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## Non-Forest Vegetation of the Central Western Cascade Mountains of Oregon

### Abstract

Although non-forested areas in the Western Cascade Mountains of central Oregon are small in area, they are of floristic, ecological, and evolutionary importance. The wettest and driest communities succeed slowly, or not at all, to forest; but long-term maintenance of mesic meadows below timberline must be attributed to continued disturbance by frost, rodents, fires, and mass wasting. In order of decreasing moisture availability, the 12 communities described are: *Caltha/Carex/Dodecatheon* Bog; *Mimulus/Lewisia/Allium* Seep; *Veratrum/Valeriana/Senecio* Wet Meadow; *Orogenia/Dicentra/Erythronium* Snowbed; *Sambucus/Cardamine/Campanula* Talus; *Rubus/Pteridium* Meadow; *Bromus/Rudbeckia* Meadow; *Selaginella/Saxifraga/Penstemon* Cliff-face; *Gilia/Polygonum/Eriogonum* Lithosolic Meadow; *Quercus/Rhus/Bromus* "Savanna"; *Eriophyllum/Castilleja/Sedum* Lithosol; *Lotus/Chrysothamnus/Allium* Tuffaceous Gravel. More than 200 vascular plant species are assigned to the communities of which they are characteristic members.

### Introduction

About 95 percent of the Western Cascade Province of Oregon is covered by coniferous forest. These forests have been the subject of much research effort, especially through the International Biological Program, and their basic vegetation patterns are now understood (Franklin and Dyrness, 1969; Dyrness, Franklin, and Moir, 1974; Hawk and Zobel 1974<sup>1</sup>). The remaining unforested portion of the Western Cascades is small in area, but the diverse habitats comprising it support 85 percent of the large Western Cascade flora, including many disjunct and endemic species of ecological and evolutionary interest. Non-forest areas are of different sizes and are variously isolated from one another. They thus offer insight into principles of dispersal, establishment, and competition in areas where living space is limited and divided among many species along steep environmental gradients. Historically, these rich sites have been ignored by researchers, but there is now a growing body of literature concerning them (Detling, 1953, 1968; Hickman, 1968, 1970, 1971, 1974, 1975, in preparation; Hickman and Pitelka, 1975). This report presents a preliminary classification of the non-forest communities of the region to facilitate further studies within the Western Cascades and to allow comparisons with the non-forest vegetation of other areas of the Pacific Northwest (Van Vechten, 1960; Archer, 1963; Horn, 1968; Kuramoto, 1968; Franklin and Dyrness, 1969).

The study area is bounded approximately by latitudes N 43° 30' and N 44° 45' and by longitudes W 122° and W 122° 30'. The region is characterized geologically by nearly horizontal flows of andesites and basalts that have been locally faulted and intruded. Oligocene and Miocene flows have been gently warped, but the Pliocene rocks that comprise many of the peaks have retained essentially their original attitudes.

<sup>1</sup> Reference added in proof: Zobel, D. B., A. McKee, G. M. Hawk, and C. T. Dyrness. 1976. Relationship of environment to composition, structure, and diversity of forest communities of the Central Western Cascades of Oregon. *Ecol. Monog.* 46: 135-56.

Erosion has produced a maturely dissected topography of valleys and steep ridges, the peaks of which stand at a height of 1600 to 1750 m. Numerous small Pleistocene glaciers were important in the erosion of the Western Cascades. Steep cirque headwalls with associated tarns occur on a number of peaks within the study area, especially on northern or eastern slopes. Erosional remnants such as dikes and plugs further diversify topographic surfaces.

July maximum temperatures average 27° C, and average annual precipitation ranges from 1500 to over 2000 mm (Franklin and Dyrness, 1969). Spring rainfall may be considerable and extend through June in unusually wet years, but little or no precipitation falls during July and August. Snowpack may reach 4 m, but is blown away from non-forested ridges and melts early in non-forested depressions. For most non-forest species, growing seasons are bounded by snowmelt (late May to mid-June) and by drying of the soil (early August to mid-September). In the wettest habitats, growth may continue until first snow (usually in early October), but is normally cut short by earlier frosts.

