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Vegetation Structure in Old-Growth Stands in the Coram Research Natural Area in Northwestern Montana

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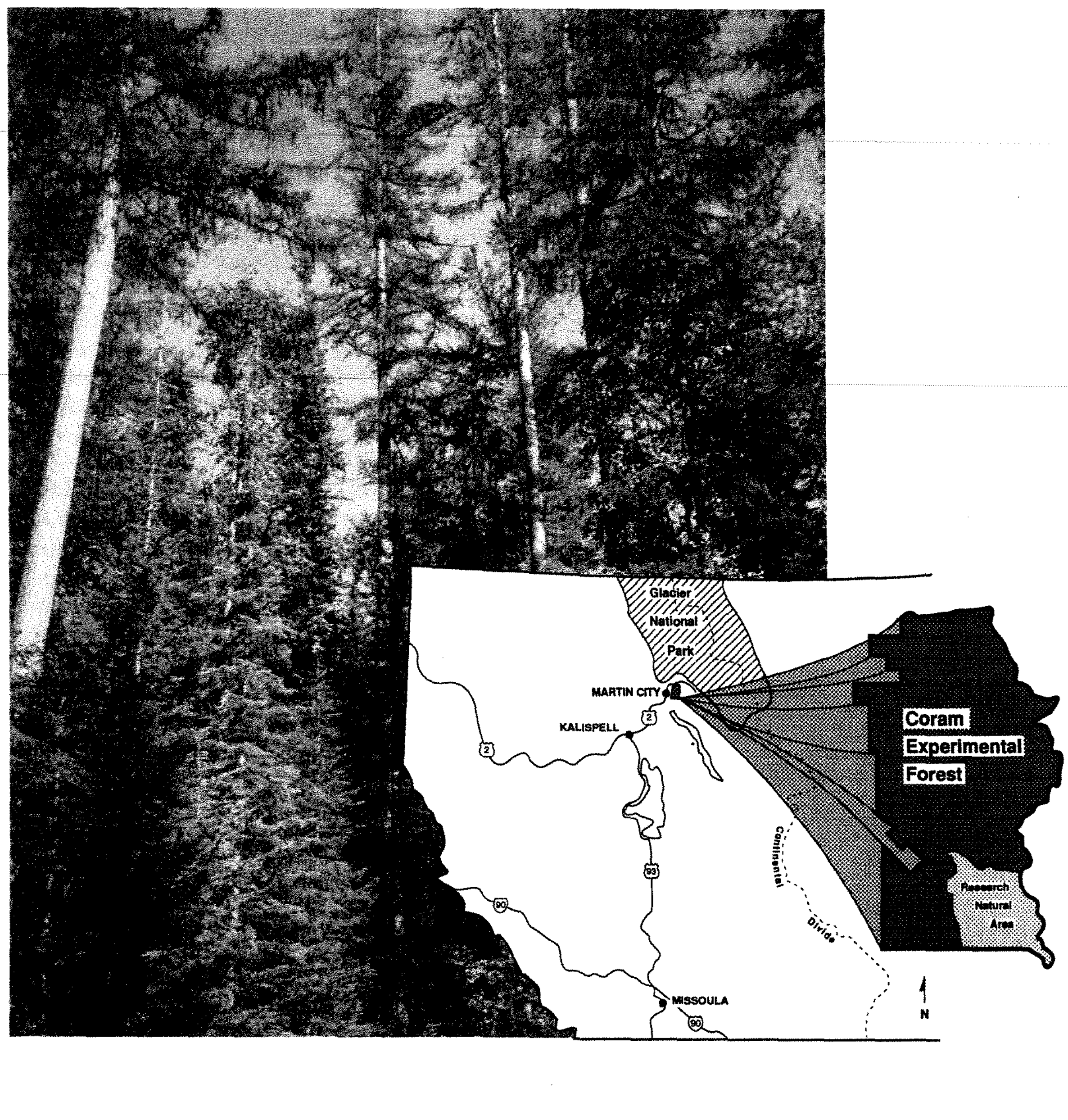

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Introduction

Old-growth forests are viewed as an unchanging climax community under classical successional theory (Christensen 1988). Recently, this paradigm has been replaced with one that views old growth as part of a shifting mosaic of stage classes resulting from disturbance (Sprugel 1991). Compared to classical successional theory, this view is spatially expanded to the landscape or ecosystem level, and temporally expanded to several centuries or more. This view adds the dimensions of temporal and spatial variability to management of natural areas set aside to protect examples of old-growth forests. Do managers arrest or allow the slow changes associated with community processes and the rapid changes caused by catastrophic disturbances such as fire?

