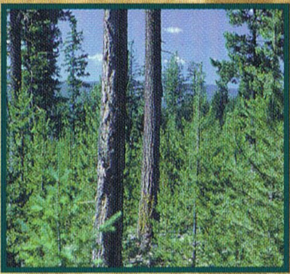
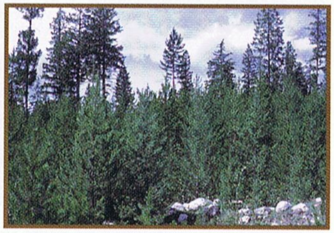
Seed Tree Systems & Wildlife Habitat



Seed Tree Silvicultural System

In mixed stands of Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) and lodgepole pine (*Pinus contorta* var. *latifolia*) in the southern interior of British Columbia, pine is often harvested by clearcutting and the Douglas-fir are left as residual standing trees. These "seed trees" are a source of Douglas-fir regeneration, providing a secondary species to lodgepole pine, which regenerates naturally from abundant cone slash. This is a relatively widespread practice that has been in place since the early to mid-1970s when lodgepole pine became an important commercial timber species. Thus, "green-tree retention" is not a new management approach to timber harvesting in this region.

Seed tree silvicultural system 1978



The same stand 19 years later in 1997

Because lodgepole pine seed regenerates naturally from abundant cone slash after harvest, pine tends to dominate young stands in these particular seed tree systems. An example of a 19-year-old stand of naturally regenerated pine that has been pre-commercially thinned and has an overstorey of residual Douglas-fir is shown in the plates. Stands such as this provide a degree of green-tree retention from one forest ecosystem to another through time.

The seed tree silvicultural system is essentially a method of even-aged management whereby a few wind-firm seed trees are left standing singly, or in groups, to furnish seed to regenerate the cleared area naturally. After a new crop is established, these seed trees may be removed in a second harvest or left indefinitely. The major distinction from shelterwood cutting is that the crown cover on standing trees is not sufficient to make the cleared area different in microclimate compared to an open clearcut area. Compared with the clearcutting silvicultural system, the seed sources are retained within the harvested area rather than near the perimeter of a given unit.

The seed tree and shelterwood systems are not necessarily distinguished on the basis of some arbitrary number of reserved trees per hectare. The amount of crown cover left to provide a significant degree of shade to shelter new seedlings is likely the best distinction. The seed tree method is a "concept" of leaving just enough trees to provide seed to regenerate a stand.

In the southern interior of BC, observations suggest that residual Douglas-fir, left after harvesting lodgepole pine from mixed stands, range from a few, up to 100+ per hectare. In most cases, the number of trees left depends on the original composition of the harvested stand. The silvicultural goal is to maintain, and perhaps increase, the proportion of Douglas-fir in the regenerated forest.

In terms of ecosystem management, green-tree retention leaves large live trees after harvest to persist through the next rotation to increase structural diversity of the regenerating stand and provide mature forest habitat. This structural diversity retains some later seral conditions such as a multi-layered canopy, provides a future supply of large snags and down logs, and may increase microsite variability for a more diverse understorey. Snags provide habitat for cavity-using birds and mammals through time.

Residual Douglas-fir trees become durable snags ("wildlife trees") with time

A major question is: ***what role do these seed tree stands play in managing the forest landscape for biodiversity objectives?*** There is a dearth of data on the effects of green-tree retention on biodiversity through time. Except for simulation models, which provide some insights into the long-term effects of alternative harvesting systems on forest ecosystems, field studies covering decades have yet to be completed.

Because of the relatively long-term history (early 1970s) of seed tree systems in Douglas-fir–lodgepole pine forests in the southern interior of BC, we studied a "natural" experiment—naturally regenerated stands of young (17 years since harvest) lodgepole pine with and without Douglas-fir seed trees, compared with old-growth stands of mixed Douglas-fir and lodgepole pine. The seed tree system in this forest type may mimic a natural disturbance regime whereby some residual old-growth Douglas-fir survive amidst fire-regenerated stands of lodgepole pine. From the perspective of wildlife habitat diversity, these seed tree stands may be comparable to mixed Douglas-fir–lodgepole pine old-growth stands in some aspects of stand structure. Indeed, these stands represent a silvicultural system that produces a potentially unique stand structure.