Succession toward climatic climax forest types is very slow in both the wettest and driest communities. In places they have persisted for more than 1000 years and can be considered topo-edaphic climaxes (Hickman, 1968). Boundaries between mesic meadows and forest are much more dynamic, with considerable invasion by trees. The precise interplay of factors responsible for the long-term maintenance of the mesic meadows is not clear, but the factors doubtless include fire; heavy snowpack; occasional snow- and landslides; rapid downslope creep of light loamy soils, especially in the spring; and the churning and cutting action of rodents, particularly *Aplodontia rufa*. Meadows may have been enlarged and modified by sheep grazing and related fires early in this century, but it was their previous existence that made grazing profitable. Comparison of current meadow boundaries with photographs from 1933 provides examples of forest encroachment on slopes that were severely burned between 50 and 100 years ago. It also demonstrates marked stability of other forest/meadow boundaries, indicating complex successional relationships.

All communities described here, even the mesic meadows, are reasonably longevous. Disturbed open habitats of little persistence such as roadsides, clearcuts, and regenerating burns are not included.

#### Methods

The 12 communities characterized below were isolated using reconnaissance sampling data from more than 40 peaks within the study area. Data were compiled during nine growing seasons over an 11-year period from 1965 to 1975. Occurrence and relative abundance of vascular plant species were recorded from each obviously distinct habitat that could be isolated on each peak. Communities chosen for description are those that recur widely in the area, often wherever certain physical conformations are found. Intergradation of associations does occur, especially in the drier meadow and lithosolic types. In spite of local intergradation, the communities are considered independent vegetation units for three reasons: 1) in some areas they do not intergrade; 2) they indicate different physical environments and different modes of adaptation; and 3) together they encompass a great diversity of species.

Scholander pressure chamber measurements of xylem sap potential in 11 of the

communities (Hickman, 1968, 1970) provided a basis for arraying the communities by available moisture. Presence of species in two or more communities aided in integrating the measures.

In 1971, extensive random quadrat sampling of a restricted area was undertaken prior to analysis of environmental gradients and construction of a vegetation map. Computer analysis supported delimitation of the six associations included in those samples, all of which were originally recognized from semi-quantitative reconnaissance techniques. Those data and the vegetation map will be published separately.

Following Daubenmire (1968), the term "community" is used here in a general sense. "Associations" are stable communities near climax, and "associates" are communities that generally succeed to forest, and so are less stable.

Nomenclature follows Hitchcock and Cronquist (1973), except where authorities are given. Voucher specimens for all species are on file at Swarthmore College.

### Results and Discussion

Franklin and Dyrness (1969) have divided the Western Cascades at this latitude into three Forest Zones. The *Tsuga heterophylla* Zone extends to a maximum elevation of 1000 m. It corresponds with the Humid Transition Zone of Merriam (1890) and the lower wet montane forest of Holdridge (1967). One non-forest association is confined to this zone. The middle elevation *Abies amabilis* Zone (representing Merriam's Canadian Zone and Holdridge's upper wet montane forest) predominates in the Western Cascades, but the lower *Tsuga mertensiana* Zone (Hudsonian Zone; upper wet montane forest) is also present above 1500 m on some of the higher peaks. The last two zones are not distinguishable on the basis of non-forest communities in the Western Cascades, but together support the remaining 11 communities described here. All Western Cascade peaks are below climatically determined timberline.

Figure 1 arrays the communities along axes representing substrate texture and soil moisture during the blooming and fruiting seasons. The *Quercus/Rhus/Bromus* community is restricted to the *Tsuga heterophylla* Zone. Seven comprise a major trend of decreasing moisture availability within the *Abies amabilis* and *Tsuga mertensiana* Zones. The remaining four (*Mimulus/Lewisia/Allium*; *Orogenia/Dicentra/Erythronium*; *Sambucus/Cardamine/Campanula*; and *Selaginella/Saxifraga/Penstemon*) occupy specialized habitats in the *Abies amabilis* and *Tsuga mertensiana* Zones and are described last.

Table 1 summarizes the development of the 12 communities on 29 Western Cascade peaks. The peaks are listed in order from north to south. While most communities are distributed throughout the area, one is found primarily in the south (*Quercus/Rhus/Bromus*), and two are best developed in the north (*Veratrum/Valeriana/Senecio* and *Bromus/Rudbeckia*). Descriptions and brief discussions of the communities follow.