The paradigm of classical successional theory is difficult to apply to forests with old trees that are maintained by periodic low-intensity fire (Mehl 1992). Old-growth forests first became a management issue in the forests of Washington and Oregon west of the Cascades, and many definitions were developed that used concepts of successional climax (Franklin and Spies 1991; Marcot and others 1991). These west-side forests are primarily affected by within-stand (autogenic) processes of succession, and some authors argue that true old growth has only developed in the absence of outside stand-initiating disturbances (Hayward 1991; Oliver and Larson 1990). This paradigm does not match stand-development patterns in the Northern Rocky Mountains. Many stands begin with a high-intensity stand-replacing fire, and rarely achieve successional climax before another stand-replacing event intervenes (Fischer and Bradley 1987). Many of the oldest stands are dominated by long-lived fire-dependent seral species that were historically maintained and protected from crown fire by repeated underburns (Achuff 1989; Arno and others 1985; Fischer and Clayton 1983; Habeck 1988). The majority of presettlement old growth was low-elevation fire-maintained stands of ponderosa pine (*Pinus ponderosa)*, western larch (*Larix occidentalis*), and Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) (Arno and others 1985; Green and others 1992).

Recognizing these differences and the resulting challenge of defining old growth, the Chief of the Forest Service issued in 1989 a directive to all Regional Offices to develop definitions for old-growth forests by geographic location and ecosystem type. This was completed for western Montana in 1992 (Green and others 1992).

Definitions that focus on stand structural characteristics, such as species composition and tree diameter, are considered objective and operational. This approach is the most common one used in the old growth definitions currently being developed by land management agencies such as the U.S. Forest Service and the Bureau of Land Management (Green and others 1992; Hamilton 1993; Vora 1994). Development of these definitions, however, is hampered by limited knowledge of old-growth stand characteristics. While structural characteristics for natural old-growth stands in the Coastal and Cascade area of the Pacific Northwest are fairly well documented, published stand descriptions for Northern Rocky Mountain forests are largely limited to second-growth managed stands (Moeur 1992).

Forest stand structure, understory composition, and tree seedling composition were measured in eight permanent tenth-hectare plots in three forest cover types (Eyre 1980): Engelmann spruce/subalpine fir (SAF cover type number 206), western larch (212), and interior Douglas-fir (210). These plots were established within the Coram Research Natural Area to document long-term changes in vegetation composition and structure, thus the use as descriptors of old growth is ancillary to their primary purpose. Sampling methodology is not optimal for the purpose of stand description; the detailed plot data does, however, present a rare snapshot of the vegetation in stands that are generally considered "old growth." Dominant trees in these stands are usually more than 200 years old, and some are as old as 500 years (Tobalske and others 1991).

Study Site

The Coram Research Natural Area is located within the Coram Experimental Forest on the Flathead National Forest, near Hungry Horse, MT, 16 km south of the west entrance to Glacier National Park and 45 km northeast of Kalispell, MT (fig. 1). The Coram Experimental Forest, including the Coram Research Natural Area, was designated a Biosphere Reserve by the Man and the Biosphere Program of the United Nations Educational, Scientific and Cultural Organization in 1976. The 340 ha Coram Research Natural Area was recommended in 1937 to preserve examples of old-growth western larch and interior Douglas-fir stands, and was officially designated as a Forest Service Research Natural Area in 1988 (Wellner 1988).

