

ECOLOGICAL RELATIONSHIPS OF INTERIOR DOUGLAS-FIR

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ABSTRACT

Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) is a common and often abundant forest species in the Rocky Mountains and other inland mountain ranges of western North America. In the Northern Rocky Mountains it occupies a greater variety of forest habitat types than any other tree. These range from semiarid habitats near the lower timberline, where it is a climax species, to inland-maritime forests where it is an early seral associate, to subalpine sites where it is a long-lived seral component. Like its coastal relative (*P. m.* var. *menziesii*), interior Douglas-fir is a "fire disturbance" species, but it has complex responses to fire because of the different successional roles and diverse competitive associates it has in different ecological site types.

Because interior Douglas-fir is abundant and has broad ecological tolerances and varied successional responses, good ecological knowledge is important for developing management strategies for it. This paper utilizes a simplified ecological classification as a basis for characterizing the different forest types involving interior Douglas-fir in the inland Northwest and Northern Rocky Mountains.

Keywords: *Pseudotsuga menziesii* var. *glauca*, forest succession, forest types, fire ecology

INTRODUCTION

Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) covers a broad geographic area in western North America, from central British Columbia to the high mountains of northern Mexico (Little 1971). In the inland portion of the Pacific Northwest and the Northern Rocky Mountains, interior Douglas-fir also occupies a wide elevational range, from about 1,200-8,500 feet (365-2,600 m). This tree grows on all aspects and on diverse topographical situations. It inhabits virtually all geologic parent materials. In the forests of Montana and central Idaho, interior Douglas-fir is by far the most ubiquitous vascular plant, being present in 67% of the 2,238 stands sampled throughout all forest types by Pfister *et al.* (1977) and Steele *et al.* (1981).

Interior Douglas-fir has the broadest ecological amplitude of any western tree, apparently reflecting its great diversity of genetic ecotypes (Monserud and Rehfeldt 1990). At one extreme in the continental climate of eastern Idaho and southwestern Montana it forms the drought-caused timberline adjacent to the high-elevation sagebrush (*Artemisia* spp.) steppe where annual precipitation averages only 15 inches (38 cm). It also extends

across the landscape to humid and luxuriant inland-maritime forests of northern Idaho where annual precipitation is 50 inches (127 cm). On dry sites interior Douglas-fir represents the potential climax, or is co-climax, often replacing various seral associates. In moist or subalpine habitats it is seral to more shade-tolerant conifers. In all of its forest types interior Douglas-fir has a dynamic relationship to fire (Fischer and Bradley 1987). It is associated with primeval fire regimes ranging from frequent surface fires to infrequent stand-replacing fires. Also, fire suppression during the 1900s has had differential effects upon the composition and structure of each Douglas-fir forest type.

CLASSIFICATION OF FOREST ENVIRONMENTS

In an earlier Washington State University silviculture symposium, Cooper and Pfister (1984) described the ecological distribution, successional relationships, and silvical characteristics of interior Douglas-fir. However, to depict the extraordinarily diverse forest types and synecological relationships involving interior Douglas-fir, I will use a different approach—a synthesized classification of the environments this tree occupies in the inland Northwest and Northern Rocky Mountains. This simplified characterization of forest environments (Figure 1) uses a moisture gradient as the horizontal axis and a temperature gradient, indicative of the length of growing season (Monserud and Rehfeldt 1990), for the vertical axis. It is based upon information presented in forest habitat type studies covering Idaho, Montana, and western Wyoming (Arno 1979; Arno *et al.* 1985; Cooper *et al.* 1987; Pfister *et al.* 1977; Steele *et al.* 1981, 1983) but should generally apply also to eastern Oregon (Johnson and Simon 1987; Hall 1989), eastern Washington (Williams and Lillybridge 1983), and the southern interior of British Columbia (McLean 1970).

In Figure 1, the entire area boxed in by dotted lines represents all forest environments, while the area enclosed by solid lines represents environments where interior Douglas-fir (depending upon successional stage) can be a major forest component. The double line passing through the diagram separates types where interior Douglas-fir is the potential climax dominant or a co-climax species (to the left) from those where it is seral and is replaced with advancing succession by more shade-tolerant conifers. The dot-dash line coursing diagonally through the diagram separates environments that prior to 1900 had frequent grass or understory fires (at left) from those that had mixed fire regimes of infrequent stand replacing fires and underburns, often in a patchy pattern on the landscape (Arno 1980). Tree growth in these diverse Douglas-fir types exhibits a large range of productivities, with yield capabilities averaging only 10-20 cubic feet/acre/year (0.7-1.4 m³/h/year) in the driest types (LmP-DF