#### *Quercus garryana/Rhus diversiloba/Bromus mollis* "Savanna" Association

On south-facing slopes at intermediate elevation in the *Tsuga heterophylla* Zone (and in the study area especially in the region of the South Fork of the McKenzie River), dry clearings and meadows contain a large number of species characteristic of the hills and fields within the Willamette Valley and other major valleys in western Oregon. This savanna-like association is not found above 600 m (except on Castle Rock, where it reaches 1150 m) and is therefore restricted to peaks with low elevation south-facing slopes. Such areas support scattered trees of *Quercus garryana*, *Arbutus menziesii*,

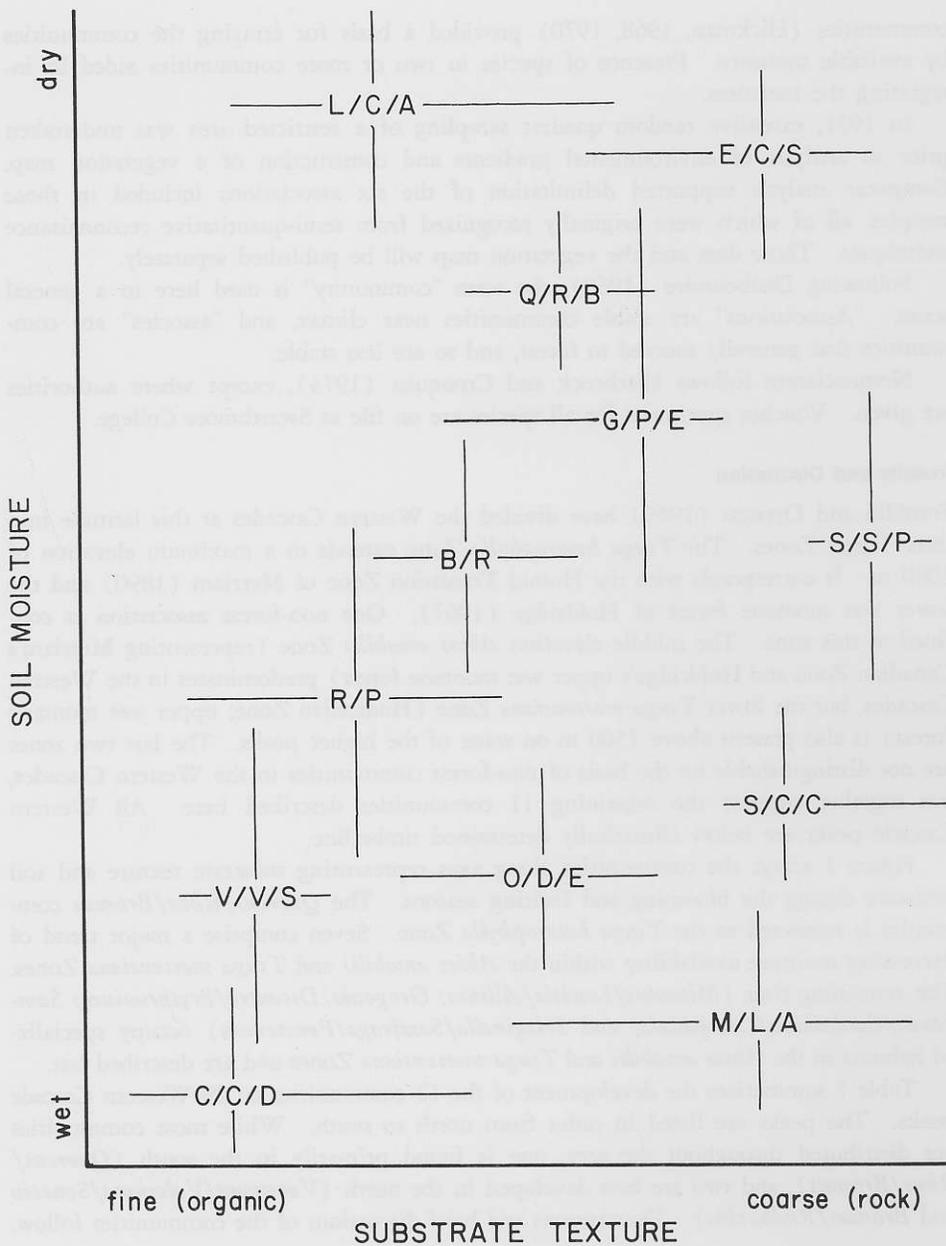


Figure 1. Substrate texture and soil moisture in 12 Western Cascade non-forest communities. Soil moisture extrapolated from maximum reproductive-season sap potentials; substrate texture from estimated average particle size, including the boulder fraction. Vertical and horizontal lines approximate the range of the two parameters encountered in the field, and suggest the degree of overlap among communities. B/R = *Bromus carinatus*/*Rudbeckia occidentalis* Meadow; C/C/D = *Caltha biflora*/*Carex sitchensis*/*Dodecatheon jeffreyi* Bog; E/C/S = *Eriophyllum lanatum*/*Castilleja hispida*/*Sedum oregonense* Lithosol; G/P/E = *Gilia aggregata*/*Polygonum douglasii*/*Eriogonum nudum* Lithosolic Meadow; L/C/A = *Lotus nevadensis douglasii*/*Chrysothamnus nauseosus albicaulis*/*Allium crenulatum* Tuffaceous Gravel; M/L/A = *Mimulus guttatus*/*Lewisia triphylla*/*Allium amplexans* Seep; O/D/E = *Orogenia fusiformis*/*Dicentra uniflora*/

