow vegetation.

Findings

Important findings from the forest communities sampled in the Three Sisters Biosphere Reserve included:

- A total of 162 vascular plant species were identified and 16 major forest plant communities were defined. The plant communities fell into five forest Series defined by the climax tree species—*Pseudotsuga menziesii*, *Tsuga heterophylla*, *Tsuga heterophylla*-



FIGURE 2. Baseline information on vegetation was obtained from permanently marked transects located across the forest and meadow community boundary.

Abies amabilis, *Abies amabilis*-*Tsuga mertensiana*, and *Tsuga mertensiana*.

- The distributions of the Series were correlated with environmental changes associated with increasing elevation, that is, decreasing temperature, increasing precipitation, greater snowpack, and shorter growing season. Within each Series, secondary environmental gradients, such as soil moisture and temperature, influenced the composition and distribution of plant communities.
- The frequency and distribution of disturbances, such as wildfire, were important in understanding the structure of forest ecosystems.

The forests were relatively young, between 175 and 250 years of age, although there also were remnant old-growth forests of 400 to 500 years. Most of the stands at lower elevations have burned at least once since the 1840s. Forests increased in average age with elevation. Old-growth forests were restricted largely to the subalpine zone.

Findings in meadow communities included:

- A total of 384 vascular plant species were identified and 23 montane and subalpine meadow communities were defined.
- The composition, structure, and distribution of meadows were correlated with landform and

topography, elevation, hydrological features, and soil characteristics. For simplicity, meadow communities can be grouped into three categories:

- Meadows occurring on flat terrain or in basins—Meadow communities on these sites experience either a water table persisting at or above the soil surface, or a deep and persistent snowpack that keeps the soils moist through the short growing season. These communities typically are graminoid-dominated.
- Meadows along steeply sloping landforms—Here, soils range from deep, loamy, and well-drained, to shallow, rocky, and potentially droughty. These meadows, which typify the highly dissected terrain of the western portion of the Three Sisters Biosphere Reserve, are forb-dominated communities.
- Meadows along the gentle slopes and rolling plains adjacent to the base of the region flanking the bases of the Three Sisters peaks—On these sites, soils vary from shallow and gravelly to deep and pumicey. These meadows are dominated by a diversity of graminoids, forbs, and low shrubs.
- The patterns of tree invasion into these meadows were diverse. Hydric, mesic, and xeric meadow communities have all experienced encroachment. Forest-meadow boundaries range from abrupt to diffuse. Tree invasion has occurred in waves, in clumps, or as isolated individuals. A majority of these trees became established between 1930 to 1970.

Implications

Information from this study provided the first extensive body of data on the composition, structure, and distribution of ecosystems in the Three Sisters Biosphere Reserve. The study results included:

- a classification and a key to forest communities in the biosphere reserve;
- a general description of the natural disturbance history in the forested portion of the biosphere reserve;
- a classification of montane and sub-alpine meadow communities; and
- a series of permanent transects for examining long-term changes in the composition and structure of forest-meadow communities.

Forest community and fire history information from the relatively untouched ecosystems of the Three Sisters Biosphere Reserve provided a baseline for comparison with the experimentally-oriented H. J. Andrews Biosphere Reserve and with other intensively managed areas along the western slope of the Cascades. Furthermore, the forest community classification was compatible with those developed by the USDA Forest Service on adjacent national forest lands.

Despite their ubiquity and aesthetic appeal, meadows in the Three Sisters Biosphere Reserve, and in the Pacific Northwest in general, have not been described adequately. These community studies provide an extensive data base on the composition, structure, and distribution of meadow communities in the central Cascade Range. Data obtained from future remeasurements of forest and meadow ecosystems will help in obtaining a better understanding of the dynamics of these and similar ecosystems that span the Sierra-Cascade Axis.