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OVERSTORY-UNDERSTORY RELATIONSHIPS IN WESTERN FORESTS

OVERSTORY-UNDERSTORY RELATIONSHIPS: SPRUCE-FIR FORESTS

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Spruce-fir *(Picea-Abies* spp.) forests in the United States occupy approximately 24 million acres (9.7 million hectares) (Forest-Range Task Force 1972). In these high-elevation, subalpine forests winter snowpacks are deep, and growing seasons, short. The rugged settings of these forests make them highly valued for summer recreation and esthetics and useful for wildlife habitat, water production and timber production.

Domestic livestock generally do not graze within these stands but may graze in the natural parks and meadows that occur as part of the forest matrix. Such wildlife as moose, elk, deer and bear use interspersed openings and stream bottoms.

Wood-producing potential usually is greatest in the lower and warmer portions of this forest zone and where moist soil conditions exist. Severe climate in the upper portion precludes extensive wood production.

The spruce-fir forest zone occurs throughout the Rocky Mountains. It can be found at elevations as low as 1,500 feet (460 meters) in the Sierra-Cascade provinces of the Pacific Northwest and as high as 12,000 feet (3,660 meters) in the southern Rocky Mountains. In nearly all cases, it is the highest forest zone in those mountain ranges. Much of the topography is rough and broken (Garrison et al. 1977). In the central and southern Rocky Mountains the spruce-fir forest covers an altitudinal zone defined by a July mean temperature of 55 degrees Fahrenheit (13 degrees Celsius) and a January mean of 15 degrees Fahrenheit (-9 degrees Celsius) (Alexander 1980).

Overstory-Understory Composition

The spruce-fir zone is characterized by open to dense forests of needle-leaved evergreen trees. Fifty percent or more of each stand is true firs, spruces or mountain hemlock *(Tsuga mertensiana)* except where western white pine *(Pinus monticola)* comprises 20 percent or more (Garrison et al. 1977).

In the northern Rockies, the zone is typified by occurrence of subalpine fir *(Abies lasiocarpa)* and Engelmann spruce *(Picea engelmannii)*. In the lower subalpine forest, Douglas-fir *(Pseudotsuga menziesii)* and lodgepole pine *(Pinus contorta)* are major components of seral stands.

Western larch *(Larix occidentalis)* is a major component in northwestern Montana; mountain hemlock occurs less often. Whitebark pine *(Pinus albicaulis)* is often a persistent, dominant seral species in the upper subalpine forest. Subalpine larch *(Larix lyallii)* may occupy north slopes at timberline (Despain 1973; Pfister et al. 1977; Steele et al. 1981). Shrubs characteristically found are boxwood myrtle *(Pachistima myrsinites)*, dwarf blueberry *(Vaccinium caespitosum)*, grouse whortleberry *(V. scoparium)*, white spirea *(Spiraea betulifolia)* and Oregon-grape *(Berberis nervosa)*. Common herbaceous plants are twinflower *(Linnaea borealis)*, queencup beadlily *(Clintonia uniflora)*, sweetscented bedstraw *(Galium triflorum)* and heartleaf arnica *(Arnica cordifolia)* (Alexander 1980).

In Wyoming the understory is quite sparse. Here bristly black current *(Ribes lacustre)*, alpine prickly current *(R. montigenum)*, sidebells pyrola *(Pyrola secunda)*, heartleaf arnica and fireweed *(Epilobium angustifolium)* are apparent (Despain 1973).