TABLE 1. Development of 12 non-forest communities on 29 Western Cascade Mountain peaks. 1 = community present, but restricted in area or without full complement of diagnostic species; 2 = community moderately well developed, but not extensive; 3 = community fully and extensively developed. Peaks are listed from north to south.

	Quercus/Rhus/Bromus	Caltha/Carex/Dodecatheon	Veratrum/Valeriana/Senecio	Rubus/Pteridium	Bromus/Rudbeckia	Gilia/Polygonum/Eriogonum	Eriophyllum/Castilleja/Sedum	Lotus/Chrysothamnus/Allium	Mimulus/Lewisia/Allium	Orogenia/Dicentra/Erythronium	Sambucus/Cardamine/Campanula	Selaginella/Saxifraga/Penstemon
Monument Peak		1		2	1		2			1	1	1
Bachelor Mt.		1	2	2	2	2	2		1	2		1
Three Pyramids			1	2	2		2				1	3
Crescent Mt.			1	3	2		2			1		
Echo Peak		2	2	3	3	3	3	1	1	2		2
South Peak		1	2	3	3	3	3	1	2	3		3
Cone Peak		2	3	3	3	3	3	3	3	3		3
Iron Mt.		1	2	3	3	3	3	3	3	3		3
Browder Ridge		1	2	3	2	3	3	1	3	2	1	2
Jumpoff Joe				2			1				3	1
Squaw Peak			2	2	1						3	
Twin Buttes			2	2	1	1	2				2	1
Carpenter Mt.			2	1	1	1			1	3	3	
Tidbits Mt.			1	1		1	3				3	2
Lookout Mt.			1	2			1				2	2
Frissell Pt.			1	1		1	2					
Castle Rock	2			1		1						
O'Leary Mt.			2	2		2	2					1
Horsepasture Mt.			2	3	2	3	2		1	2	1	1
English Mt.		2	2	1	1	1	1		1	1		
Lowder Mt.		3	3	2	3	1	3		1	2	1	
Tipsoo Butte	1			1		1	2				1	
Olallie Mt.			1	2	1	2	1		1	1		
Rebel Rock	3		1	3	3	3	3	1	2	2		
Indian Ridge		1	1	2			1		1	2		1
Sardine Butte		1		1	1		1				1	1
Huckleberry Mt.				1			1					
Fairview Peak		2		1		3	3		1	1	1	1
Bohemia Mt.	1	1	1	2		3	3	2	1	2	2	3

Erythronium grandiflorum Snowbed; Q/R/B = Quercus garryana/Rhus diversiloba/Bromus mollis "Savanna"; R/P = Rubus parviflorus/Pteridium aquilinum Meadow; S/C/C = Sambucus racemosa arborescens/Cardamine integrifolia sinuata/Campanula rotundifolia Talus; S/P/P = Selaginella wallacei/Saxifraga bronchialis vesperina/Penstemon rupicola Cliff-face; V/V/S = Veratrum viride/Valeriana sitchensis/Senecio triangularis Wet Meadow.