Annual precipitation in the Coram Research Natural Area averages 89 cm at the lower elevations and over 102 cm along the upper boundary (Farnes and others 1995). Approximately 70 percent of the precipitation occurs during the winter and early spring months as snow. Temperature averages 16 °C during the summer months. Frost-free days are approximately 150, but frost may occur in any month. Elevations range from 1,067 to 1,463 m, with most slopes southwest facing. One small ephemeral stream occurs in the center of the Coram Research Natural Area, and another on the southern boundary, both draining to the west and containing some northwest-facing slopes. Slopes range from 5 to 50 percent.

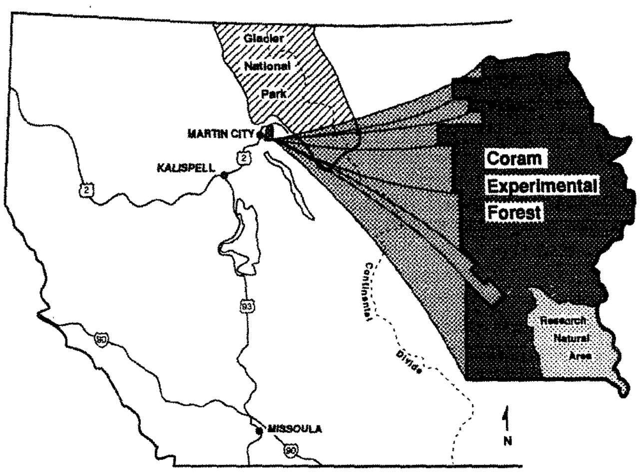

Figure 1—Location of the Coram Experimental Forest and Coram Research Natural Area in Montana, U.S.A.

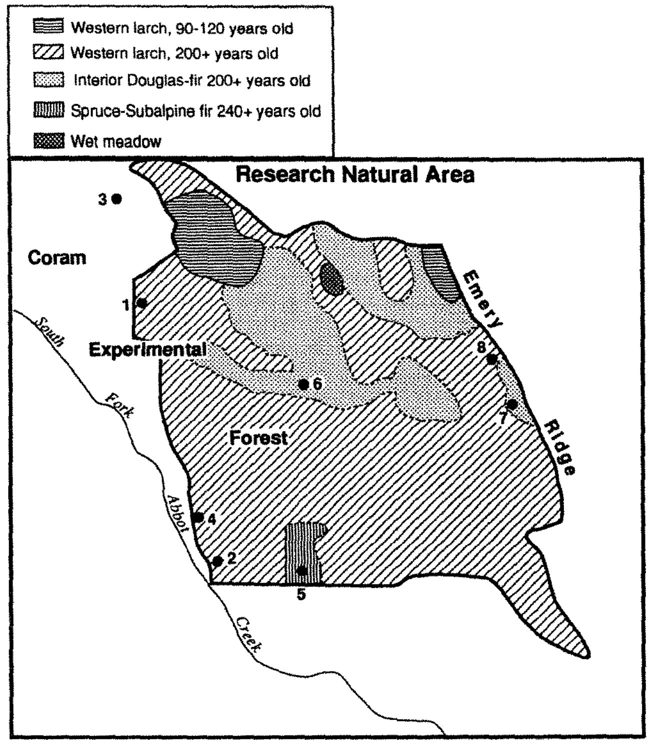

Figure 2—Vegetation types and location of permanent monitoring plots within the Coram Research Natural Area.

Approximately 80 percent of the Coram Research Natural Area is forested with stands of mixed western larch and Douglas-fir more than 200 years old (fig. 2). About three-fourths of these stands classify as the Society of American Foresters (SAF) western larch cover type (Eyre 1980), even though they contain nearly an equal mix of Douglas-fir and western larch. Approximately one-fourth of the mixed stands are dominated by Douglas-fir and are classified as SAF Interior Douglas-fir cover type. About 10 percent of the Research Natural Area is a younger (100 year old) mixed western larch/Douglas-fir stand that belongs to the western larch cover type. The remaining 10 percent of the Research Natural Area is composed of a small patch (5 ha) of spruce-subalpine fir cover type, a wet meadow, and a 10 ha area of western larch cover type that contains a codominant western white pine element. Other common trees are subalpine fir (*Abies lasiocarpa*), an Engelmann/white spruce hybrid (*Picea* *engelmannii* x *P. glauca*) (Habeck and Weaver 1969), western white pine (*Pinus monticola*), western hemlock (*Tsuga heterophylla*), and more rarely, lodgepole pine (*Pinus contorta*), and western redcedar (*Thuja plicata*). Most of the area is classified as a subalpine fir climax series or habitat type, with patches of western hemlock and Douglas-fir types (Pfister and others 1977).