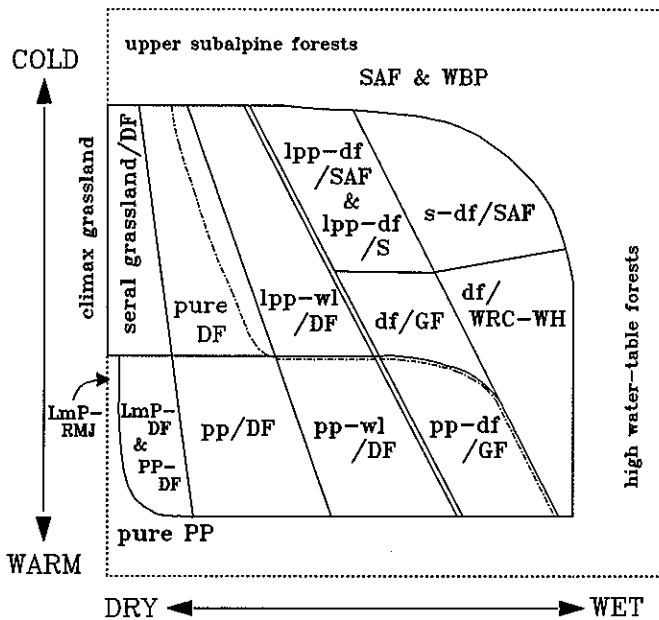


Figure 1.—Schematic classification of Douglas-fir forest types in the Northern Rocky Mountains and inland Pacific Northwest. Lower case abbreviations indicate seral species; upper case indicates climax species. df = Douglas-fir; gf = grand fir; lmp = limber pine; rmj = Rocky Mountain juniper; pp = ponderosa pine; s = spruce; saf = subalpine fir; wbp = whitebark pine; wl = western larch; wh = western hemlock; wrc = western redcedar.

and well over 100 cubic feet/acre/year (7 m³/ha/year) in the wettest type (df/WRC-WH) (Pfister *et al.* 1977; Steele *et al.* 1981, 1983).

Descriptions of the contrasting forest types involving interior Douglas-fir begins with the driest types shown in Figure 1.

LmP-DF and PP-DF

On the warmest and driest sites inhabited by interior Douglas-fir (LmP-DF and PP-DF type, Figure 1), this species shares potential climax status with the even more drought-tolerant ponderosa pine (*Pinus ponderosa* vars. *ponderosa* and *scopulorum*), limber pine (*P. flexilis*), and Rocky Mountain juniper (*Juniperus scopulorum*). The PP-DF stands have remained open even with fire suppression evidently due to soil drought and inherent stockability limitations (Pfister *et al.* 1977). They are typified by the DF/*Agropyron spicatum* and DF/*Festuca scabrella* habitat types of Pfister *et al.* (1977). Maximum heights of mature trees are about 60-70 feet (18-21 m). Sites warmer and drier than these are characterized by (pure) ponderosa pine habitat types.

The LmP-DF stands are frequently found on calcareous substrates. They are abundant immediately east of the Continental Divide in Montana and Wyoming where they adjoin limber pine-juniper, bunchgrass, or sagebrush communities on even drier sites. LmP-DF stands often occur on excessively well-drained soils where annual precipitation averages as little as 12 inches (30 cm). LmP/*Festuca idahoensis* and LmP/*Hesperochloa kingii* are common habitat types (Pfister *et al.* 1977; Steele *et al.* 1983). The trees are stunted, with maximum

heights of only 30-40 feet (9-12 m) at maturity. With fire suppression, LmP-DF stands have expanded to cover large areas immediately east of the Rockies in northern Montana (Gruell 1983). These communities could be considered ecologically similar to the pinyon pine-juniper woodlands found farther south in the Intermountain West.

pp/DF

These are the warm dry forests in which ponderosa pine (both varieties) is seral and interior Douglas-fir is the potential climax. Both species can attain tall tree stature (Douglas-fir maximum height about 90 feet [27 m] in western Montana), and stands can support full stocking (150-200 square feet/acre [34 to 46 square m/ha]) (Pfister *et al.* 1977). Prior to 1900 most of this type experienced frequent surface fires and was dominated by ponderosa pine. During the twentieth century most stands have had few if any surface fires, and as a result Douglas-fir is becoming dominant (Arno 1988). Common habitat types include much of the DF/*Physocarpus malvaceus*, DF/*Symphoricarpos albus*, and DF/*Arctostaphylos uva-ursi* types.

seral grassland/DF

The dry lower timberlines or forest-grassland ecotones of high-elevation semiarid regions in the Northern Rockies are commonly formed by Douglas-fir communities. Near the Continental Divide in Montana many of these communities are composed entirely of young conifers that have colonized what were formerly fire-maintained mountain grasslands. This colonization has occurred since 1900 and is related to a corresponding decrease in fire occurrence (Arno and Gruell 1986). The young trees are slow growing and sometimes form dense thickets. Habitat types include DF/*Festuca idahoensis* and DF/*Calamagrostis rubescens*, *Agropyron spicatum* phase and *Festuca idahoensis* phase.