and *Philadelphus gordonianus*, and scattered shrubs of *Rhus diversiloba*, *Ceanothus sanguineus*, and *Ribes sanguineum*. Annuals are abundant and account for about 50 percent of the cover. Especially important are the grasses *Bromus mollis*, *B. tectorum*, *Cynosurus echinatus*, and *Aira caryophyllea*, and secondarily such annual forbs as *Polygonum spargulariaeforme*, *Clarkia rhomboidea*, *C. amoena lindleyi*, *Linanthus bicolor*, *Orthocarpus attenuatus*, *Githopsis specularioides*, *Conyza canadensis*, *Madia gracilis*, and *M. exigua*. The dominant perennial herbs include *Brodiaea hyacinthina*, *B. congesta*, *Berberis aquifolium*, *Psoralea physodes*, *Convolvulus nyctagineus*, and *Apocynum androsaemifolium*.

Bedrock in these habitats is always near the surface, and soils are thin stony loams. Steep slopes and recurrent past fires may be responsible for these conditions. There is no current sign of succession to a Douglas-fir-dominated dry forest. While, in the absence of further fires, this must be expected eventually to occur, the "savanna" association is reasonably long-lived, and may be maintained indefinitely by periodic fires.

#### *Caltha biflora*/*Carex sitchensis*/*Dodecatheon jeffreyi* Bog Association

Continually wet habitats of gentle or level slope where snowmelt or spring water saturates rich organic soils throughout the summer support a number of species characteristic of sphagnum bogs. True bogs are rare in the Western Cascade Province. A similar environment occurs on mats of *Carex sitchensis* and *C. aquatilis* surrounding small tarns above 1500 m. In addition to the nominate species, dominants include *Sphagnum* spp., *Deschampsia cespitosa*, *Ranunculus gormanii*, *Aster alpigenus*, *Pedicularis groenlandica*, *Tofieldia glutinosa brevistyla*, the shrubs *Vaccinium uliginosum* and *Lonicera utahensis*, and shrubs and small trees of *Salix geyeriana meleina* and *S. commutata*. Other important species are *Lycopodium sitchense*, *Equisetum arvense*, *Muhlenbergia filiformis*, *Carex luzulina*, *C. limosa*, *C. muricata*, *C. rostrata*, *Scirpus cespitosus*, *S. congdonii*, *Eleocharis pauciflora*, *Dulichium arundinaceum*, *Lysichitum americanum*, *Habenaria dilatata*, *H. saccata*, *Polygonum bistortoides*, *Spiraea densiflora*, *Trifolium longipes*, *Parnassia fimbriata*, *Drosera rotundifolia*, *D. anglica*, *D. x "obovata"*, *Viola mackloskeyi*, *V. adunca*, *Hypericum anagaloides*, *Perideridia gairdneri*, *Sium suave*, *Kalmia microphylla*, *Menthanthes trifoliata*, *Lycopus uniflora*, *Mimulus moschatus*, *Galium trifidum pacificum*, and *Microseris borealis* Bong.

Within large and complex sphagnum bogs, such as Quaking Aspen Swamp, and among smaller bogs, several distinct phases of this association are evident. Detailed studies of the vegetation of Quaking Aspen Swamp will be published separately.

There is variation in the longevity of *Caltha/Carex/Dodecatheon* communities. Bog soils are not usually appropriate for colonization by the dominant Cascade conifers. In some sites, however, cold- and water-tolerant species such as *Picea engelmannii* and *Abies lasiocarpa* are encroaching. In large open areas heavy winter snow and ice frequently break and kill invading saplings and young trees. In such sites, the association is topo-edaphic climax.

#### *Veratrum viride*/*Valeriana sitchensis*/*Senecio triangularis* Wet Meadow Associates

Open areas, most frequently on east- or northwest-facing slopes, which have fairly constant sources of moisture and sufficiently gentle slopes to build up deep organic

soils, support a characteristic wet meadow community. Variants of this associates occur in the High Cascades of Oregon, North Cascades, and Olympic Mountains of Washington (cf. Franklin and Dyrness, 1969). Additional important species include *Polystichum andersonii*, *Luzula parviflora*, *Mitella breweri*, *Ribes bracteosum*, *Rubus spectabilis*, *Hypericum formosum scouleri*, *Viola glabella*, *Circaea alpina*, *Oplopanax horridum*, *Ligusticum grayi*, *Hydrophyllum tenuipes*, *H. fendleri albifrons*, and *Mertensia bella*.