In the southern Rockies, Engelmann spruce may be more abundant than subalpine fir. Associated trees are corkbark fir *(Abies lasiocarpa* var. *arizonica)*, blue spruce *(Picea glauca)* and bristlecone pine *(Pinus aristata)*. The characteristic shrubs are species of current *(Ribes* spp.), blueberry *(Vaccinium oreophyllum)*, Oregon-grape *(Berberis repens)*, dwarf juniper *(Juniperus communis* var. *montana)*, red elderberry *(Sambucus racemosa)* and shrubby cinquefoil *(Potentilla fruticosa)*. Such herbaceous plants as bracken fern *(Pteridium* spp.), vetch *(Vicia* spp.), deers-ears *(Swertia radiata)*, Arizona fescue *(Festuca arizonica)*, mountain muhly *(Muhlenbergia montana)*, mountain timothy *(Phleum alpinum)* and sedges *(Carex* spp.) may be common in much of the zone (Lowe 1964).

In the coastal ranges of California and southern Oregon, California red fir *(Abies magnifica)* and mountain hemlock represent the spruce-fir zone while farther north Pacific silver fir *(Abies amabilis)* and Alaska cedar *(Chamaecyparis nootkatensis)* become important. Noble fir *(Abies procera)* and subalpine fir often are associated species (Franklin 1980; Gordon 1980). Shrubs include grouse whortleberry, big huckleberry *(Vaccinium membranaceum)*, sticky flowering current *(Ribes viscosissium)* and mountain snowberry *(Symphoricarpos oreophilus)*. Herbaceous species include common beargrass *(Xerophyllum tenax)*, Brewers goldaster *(Chrysopsis breweri)*, lousewort *(Pedicularis semibarbata)*, hairstem gayophytum *(Gayophytum ramosissimum)*, whitevein pyrola *(Pyrola picta)* and monardella *(Monardella* spp.).

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In California, a subalpine mixed-conifer forest that includes spruce-fir zone species and several *Pinus* spp. is prevalent (Parsons 1980). *Picea* spp. generally are absent in the coastal ranges. The understory is of minor importance but often includes Parry manzanita *(Arctostaphylos parryana)*, alpine prickly current, lupine *(Lupinus* spp.), western wheatgrass *(Agropyron smithii)* and California brome *(Bromus carinatus)*.

Overstory and Understory Relationships

Little information is available on understory relations within the spruce-fir zone. Preliminary information from various seral stages of subalpine fir habitat types in Montana (Arno and Simmerman 1982) suggests that the sum of individual shrub and herbaceous species cover provides about 75 percent canopy cover when the developing tree stands are approximately 10 years old. The understory cover reaches 100 percent at about stand age 50. From stand age 75 to nearly 250, the sum of individual species cover seemed to remain rather consistent at 110 percent even though tree basal area may reach 200 square feet per acre.

However, the opposite situation also has been reported. In central northern Wyoming, stands of Engelmann spruce and subalpine fir 30 to 130 years of age had little shrub and herbaceous species cover (Despain 1973). Herbaceous plant cover declined from 18 percent 100 feet (30 meters) into meadow areas to nearly zero immediately inside the timber stand. Thereafter, herbaceous cover increased again, reaching 13 percent 100 feet (30 meters) inside the stand (fig. 1). The increase inside the stand correlated with an increase in tree age and a decrease in total stand density. This appears to correspond to Arno's results wherein the understory may be more highly developed under old stands that are less dense than pole-size stands. The higher herbaceous cover in the meadow corresponds to findings of Wallmo et al. (1972) that in Colorado, 15-year-old cut strips were producing 853 pounds per acre (956 kilograms per hectare) of understory species, but uncut timber strips were producing 391 pounds per acre (438 kilograms per hectare). The predominant species in both cut and uncut strips were blueberries, but a greater species diversity was present in the cut strips. This increased production by understory species was expected to persist well beyond 20 years after logging, although increased dominance of the tree reproduction would likely decrease understory yields in the later years (Regelin and Wallmo 1978).