Western larch often initiates after stand-replacing fires (Parker 1982) and then persists for 300 to 700 years (Barrett and others 1991; Fischer and Bradley 1987). It is the most fire-resistant conifer in the Northern Rocky Mountains (Fischer and Bradley 1987). Some individuals within a stand may survive severe fires due to thick, fire-resistant bark and replacement of heat-killed foliage via epicormic branching (Barrett and others 1991). With occasional severe fire and more common nonlethal underburns, western larch dominance of the stand may be perpetuated as "fire-maintained old growth" (Davis 1980; Fischer and Bradley 1987; Habeck and Mutch 1973). In the prolonged absence of fire, these old-growth larch stands will be replaced by more shade-tolerant species (subalpine fir, spruce, and western hemlock) as succession proceeds (Schmidt and Shearer 1990).

Douglas-fir functions as either a seral or climax species, depending on the site (Pfister and others 1977). Most Douglas-fir found in the Coram Research Natural Area occurs with western larch on sites that would be dominated by subalpine fir at climax. In the prolonged absence of fire, Douglas-fir will be competitively excluded on these sites by ;more shade-tolerant species. On a few drier sites, however, Douglas-fir may function as the climax dominant. Fire maintains an open parklike stand, dominated by large, old trees (Fischer and Bradley 1987).

Based on tree ages and fire scar transects (Arno and Sneck 1977), most of the Research Natural Area has experienced no catastrophic stand-replacing disturbances for more than 350 years (Sneck 1977). The 40,000 ha Half Moon fire that started August 23, 1929, was the last stand-replacing fire to burn near the Coram Research Natural Area (Gisborne 1929). In 1890, a lightning-caused fire began on the Coram Experimental Research Natural Area and burned a small area within the northwest corner of the Research Natural Area (Sneck 1977).

Lightning storms frequently occur over the area and strikes are numerous. Most storms are accompanied by moderate to heavy showers; few fires start in proportion to the intensity of the storms (Coram Experimental Forest 1961). On August 14, 1951, a lightning-caused fire began near the center of the Research Natural Area and was limited to less than 0.04 ha by the suppression crew. This is the only other known fire to burn within the boundary of the Coram Research Natural Area since the 1890 fire. Five other lightning-caused fires, (three in 1940, one in 1941, and one in 1951) occurred within a 1.6 km band around the Research Natural Area.

Table 1—Cover and habitat types, dominant tree species, and site attributes for permanent plots in the Coram Research Natural Area, northwestern Montana.

Plot	Age	SAF cover type	Habitat type[a]	Dominant canopy species[b]	Slope	Aspect	Elevation
	Years				*Percent*	*Degree azimuth*	*m*
1	200+	Western larch 212	ABLA/CLUN/ARNU	Western larch, Douglas-fir, western white pine	15	240	1,090
2	200+	Western larch 212	ABLA/CLUN/ARNU	Western larch, western white pine	Flat	—	1,085
3	100	Western larch 212	ABLA/CLUN/ARNU[c]	Douglas-fir, western larch	25	210	1,115
4	200+	Western larch 212	TSHE/CLUN/ARNU	Douglas-fir, western larch, spruce, western white pine	<5	280	1,075
5	240+	Spruce-subalpine fir 206	ABLA/CLUN/ARNU	Spruce, Douglas-fir, western larch	23	278	1,100
6	300+	Interior Douglas-fir 210	PSME/LIBO/SYAL	Douglas-fir, western larch	49	241	1,190
7	200+	Interior Douglas-fir 210	ABLA/CLUN/XETE	Douglas-fir	22	250	1,355
8	200+	Western larch 212	ABLA/CLUN/XETE	Western larch, Douglas-fir	27	257	1,370

[a]Based on Pfister and others 1977. Species codes: ABLA = *Abies lasiocarpa*; ARNU = *Aralia nudicaulis*; CLUN = *Clintonia uniflora*; LIBO = *Linnaea borealis*; PSME = *Pseudotsuga menziesii*; SYAL = *Symphoricarpos albus*; TSHE = *Tsuga heterophylla*; XETE = *Xerophyllum tenax*.
[b]First species listed is most abundant; remaining species are in order of abundance.
[c]Seral burned site, lacking indicator species.