Farther north, a variant of this community occupies large open expanses, even on south-facing slopes. In the Western Cascades, it tends to be a forest-edge community, and is even found fully developed, but sparser in cover, under canopies of *Alnus sinuata* thickets. It also occurs under relatively open stands of *Abies amabilis*, *Chamaecyparis nootkatensis*, and *Tsuga mertensiana* on north slopes.

In the fully exposed habitats of bogs, but higher and drier than the *Caltha/Carex/Dodecatheon* association, this community recurs with the first two dominants replaced, respectively, by *Veratrum californicum caudatum* (and fertile hybrids between it and *V. viride*) and by *Heracleum lanatum*. *Oplopanax horridum* and *Polystichum andersonii* are absent from this phase, but there is otherwise co-occurrence of the characteristic species. As with the previous association, winter-kill of young trees makes this phase much more nearly non-forest climax than the normal forest-edge phase. The latter is quite susceptible to invasion by trees but retains its characteristics even under forest canopy.

#### *Rubus parviflorus/Pteridium aquilinum* Meadow Associates

*Rubus/Pteridium* meadows occupy moderately steep mountainsides of variable exposure, but are least common on north slopes. Soils are deep brown loams that retain an adequate supply of moisture for plant growth until late summer, when plants in drier patches desiccate. Most of the component species are herbaceous perennials which normally have time to set seed during the moist early summer, but vegetative reproduction is also important, especially in the dominants. These meadows support *Lilium washingtonianum*, *Polygonum phytolaccaefolium*, *Lathyrus nevadensis lanceolatus pilosellus*, *Vicia americana truncata*, *Epilobium angustifolium*, *Ligusticum grayi*, *Mertensia paniculata*, *Erigeron aliciae*, *Cirsium callilepis oregonense*, and occasional ephemeral annuals such as *Galium bifolium* and *Gayophytum humile*, which grow in the shade of the taller perennials.

Several species occur both in these meadows and in the surrounding forest-edges, which are drier than those occupied by the *Veratrum/Valeriana/Senecio* community. They include *Dicentra formosa*, *Ribes binominatum*, *R. viscosissimum*, *Holodiscus discolor*, *Amelanchier alnifolia semiintegrifolia*, *Lupinus latifolius*, *Angelica arguta*, *Polemonium carneum*, *Penstemon serrulatus*, *Achillea millefolium lanulosa*, and *Luina stricta*.

The *Rubus/Pteridium* meadow is an extremely widespread type in the Pacific Northwest, especially at lower elevations, with variants occurring in the Coast Ranges, Olympic Mountains, and North Cascades. This associates has likely expanded due to grazing at the expense of grass-dominated meadows such as the following *Bromus/Rudbeckia* associates, but no quantitative evidence on this issue exists. Of all the non-forest communities, this one shows the most dynamic relationships with the surrounding forests. While fire or other disturbance may enlarge the meadows, invasion by trees is common,

especially in recently burned areas. Even though forest/meadow boundaries are constantly in flux, many areas appear to be quite stable and are probably maintained by a combination of extensive rodent churning and seasonally extensive downslope movement of the light-textured loams, both of which interfere with tree establishment.

#### *Bromus carinatus*/*Rudbeckia occidentalis* Meadow Associates

A drier and higher elevation counterpart of the previous meadow type, this associates still includes some of the forage grasses that probably have been reduced in abundance by grazing. The current grass dominants (*Bromus carinatus*, *Elymus glaucus*, *Stipa occidentalis californica*, and sometimes *Melica spectabilis*) are not such good forage as the less commonly encountered fescues (*Festuca ovina*, *F. viridula*, *F. idahoensis*), which may once have been dominant. Soils are light and loamy, with included fragments of andesite, and are subject to churning both by rodents and by frost. This associates may include many of the species of the preceding and following communities, but is characterized by the presence of the perennial herbs *Carex pachystachya*, *Habenaria unalascensis*, *Rumex acetosella*, *Fragaria virginiana platyptala*, *Potentilla glandulosa*, *Linum perenne lewisii*, *Hackelia micrantha*, *Artemisia ludoviciana latiloba*, and *Agoseris grandiflora*; the annuals *Polygonum minimum*, *Gayophytum diffusum*, *Gilia capitata*, *Phacelia linearis*, *Collinsia parviflora*, and *Orthocarpus imbricatus*; and occasional individuals of the snowbed perennials *Erythronium grandiflorum*, *Lewisia triphylla*, *Dicentra uniflora*, and *Orogenia fusiformis*.