This study was designed to compare:

1) Stand structure attributes (species diversity and structural diversity of herb, shrub and tree layers), and
2) Species richness and diversity of small mammal communities, as a measure of wildlife habitat diversity

in young pine, seed tree and old-growth stands.

Experimental Design

This study was located in the Bald Range, 25 km west of Summerland in south-central BC. This area is within the Montane Spruce (MS*dm*) biogeoclimatic zone at an elevation range of 1400–1520 m. Clearcut harvesting of lodgepole pine with both uniform and group seed tree reserves of Douglas-fir began in the area in 1977.

Stands without seed trees were called "young pine," stands with residual Douglas-fir were "seed tree," and uncut stands were termed "old growth." When our study began in 1995, the young pine stands were 17 years old, the seed tree stands had understorey pine stands 17 years old (one 18-year-old stand), with overstorey Douglas-fir ranging in average age from 106 to 149 years. Old-growth stands had a tree species composition (and range in average age) of lodgepole pine (70 to 93 years), Douglas-fir (81 to 133 years), subalpine fir (99 to 102 years), and spruce (85 years). There were three replicates of each stand type.

Young pine

Seed tree

Old growth

Stand structure attributes of the coniferous tree layers (density, diameter, height, basal area and down wood) and understorey vegetation in the moss, herb and shrub–deciduous tree layers (percentage cover and crown volume index), as well as species diversity and structural diversity of these layers were measured. Abundance, species richness and species diversity of small mammal communities were also measured.

Stand Structure of Coniferous Tree Layers

Douglas-fir veteran trees averaged 77 stems/ha in the seed tree stands compared with 12 stems/ha in the old-growth stands. However, the main canopy in the old-growth stands averaged 303 stems/ha of Douglas-fir, and contained some trees which would have been classified as veterans in the seed tree stands. The lodgepole pine main canopy in the young pine stands had a significantly higher density (1135 stems/ha) than either of the seed tree (575 stems/ha) or old-growth (390 stems/ha) stands. In the subcanopy height classes, Douglas-fir occurred at a significantly higher density (488 stems/ha) in the old-growth than in either of the young pine (42 stems/ha) or seed tree (53 stems/ha) stands. Conversely, lodgepole pine dominated the subcanopy in the young pine (1563 stems/ha) followed by the seed tree (885 stems/ha) and old-growth (40 stems/ha) stands.

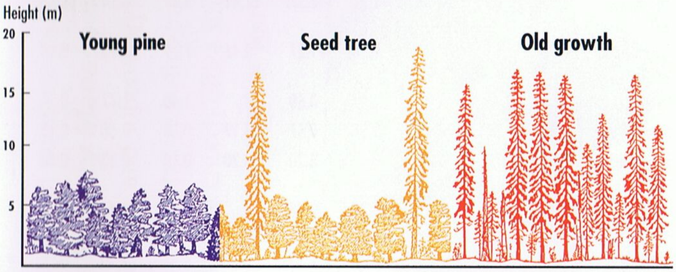


Figure 1. *Vertical stratification of tree height classes in treatment stands.*

Douglas-fir dominated the regeneration layer (<1.3 m height) in the old-growth (1668 stems/ha) followed by the seed tree (732 stems/ha) and young pine (63 stems/ha) stands. Lodgepole pine was at comparable numbers in the young pine and seed tree stands with very few pine seedlings occurring as regeneration in the old-growth stands. Some subalpine fir and spruce were present in the main canopy of the seed tree and old-growth stands. These two tree species were present in all stands in the subcanopy and regeneration height classes with subalpine fir occurring most often as regeneration in old-growth stands. Spruce occurred at significantly higher densities in the subcanopy and regeneration height classes of the young pine than in the other stands.

Because of the difference in vertical stratification of the main canopy and subcanopy layers between the old-growth stands and the seed tree and young pine stands, it is not surprising that mean diameters of Douglas-fir, lodgepole pine and subalpine fir were highest in the old-growth stands. Despite these differences in diameters, basal area of each species was similar within height classes among treatment stands.

Dead standing trees (snags) were present in the old-growth stands only. In terms of density, Douglas-fir snags varied from 5 to 109 stems/ha in the main and subcanopy layers, respectively. Lodgepole pine snags were at similar numbers in the main canopy (273 stems/ha) and subcanopy (240 stems/ha). Subalpine fir had seven dead stems/ha in the subcanopy and 57 dead stems/ha in the main canopy.