Methods

In 1985, four long-term baseline monitoring plots were established within or near the Coram Research Natural Area (Habeck 1985) and remeasured in 1990. All were established in western larch cover types: three in 200 plus year old stands and one in the 100 plus year old stand (fig. 2; table 1). Plot two, one of the three old-growth western larch plots, was placed on a site with codominant western white pine. Plots one, two, and three were placed in subalpine fir habitat types; plot four was placed in a western hemlock habitat type (table 1). All four plots were at the lowest elevations on the western edge of the Research Natural Area.

Management personnel identified a need for additional plots to include forest cover types and habitat types that were not represented in the original monitoring system. In 1993, plots six and seven were placed in stands of 200 plus year old interior Douglas-fir, one in a 200 plus year old spruce-subalpine fir stand, and plot eight was placed in an upper elevation 200 plus year old western larch stand (fig. 2; table 1).

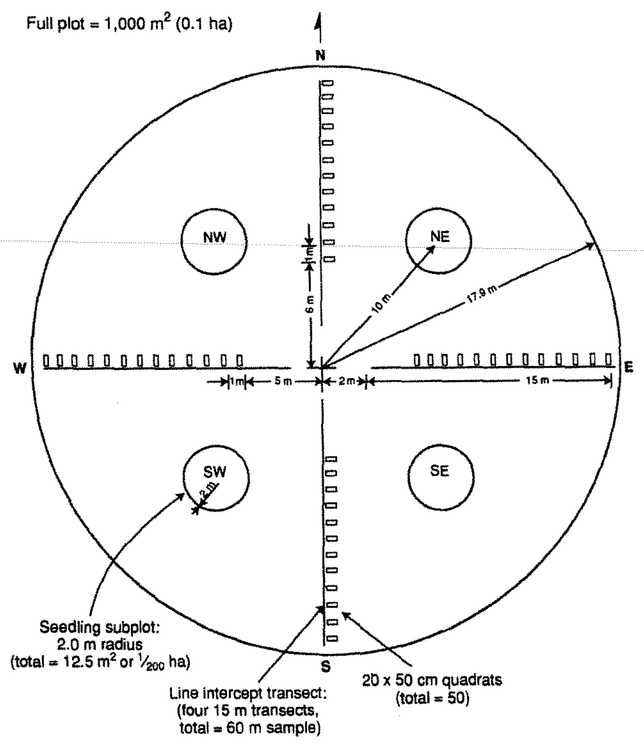

Figure 3—Design of permanent plots illustrating plot dimensions and location of line intercepts, seedling subplots, and understory herbaceous microplots.

The Coram Research Natural Area was mapped using SAF forest cover types (Wellner 1988); these formed the basis for plot selection and placement. Possible sampling locations within each cover type were identified using aerial photographs and cover type maps. After field reconnaissance of the target stand, plot location was selected to represent the stand canopy structure and understory composition observed within the stand. Plots were placed in areas that were relatively homogeneous, avoiding obvious ecotones or discontinuities. Plot design and sampling methodology generally follows Greene (1984). Plots are permanently monumented at the center and at the four cardinal points (N, S, E, and W from true north) with steel fenceposts (fig. 3). Plots are 1,000 m^2 (0.1 ha) (not corrected for slope).

All trees were tagged at breast height (1.4 m from ground) with aluminum numbered tags affixed with aluminum nails. Tree diameter breast height (d.b.h.) was measured at the tag to ensure that repeat measures would be done at the same spot. Diameters were estimated to the nearest 0.01 inch with a steel d.b.h. tape and converted to metric measures. Only trees greater than 2.5 cm diameter at the base were tagged and measured.