pure DF

Also at or near the colder forest-grassland ecotones are long-established pure Douglas-fir forests, most of which formerly underburned at intervals of 20-50 years. Under the influence of fire suppression during the twentieth century these stands have thickened and have occasionally burned in severe stand-replacing fires. Common habitat types are DF/*Carex geyeri* and DF/*Arnica cordifolia*, and on droughty limestone soils DF/*Calamagrostis rubescens*.

lpp-wl/DF

In similarly cool but more moist sites, the seral species lodgepole pine (*P. contorta* var. *latifolia*) and western larch (*Larix occidentalis*) are associated with Douglas-fir. Lodgepole pine and larch were favored by a mixed fire regime. But with fire suppression and partial cutting, Douglas-fir has tended to gain dominance. Common habitat types include most of the DF/*Vaccinium globulare* and DF/*Linnaea borealis* in western Montana (Pfister *et al.* 1977).

pp-wl/DF

In warmer but similarly moist sites, ponderosa pine is also a major seral associate, along with larch and lodgepole pine, and was maintained in open mixed stands by frequent underburns (Arno *et al.* 1985).

pp-df/GF

This type is often comparable to pp-wl/DF with the addition of the shade-tolerant grand fir (*Abies grandis*), which is confined to moist regions of the inland Northwest. In west-central Idaho and eastern Oregon, larch and lodgepole pine are often absent, whereas farther north they tend to be components of this type. Ponderosa pine is a major associate that was maintained in mixed stands by frequent underburns (Hall 1976; Freedman and Habeck 1985). Fire suppression and partial cutting has favored Douglas-fir and ultimately grand fir. This type is especially common in west-central Idaho and is abundant in the vicinity of McCall, where advancing succession is transforming the Ponderosa State Park into a grand fir forest. Common habitat types include GF/*Spiraea betulifolia*, GF/*Acer glabrum*, and GF/*Linnaea borealis*.

df/GF

This type occurs on cooler sites where ponderosa pine has historically been scarce or absent and a mixed fire regime favored lodgepole pine, larch, and Douglas-fir, while fire suppression and partial cutting has favored grand fir. The latter is more vulnerable to fire injury and mortality than is Douglas-fir. GF/*Clintonia uniflora* and GF/*Asarum caudatum* are common habitat types (Pfister *et al.* 1977; Cooper *et al.* 1987; Steele *et al.* 1981).

df/WRC-WH

This inland-maritime Douglas-fir type is confined to the wettest area of the inland Northwest, where annual precipitation at low elevations averages more than 32 inches (81 cm) (Pfister *et al.* 1977). Superficially, this moist, interior Douglas-fir type seems similar to the Pacific Coast Douglas-fir (*P. m.* var. *menziesii*) forests, where western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) are also the climax species. However, interior Douglas-fir is generally a short-lived tree in this type, succumbing to root rots or other pathogens within about 100 years, unlike its long-lived coastal relative. In the inland-maritime forests, in further contrast to coastal forests, Douglas-fir shares dominance or is out-competed by several other seral species (Cooper *et al.* 1987). In conjunction with major fires, which averaged about one per century, seral Douglas-fir was often a co-dominant of stands on south-facing slopes, ridgetops, and other relatively dry sites, usually in association with lodgepole pine, western larch, western white pine (*P. monticola*), and lesser amounts of other species (Arno and Davis 1980). With fire suppression, grand fir, western redcedar, and western hemlock have gained dominance. The common habitat types for Douglas-fir stands are WRC/*Clintonia uniflora* and WH/*Clintonia uniflora*.

lpp-df/SAF and lpp-df/S

In cold moist sites, interior Douglas-fir is a seral component of subalpine fir (*Abies lasiocarpa*) and spruce habitat types. The spruce habitat types are transitional between cool-moist Douglas-fir habitat types and subalpine fir habitat types. For example, with increasing elevation on cool aspects a sequence from DF/*Linnaea borealis* habitat type to S/*L. borealis* to SAF/*L. borealis* is sometimes found. The spruce habitat types are most abundant in continental climates of northwestern, central, and southern Montana, northwestern Wyoming, and eastern Idaho (Pfister *et al.* 1977; Steele *et al.* 1983). Hybrid spruce—*Picea engelmannii* x *P. glauca* (Habeck and Weaver 1969)—is the indicated potential climax or a co-climax with Douglas-fir.