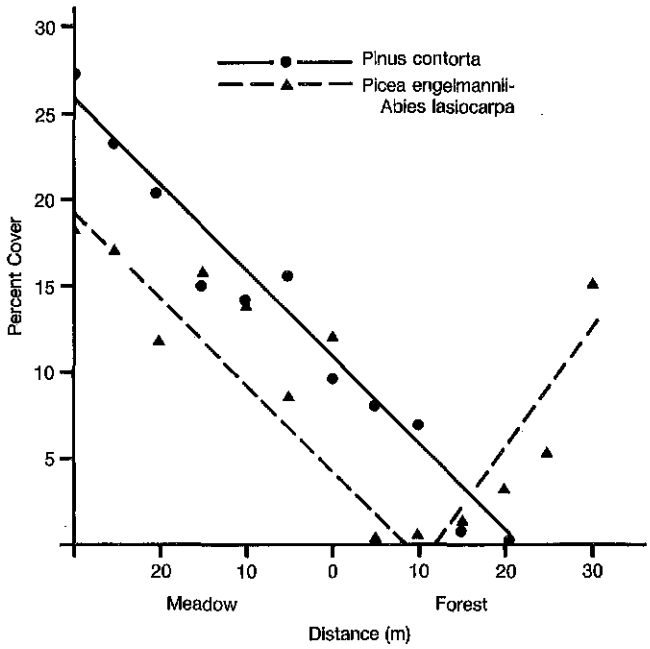

Figure 1. Average herb cover along forest-meadow boundary transects (from Despain 1973.

Data from Pfister et al. (1977) and Steele et al. (1981) were used by this author to compare tree overstory canopy coverage to understory shrub and herb canopy coverage among mature stands of various subalpine fir and spruce habitat types. No definable relationship was found. Yarie (1980) presented data from British Columbia for three habitats ranging from xeric to hygric dominated by mountain hemlock and Pacific silver fir. His data indicate increased understory biomass and production in habitats that support less tree overstory biomass (table 1). The values reflect the understory-overstory relationships among mature stands

Table 1. Comparative understory-overstory values for three mature forest communities in different habitats (from Yarie 1980)

Values	Habitat					
	Hygric		Mesic		Xeric	
Overstory biomass-tons/acre (t/ha)	272	(609)	248	(556)	154	(345)
Understory biomass-lb/acre (kg/ha)	393	(441)	590	(661)	3559	(3990)
Understory production-lb/acre/yr (kg/ha/yr)	232	(260)	127	(142)	563	(631)

in different habitats. They do not apply to differences among seral stages.

Thinning of second-growth spruce-fir stands increases volume and number of understory species, especially where stand density is reduced to low levels. However, data are not available to quantify changes in understory production and composition associated with various habitat-types, management strategies and site indexes (Alexander and Edminster 1980).

Summary and Assessment

Limited information is available concerning overstory-understory relationships in the spruce-fir forest zone. The zone is rather loosely defined and contains variable species compositions and variable environmental conditions. Habitats in the central Rocky Mountains are colder and drier than habitats in coastal mountain ranges. Thus, information on the type's overstory-understory relationships on the east side may not apply on the west side and vice versa.

Preliminary findings indicate:

- understory plants are more abundant and more productive if all trees are removed;
- canopy coverage of understory shrubs and herbs on some sites may be fairly high in the early years of tree stand development;
- canopy coverage of understory plants generally decreases as a dense pole-stage forest develops;
- canopy coverage of understory plants may, in some habitats, increase as the tree stand becomes increasingly mature; in other habitats, coverage may decrease;
- the effect of forest stand thinning on the understory has not been quantified;
- understory species and cover vary greatly among habitat types;
- information is particularly limited concerning the relation of understory productivity to age and development of the tree overstory for specific habitat types. In fact, little information is available even for a generalized situation.

Research is needed on virtually all aspects of overstory-understory relationships in the spruce-fir zone. Potential areas of study include: the primary competitive mechanisms; qualitative and quantitative expressions of understory response to overstory manipulation; understory species involved in the different overstory densities and seral stages (this has received some documentation in forest habitat-type studies; understory values for livestock, wildlife and other multiple-uses; and relationships of these items to different habitat-type or site situations.

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