Mean volume (m^3/ha) of down wood was similar among treatment stands ranging from 83 in the seed tree to 114 in the young pine, to 120 in the old-growth stands.

Understorey Vegetation

Mean total percent cover of herbs and mosses was similar among treatment stands. Mean total crown volume index was also similar across stands for herbs and mosses. Prominent herb species in these stands included fireweed (*Epilobium angustifolium*), grasses, Arctic lupine (*Lupinus arcticus*), heart-leaved arnica (*Arnica cordifolia*), wild strawberry (*Fragaria virginiana*), and white-flowered hawkweed (*Hieracium albiflorum*). In terms of total herbaceous species, three species occurred in the young pine only, two species in the seed tree only, and 12 in the old-growth stands only.

Table 1. *Mean percent cover (%) and crown volume index (m^3/0.01 ha) for plant species in shrub–deciduous tree (S–DT), herb, and moss layers.*

Vegetation		Young pine	Seed tree	Old growth
(% cover)	S–DT	40.8[a]	25.0[a]	9.4[a]
	Herbs	22.8	23.2	25.2
	Moss	11.1	8.9	10.0
(Volume)	S–DT	41.8	21.6	5.8
	Herbs	10.5	8.8	7.4
	Moss	2.8	2.2	2.5

a–a significant difference by ANOVA

Prominent moss species included common lawn moss (*Brachythecium albicans*), broom moss (*Dicranum* sp.), fire moss (*Ceratodon purpureus*), and juniper haircap moss (*Polytrichum juniperinum*). In terms of total moss species, three species occurred in the old-growth stands only.

Mean total percent cover of shrubs–deciduous trees was significantly higher in the young pine (40.8%) than old-growth (9.4%) stands. The seed tree had 25.0% mean cover of shrubs–deciduous trees. Although not significant, mean total crown volume index of shrubs–deciduous trees also tended to follow this pattern: young pine (41.8), seed tree (21.6), and old growth (5.8). Prominent shrubs included Sitka alder (*Alnus sinuata*), kinnikinnick (*Arctostaphylos uva-ursi*), twinflower (*Linnaea borealis*), Utah honeysuckle (*Lonicera utahensis*), falsebox (*Paxistima myrsinites*), birch-leaved spirea (*Spiraea betulifolia*), and grouseberry (*Vaccinium scoparium*). In terms of total shrubs–deciduous tree species, seven species occurred in the young pine only, six species in the seed tree only, and two species in the old-growth stands only.

Habitat Diversity

Total species richness was similar among the young pine (45 species present), seed tree (43), and old-growth (49) stands. Mean species richness of herbs and coniferous trees was similar among treatment stands, whereas richness of shrubs–deciduous trees was significantly different among treatment stands. The young pine stands had a mean richness of 8.73, which was higher than that in the old-growth stands (5.00). Mean species richness of mosses was similar among treatment stands. Mean species diversity of mosses, herbs and shrubs–deciduous trees was similar among treatment stands. Species diversity of coniferous trees was higher in the seed tree and old-growth stands than in the young pine stands. This latter result is not surprising considering the dominance of lodgepole pine in the young pine stands.

***Table 2.** Mean species richness and diversity of coniferous trees (ConT), shrubs–deciduous trees (S–DT), herbs and mosses*

Species diversity		Young pine	Seed tree	Old growth
Richness	ConT	3.63	3.13	2.73
	S–DT	8.73[a]	7.20	5.00[a]
	Herbs	5.80	5.33	5.33
	Moss	2.80	2.40	3.13
Diversity	ConT	0.12	0.74	0.89
	S–DT	1.67	1.20	1.47
	Herbs	1.33	1.16	1.30
	Moss	0.94	0.91	1.06

a–a significant difference by ANOVA

Mean structural diversity in terms of richness of height classes (or layers of vegetation) of herbs and shrubs–deciduous trees appeared consistently higher in the young pine than seed tree and old-growth stands. Richness of height classes was significantly different for coniferous trees with the seed tree stands higher than either of the young pine or old-growth stands. Structural diversity indicated no difference in herb and coniferous tree layers. However, mean structural diversity of the shrub–deciduous tree layer was significantly different among treatment stands. The young pine stands had significantly higher structural diversity of shrubs–deciduous trees than the seed tree stands. In addition, the seed tree stands also had higher structural diversity of this vegetative layer than the old growth.