Lodgepole pine is a major seral associate of Douglas-fir (except on some limestone sites) in these hybrid spruce and subalpine fir habitat types. These are exemplified by S/*Arnica cordifolia*, S/*Juniperus communis*, S/*Linnaea borealis*, S/*Galium triflorum*, S/*Clintonia uniflora*, SAF/*Xerophyllum tenax*, SAF/*Vaccinium globulare* phase; SAF/*Vaccinium scoparium*, *Calamagrostis rubescens* phase; and SAF/*Calamagrostis rubescens* (Arno *et al.* 1985; Pfister *et al.* 1977; Steele *et al.* 1983). Here, lodgepole pine is favored most by large stand-replacing fires, Douglas-fir is favored by underburns and patchy fires, and the more fire-sensitive subalpine fir and hybrid spruce are favored by prolonged periods without fire (Figure 2). Western larch is a common seral associate in this type and is favored by fire disturbance.

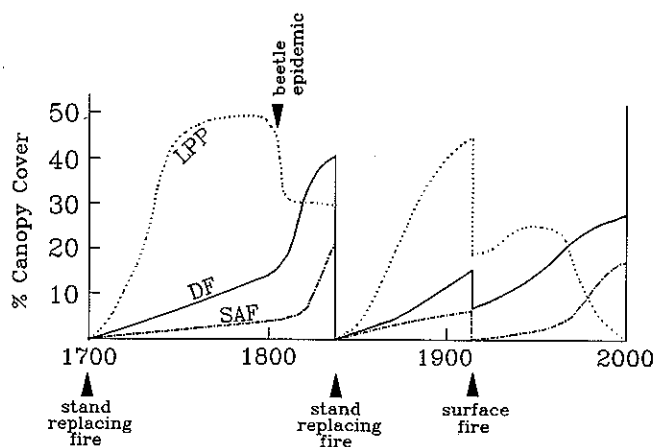


Figure 2. — Schematic representation of stand development patterns in relation to major disturbances in the lpp-df/SAF type.

s-df/SAF

This is the cold-moist extreme of interior Douglas-fir types. Characteristic habitat types include SAF/*Clintonia uniflora*, SAF/*Menziesia ferruginea*, and SAF/*Galium triflorum*. Spruce (*Picea engelmannii* and *Picea engelmannii* x *glauca*) is commonly a major component of seral and near-climax stands (Arno *et al.* 1985; Pfister *et al.* 1977). Lodgepole pine, western larch, Douglas-fir, and western white pine are favored by the occasional major fires which occur at intervals of 100-250 years (Arno 1980; Barrett *et al.* manuscript in review).

OTHER DOUGLAS-FIR COMMUNITIES

This simplified classification does not include every environmental situation with which interior Douglas-fir is associated in the inland Northwest and Northern Rocky Mountains. For example, exceptions occur on limestone substrates, especially east of the Continental Divide, where Douglas-fir often dominates much of the subalpine zone, while lodgepole pine, subalpine fir, and spruce appear to be restricted by soil drought (Despain 1973; Pfister *et al.* 1977). At its upper limits on these sites Douglas-fir occasionally forms mixed stands with whitebark pine (*Pinus albicaulis*).

Interior Douglas-fir is generally restricted from upper subalpine forest habitats by insufficient growing-season warmth and repeated frost damage (Arno and Hammerly 1984; Pfister *et al.* 1977). Douglas-fir's usual upper elevational limits approximately coincide with those of western larch and western white pine but are below those of the frost-tolerant lodgepole pine. Occasionally in extremely wind-exposed lower subalpine habitats, Douglas-fir is abundant in a shrubby wind-sheared (krummholz) form. Such wind-dwarfed communities containing Douglas-fir occur at scattered locations along and east of the Continental Divide in Montana (Arno and Hammerly 1984).

Quaking aspen (*Populus tremuloides*)/Douglas-fir communities occur occasionally in the Northern Rockies. The extent of seral aspen stands has been shrinking as they are replaced successionaly by Douglas-fir and other conifers in the absence of fire (Gruell 1980). Seral aspen stands containing Douglas-fir and other conifers become much more extensive southward, in the Middle and Southern Rocky Mountains. Also in these regions, Douglas-fir is a component of diverse mixed conifer forests containing subalpine fir, white fir (*Abies concolor*), Engelmann spruce, blue spruce (*Picea pungens*), ponderosa pine, aspen, and Gambel oak (*Quercus gambelii*). Farther south in the mountains of Arizona, New Mexico, and northern Mexico, several additional species are found in association with Douglas-fir in the mixed conifer forests that are confined to relatively high elevations (Moir and Ludwig 1979). Nevertheless, Douglas-fir is much more abundant in the inland Northwest and Northern Rockies, and it covers a far greater range of environments, including most of the commercially valuable forests.

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