A well-defined phase of this meadow on yet drier soils is dominated by *Carex rossii* and *Viola nuttallii bakeri*, with *Calochortus subalpinus*, *Lupinus laxiflorus*, and *Cirsium callilepis oregonense*. Further data may indicate the desirability of proposing this as a distinct associates.

Probably because of its shallower, drier soils that are also subject to churning, this associates is less frequently invaded by trees than are *Rubus*/*Pteridium* meadows. Some areas, however, are being colonized by sparse young *Abies grandis*, *A. amabilis*, or *A. procera*, so this community is considered an associates.

#### *Gilia aggregata*/*Polygonum douglasii*/*Eriogonum nudum* Lithosolic Meadow Association

The driest of the meadow associations in the Western Cascades includes many disjunct species. Soils are usually derived from friable or scoriaceous parent material and are lithosolic with a loamy matrix. Most species can tolerate low xylem sap potential (Hickman, 1970). Those which cannot die back earlier in the summer than those in the moister meadow communities. Although there are many annuals, there are no truly ephemeral species in this association. Additional species include the annuals *Polygonum cascadenense*, *Gayophytum diffusum*, *G. humile*, *Microsteris gracilis*, *Collomia linearis*, and *Navarretia divaricata*; and the perennial or biennial herbs *Calochortus subalpinus*, *Rumex acetosella*, *Cerastium arvense*, *Potentilla glandulosa*, *Lupinus laxiflorus*, *Phacelia heterophylla*, *Monardella odoratissima*, and *Aster ledophyllus*.

As in all the remaining associations, succession is negligibly slow here. Continuous erosion keeps soils thin and sterile, and water stress in late summer is too great to be tolerated by tree seedlings and saplings. Although the specific stabilizing mechanisms differ, this and all remaining associations can be considered topo-edaphic climax.

*Eriophyllum lanatum*/*Castilleja hispida*/*Sedum oregonense* Lithosolic Association

This association cannot be considered meadow because soil development is minimal. It occurs on steep south- or west-facing slopes where lithosols creep downslope, on sloping, weathered outcrops, and on flat ridgetops of deflation armor. Many species are able to establish in cracks of outcrops or in occasional small pockets of finer material. No annuals are characteristic, but those of the preceding association sometimes grow here as well. Other herbaceous or shrubby perennials are *Aspidotis densa*, *Cheilanthes gracillima*, *Juniperus communis montana*, *Poa cusickii*, *P. incurva*, *Zygadenus venenosus*, *Comandra umbellata*, *Eriogonum umbellatum*, *E. compositum*, *Arenaria capillaris americana*, *Silene douglasii*, *Delphinium menziense pyramidale*, *Erysimum asperum*, *Sedum divergens*, *S. stenopetalum*, *Pachistima myrsinites*, *Lomatium martindalei*, *Sanicula graveolens*, *Arctostaphylos nevadensis*, *Phlox diffusa longistyla*, *Phacelia heterophylla*, *Penstemon procerus brachyanthus*, *Antennaria microphylla*, *Erigeron foliosus confinis*, *Haplopappus hallii*, *Senecio integerrimus exaltatus*, *Microseris nutans*, and *Hieracium scouleri*.

*Lotus nevadensis douglasii*/*Chrysothamnus nauseosus albicaulis*/*Allium crenulatum* Tuffaceous Gravel Association

In this association plants are characteristically super-dispersed with much intervening area of fine scoriaceous gravel derived from topographically resistant but deeply weathering fine breccias or tuffaceous volcanics. The gravelly surface layer, which creeps steadily downslope, covers a thin layer of loamy mineral soil. Weathered bedrock is usually no deeper than 10 cm. This association, the driest in the Western Cascades, is confined to gentle slopes and is most characteristic of the Iron Mountain-Echo Mountain ridge, which has an unusually high proportion of tuffaceous Pliocene volcanics. It is further characterized by the presence of *Ivesia gordonii*, *Trifolium productum*, *Penstemon deustus*, *Aster gormanii*, and *Crepis occidentalis*, all of which are disjunct species in the Western Cascades. In addition it may support low densities of species characteristic of the *Eriophyllum*/*Castilleja*/*Sedum* association.