***Table 3.** Mean structural richness and diversity of coniferous trees (ConT), shrubs–deciduous trees (S–DT) and herbs*

Structural diversity		Young pine	Seed tree	Old growth
Richness	ConT	3.00	4.00*	3.07
	S–DT	5.20	3.67	2.60
	Herbs	3.67	2.80	1.93
Diversity	ConT	0.64	0.89	0.56
	S–DT	1.80[a]	1.05[a]	0.77[a]
	Herbs	1.62	0.93	0.52

* significant difference by ANOVA a–a significant difference by ANOVA

Small Mammal Communities

A total of 425 red-backed voles, 538 deer mice, 234 northwestern chipmunks, 233 montane shrews, 71 common shrews, 43 heather voles, 35 long-tailed voles, 32 meadow voles, 23 western jumping mice, and 23 short-tailed weasels were captured during the three years of the study.

Mean numbers of deer mice were similar among treatment stands and changes in abundance through the summer and fall of 1995 to 1997 reflect this pattern. Mean numbers of red-backed voles were significantly different with consistently higher (3.1 to 7.3 times) abundance in the old growth than in either of the young pine or seed tree stands. This difference was evident in all years.

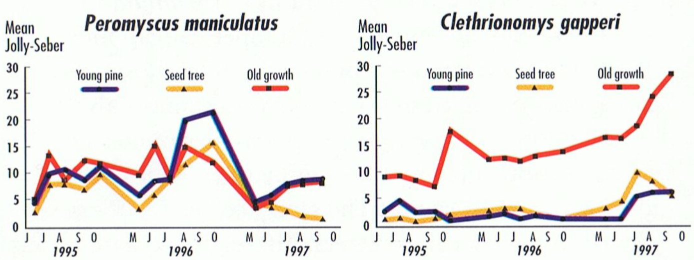


***Figure 2.** Mean (n = 3) population density (no./ha) from Jolly-Seber estimates in the young pine, seed tree and old-growth stands from 1995 to 1997 for* Peromyscus maniculatus *and* Clethrionomys gapperi *at the Summerland study area.*

Table 4. Mean abundance/ha for small mammal species during each year in the three treatment stands for Jolly-Seber population estimates at the Summerland study area

Species	1995 Young pine	1995 Seed tree	1995 Old growth	1996 Young pine	1996 Seed tree	1996 Old growth	1997 Young pine	1997 Seed tree	1997 Old growth
Deer mouse	8.90	7.05	10.21	12.76	9.02	11.96	6.87	2.67	5.56
Red-backed vole	2.70	1.53	10.17	1.70	2.57	12.41	3.77	6.14	18.76
Northwestern chipmunk	5.79	8.92	2.79	9.16	11.57	3.46	7.79	10.99	3.10
Heather vole	0.67	0.73	0	1.17	0.60	0	1.40	1.77	0
Meadow vole	0.47	0.67	0.50	0.23	0.57	0.17	0.30	0.60	0.13
Long-tailed vole	0.13	1.70	0.40	0	0.20	0.20	0.13	0.33	0.33
Jumping mouse	0	0.20	0	0.20	0.33	0	0.43	0.47	0
Montane shrew	2.07	2.13	0.20	2.53	2.93	0.33	1.87	2.20	0
Common shrew	1.07	0.07	0.13	1.07	0.73	0.40	0.27	0.40	0
Short-tailed weasel	0.13	0.13	0.33	0.07	0	0	0.47	0.33	0.07

Deer mouse
Peromyscus maniculatus

Red-backed vole
Clethrionomys gapperi

The third major species, the northwestern chipmunk, also exhibited significantly different mean numbers among treatment stands. The seed tree (3.1 times) and young pine (2.4 times) stands had higher abundance of chipmunks than the old-growth stands. There was no difference in mean number of chipmunks between the seed tree and young pine stands. Heather voles were consistently present at low numbers (approximately 1 animal/ha) in both young pine and seed tree stands, but were absent from the old-growth stands. This difference in mean numbers of heather voles was significant overall and also between the old-growth and each of the young pine and seed tree stands. Another relatively uncommon species, the western jumping mouse, also tended to have consistently higher mean numbers in the young pine (0.21/ha) and seed tree (0.33/ha) than old-growth stands, where it was absent.

