OVERSTORY-UNDERSTORY RELATIONSHIPS IN WESTERN FORESTS
OVERSTORY-UNDERSTORY
RELATIONSHIPS:
SPRUCE-FIR FORESTS

Warren P. Clary

Spruce-fir (Picea-Abies spp.) forests in the
United States occupy approximately 24 million a­
cres (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 pro­
duction 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 in­
terspersed openings and stream bottoms.

Wood-producing potential is greatest in the
lower and warmer portions of this forest zone
where moist soil conditions exist. Severe clima­
tic 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 tem­
perature of 55 degrees Fahrenheit (13 degrees Cels­
ius) 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 montico­
la) 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
(Lun­
naea borealis), quenecup bealily (Clintonia un­i­
flora), sweet-scented bedstraw (Galium triflorum)
and heartleaf arnica (Arnica cordifolia) (Alexander
1980).

In Wyoming the understory is quite sparse.
Here bristy 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. arizoni­
ca), blue spruce (Picea glauca) and bristlecone
pine (Pinus arisita). The characteristic shrubs are
species of current (Ribes spp.), blueberry (Vaccini­
um oreophyllum), Oregon-grape (Berberis repens),
dwarf juniper (Juniperus communis var. montana),
red elderberry (Sambucus racemosa) and shrubby
cinquefoil (Potentilla fruticosa). Such herbaceous
plants as buckwheat fern (Pteridium spp.), vetch
(Vicia spp.), deer-ears (Swertia radiata), Arizona fescue
(Festuca arizonica), mountain muhly (Muhlenber­
gia 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 arubi­
alis) and Alaska cedar (Chamaecyparis nootkatensis) be­
come important. Noble fir (Abies procera) and
subalpine fir often are associated species (Franklin
1980; Gordon 1980). Shrubs include grouse
whortleberry, big huckleberry (Vaccinium mem­
branaceum), sticky flowering current (Ribes
viscosissium) and mountain snowberry (Symporhi­
carpus oreophilus). Herbaceous species include
common beargrass (Xerophyllum tenax), Brewers
goldaster (Chrysopsis breweri), lousewort (Pedicu­
laris semibarbata), hairstem gayophytum (Gayophy­
tum ramosissimum), whitevein pyrola (Pyrola picta)
and monardella (Monardella spp.).

1Principal range scientist, Intermountain Forest and Range Experi­
ment Station, Shrub Sciences Laboratory, Provo, Utah, 84601.
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 annual 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 833 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).

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.

![Figure 1. Average herb cover along forest-meadow boundary transects (from Despain 1973).](image)

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

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hygric</td>
</tr>
<tr>
<td>Overstory biomass-tons/acre (t/ha)</td>
<td>272 (609)</td>
</tr>
<tr>
<td>Understory biomass-lb/acre (kg/ha)</td>
<td>393 (441)</td>
</tr>
<tr>
<td>Understory production-lb/acre/yr (kg/ha/yr)</td>
<td>232 (260)</td>
</tr>
</tbody>
</table>
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.

Literature Cited


Arno, Stephen F. and Dennis G. Simmerman. 1982. Review draft of forest succession on four habitat types in Western Montana. Fire Effects Research and Development Program, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory, Missoula, Mont. 129p.


Regelin, Wayne L. and Olof C. Wallmo. 1978. Duration of deer forage benefits after clearcut logging of subalpine forest in Colorado. USDA