*Mimulus guttatus*/*Lewisia triphylla*/*Allium amplectens* Seep Association

Occasionally snowmelt trickles over outcrops, especially on south- or west-facing slopes where the thin soils common to non-forest habitats have eroded away because of fires, frost action, and other factors. These habitats desiccate about midsummer, and plants found here tend to be ephemeral annuals or stoloniferous or cormose perennials with ephemeral above-ground parts. Such plants survive the dry late summer in dormant condition. Other prominent species include *Polygonum kelloggii*, *Montia parvifolia*, *Saxifraga integrifolia*, *S. occidentalis rufidula*, *Gayophytum humile*, *Linanthus barknessii*, *Romanzoffia sitchensis*, *Mimulus breweri*, and *M. moschatus*.

Individual communities are usually small, being restricted in size by outcrop and spring co-occurrence. Nevertheless, they recur widely and faithfully. Occasionally they are shaded by adjacent forest, but successful invasion by trees of the outcrop seeps themselves has not been observed.

*Orogenia fusiformis/Dicentra uniflora/Erythronium grandiflorum* Snowbed  
Association

Beneath north-facing outcrops on steep slopes, as well as in wind-protected sites of other exposure, snow accumulates in winter to depths which may exceed 8 m. Several species, primarily of alpine or boreal affinity, flower, rapidly set seed, and desiccate at the edge of these snowbanks as they melt. Besides the nominates, such species include *Claytonia lanceolata* and *Mertensia bella*, as well as less consistently snowbed species such as *Trillium ovatum*, *Senecio triangularis*, and *Hydrophyllum occidentale*. This association is usually replaced later in the growing season by depauperate stands of *Rubus/Pteridium* or *Bromus/Rudbeckia* meadows.

*Sambucus racemosa arborescens/Cardamine integrifolia sinuata/Campanula rotundifolia* Talus Association

Steep talus piles of large rectangular blocks develop beneath high north-facing vertical faces of dense andesite. Vegetation in these piles is both sparse and of low diversity, but it is quite constant. Both shrubs and herbs are tolerant of burial of lower stems. Most of the herbs have primarily basal leaves, which reach the surface on long etiolated petioles. Other species are *Aquilegia formosa*, *Thalictrum occidentale*, *Acer circinatum*, and *Gentiana calycosa*. The gentian, which is faithful to these habitats, is ecologically, geographically, and morphologically distinct from other races of *G. calycosa* and merits taxonomic recognition, but no name has yet been proposed.

*Selaginella wallacei/Saxifraga bronchialis vespertina/Penstemon rupicola*  
Cliff-face Association

On dikes, cirque headwalls, or other steep erosional surfaces, slow weathering processes produce crevices and pockets that provide some protection from the excessive wind and insolation that characterize the adjacent habitats of the *Eriophyllum/Castilleja/Sedum* and *Lotus/Chrysothamnus/Allium* associations. Occasional small seeps provide moisture for these partially shaded areas until relatively late in the growing season, and they are exposed to moisture-bearing northwesterly winds but not dry easterly winds. It is thus a moister environment than those surrounding it, although drainage is usually extremely rapid. Occurring with the dominants are *Selaginella densa scopulorum*, *Polypodium hesperium*, *Arenaria rubella*, *Saxifraga cespitosa*, *Heuchera micrantha*, *Douglasia laevigata*, *Linanthes nuttallii*, *Polemonium pulcherrimum*, and *Castilleja rupicola*. Certain of these species, especially *S. bronchialis vespertina*, *D. laevigata*, *A. rubella*, *P. pulcherrimum*, and *C. rupicola*, grow only on the windward sides of the outcrops. If the outcrop does not face somewhat north of west, into the prevailing northwesterly winds, they are not likely to be found at all. This association is restricted to peaks having extensive outcrops of tuffaceous or friable rock, although the cliff-faces themselves are sometimes dense diabase intrusives.

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