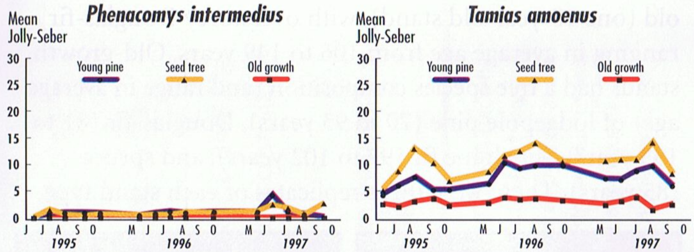


Figure 3. *Mean (n = 3) population density (no./ha) from Jolly-Seber estimates in the young pine, seed tree and old-growth stands from 1995 to 1997 for* Phenacomys intermedius *and* Tamias amoenus *at the Summerland study area.*

Heather vole
Phenacomys intermedius

Northwestern chipmunk
Tamias amoenus

There was no difference in mean numbers of long-tailed voles among treatment stands. However, mean abundance of meadow voles tended to be higher in the seed tree (0.61/ha) than in either of the young pine (0.33/ha) or old-growth (0.27/ha) stands.

The insectivore members of these small mammal communities exhibited significant differences among treatment stands. The overall mean abundance of montane shrews was significantly higher in the young pine (2.16/ha) and seed tree (2.42/ha) than in the old-growth (0.18/ha) stands. This difference in mean numbers was also true for common shrews between the young pine (0.80/ha) and old-growth (0.18/ha) stands.

Western jumping mouse
Zapus princeps

Long-tailed vole
Microtus longicaudus

Meadow vole
Microtus pennsylvanicus

Shrew
Sorex spp.

Short-tailed weasel
Mustela erminea

On average, montane shrews occurred at 3.2 times greater numbers than common shrews.

Mean numbers of the short-tailed weasel, a principal predator of several of these small mammal species, were similar among treatment stands.

Mean species richness of the small mammal communities was significantly different among treatment stands. Both the young pine (5.71) and seed tree (6.24) stands had more species (1.4 to 1.6 times) than the old-growth (3.96) stands and this pattern was consistent throughout the three years of the study. Similarly, small mammal richness was higher in the seed tree than young pine stands. Mean species diversity also followed this pattern with significantly higher diversity in the young pine and seed tree stands than in the old-growth stands, as represented by both the log-series alpha and Shannon-Wiener indices. There was no difference in species diversity between the young pine and seed tree stands, and these differences were consistent throughout the study.

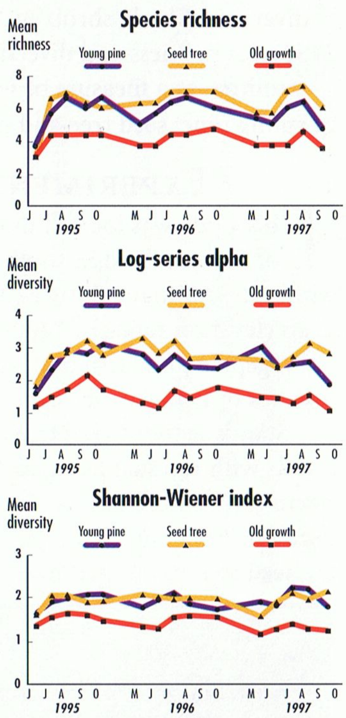


Figure 4. *Mean (n = 3) species richness and species diversity represented by log-series alpha and Shannon-Wiener indices for small mammal communities in the young pine, seed tree, and old-growth stands from 1995 to 1997 at the Summerland study area.*

Seed Trees and Habitat Diversity

The seed tree silvicultural system has been in use in the southern interior of BC for nearly 30 years, particularly in mixed Douglas-fir–lodgepole pine forests but also in mixed western larch (*Larix occidentalis*)–lodgepole pine forests as well.

Larch seed trees with understorey of larch and lodgepole pine

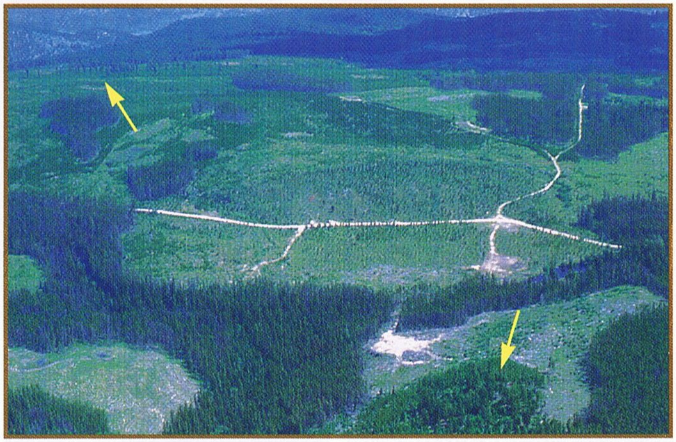
The goal of promoting a multistoried canopy appeared to be achieved by the significantly higher number of height classes of coniferous trees in the seed tree than young pine and old-growth stands. Similarly, the high structural richness and diversity of herbs and shrubs–deciduous trees found in the young pine stands also occurred to some degree in the understorey component of the seed tree stands.

Comparison of vertical stratification between the young pine and old-growth stands was difficult because of the considerable difference in tree heights within the main and subcanopies. Thus, although structural richness was low in the old-growth stands, species diversity of coniferous trees and provision of snags for cavity-using wildlife species was high.

Thus, rather than a gradient of stand structure attributes across these stand types, each stand likely offers its own unique structural diversity to the forest landscape. Total species richness of our plant communities was similar but there were unique assemblages of plant and small mammal species found in each of the stand types that supports the premise of a mosaic of different stands across the landscape.

Seed tree stand surrounded by old-growth forest

Seed tree stand surrounded by young successional forest



Landscape mosaic of recent clearcuts, young pine, seed tree and old-growth forest (arrows pointing to seed tree stands)

Impact on the Forest Sector

The forest sector gains valuable knowledge from this research in two ways. First, several companies are in the process of preparing Total Resource Plans in areas similar to that encompassed by this study. For a considerable portion of these areas, it is required that seed tree systems be used as the silvicultural system of choice. Over the past 20 to 25 years, the seed tree system has been applied as a "blanket prescription" across fairly broad areas. Now these areas are far enough along that any benefits to wildlife habitat can be quantified in a reliable manner as documented in this study. Second, the recently completed timber supply review and allowable annual cut determination directs some licensees to begin to increase the proportion of harvest in the Interior Douglas-fir biogeoclimatic zone. As little harvesting effort has been exercised in this zone in recent years, the information derived from this study will direct management efforts to achieve the desired biodiversity guidelines set out by the Forest Practices Code, while maintaining a level of harvest that ensures an adequate wood supply to mills in the southern interior.

Conclusions

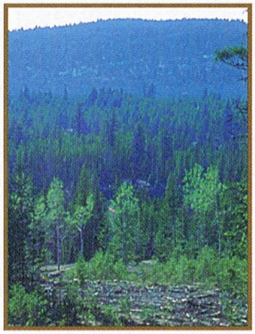
Our results indicate that:

1) Rather than a gradient of stand structure attributes (species diversity and structural diversity of herbs, shrubs and tree layers) across young pine, seed tree and old-growth stands, each stand offers it own unique structural diversity to the forest landscape; and
2) The gradient of small mammal species richness and diversity is seed tree ≥ young pine > old growth.

Benefits of seed tree stands include:

1) Diversity of coniferous tree species (higher component of Douglas-fir) in the regeneration cohort, and overall, within the coniferous component of the forest.
2) Structural richness and diversity of coniferous trees in the multistoried canopy to provide some components of old-growth forest structure.
3) Structural richness and diversity of herb and shrub–deciduous tree layers found in young pine stands also occurs to some degree in the understorey component.
4) A source of snags and down wood in the future forest.
5) Some large high-value timber if retained and included in the next harvest.
6) All of the small mammal species found in old-growth forest with higher species richness and diversity of small mammals than in old-growth stands.
7) Unique stand structure attributes that will enhance wildlife diversity over the forest landscape.
8) Emulation of a natural disturbance regime whereby some residual old-growth Douglas-fir survive amidst fire-regenerated stands of lodgepole pine.

The benefits outlined above are consistent with those objectives for maintaining biodiversity as found in the biodiversity guidebook. Because of these attributes (1–8), future timber harvesting in mixed Douglas-fir–lodgepole pine forests of the southern interior should continue to use this seed tree system. This strategy should meet the biodiversity guidelines under the Forest Practices Code and maintain wood supplies to mills. Future research should address questions of what range of stems/ha of Douglas-fir should be reserved and their distribution across the landscape.



Residual Douglas-fir amidst fire-regenerated stands of lodgepole pine

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