On each plot, five to 12 trees were cored at d.b.h. to determine age. Trees were chosen to represent the range of d.b.h. classes for each species occurring on the plot. Cores that missed center slightly were extrapolated to the approximate date. Five to 10 years were added to d.b.h. years to get the age of origin.

Trees less than 2.5 cm at the base and greater than 3 cm tall were measured as seedlings in four 12.5 m^2 subplots. Seedling subplots are 10 m from plot center, located on the 45° angle from each cardinal point (fig. 3). Subplot centers are marked with iron rebar or metal stakes.

Seedlings were either tagged with a metal tag secured to the ground with a large nail, placed 10 cm in front of the seedling toward the center stake (for the four 1993 plots), or tagged with an aluminum tag loosely tied to the seedling itself. Seedlings were also mapped in the 1993 plots by measuring direction and distance from the center stake. Height was measured to the nearest centimeter, and the diameter at base was evaluated and classified into one of the following diameter classes: 1 (less than 0.5 cm); 2 (0.5 to 1.0 cm); 3 (1.1 to 1.5 cm); 4 (1.6 to 2.5 cm).

Shrub and herbaceous cover was measured on plots one through four using the methodology proposed by Greene (1984). Shrub canopy cover was measured along four line-intercept transects (Bonham 1989), each beginning 2 m from the center post, stretching to 17 m (15 m lengths, 60 m in all) on one of the cardinal points (fig. 3). Herbaceous frequency and canopy cover was estimated along these same transects in 50 microplots each 20 x 50 cm in size (Daubenmire 1959). Twelve microplots were placed along the north and south lines, with microplots starting at the 6 m point, placed every meter, with the inner corner of the microplot on the meter mark of the tape. Thirteen microplots, beginning at 5 m, were placed along the west and east lines. North and south microplots were placed on the east side of the line, east and west microplots on the north side. Within each microplot, canopy cover of each species was classified into seven cover classes: t (0 to 1 percent); 1 (1 to 5 percent); 2 (6 to 25 percent); 3 (26 to 50 percent); 4 (51 to 75 percent); 5 (76 to 95 percent); 6 (greater than 95 percent).

An alternative sampling approach was used for plots five through eight to be sure all common species on the plot were recorded and to reduce the time required to sample 50 microplots. Understory vegetation cover was recorded in each quadrant (NE, SE, SW, NW) of the plot (250 m^2) using the following cover classes: t (0 to 1 percent), c (1 to 5 percent), 1 (6 to 15 percent), 2 (16 to 25 percent), 3 (26 to 35 percent), 10 (greater than 95 percent) (Jensen and others 1992). Each quadrant was surveyed by ocular reconnaissance in parallel 1 m swaths for approximately 30 minutes. Species were recorded for presence and then estimated for cover to the nearest percent at the end of the reconnaissance period and recorded in the proper cover class.

Permanent photopoints were established at each plot, using the plot monuments for relocation. Photos were taken with the plot stake in the bottom center of the photo, with the photo taken in a cardinal direction (N, S, E, or W). At minimum, eight photos were taken, one photo from each of the four exterior posts toward the center of the plot, and a second photo in the opposite direction, facing away from the plot. At some of the plots, additional photos were taken from the center of the plot or in the other two cardinal directions from an outer post.

Species nomenclature follows Hitchcock and Cronquist (1973). All plants were identified to species or collected and identified later in the lab.

Plot data, including photographs, are maintained by the Natural Areas Program and by the Silviculture Research Work Unit, both located at the Intermountain Research Station in Missoula, MT.

Western Larch Forest Cover Type: Old-Growth Stands

Plot One

Plot one is in a western larch stand on a gentle (15 percent) southwest-facing slope at the low-elevation boundary of the Coram Research Natural Area (table 1; fig. 2). The canopy, about 35 m high (table 2), is dominated by 200 to 300 year old western larch and Douglas-fir and 100 to 150 year old western white pine (fig. 4). The mid canopy is 100 to 150 year old spruce

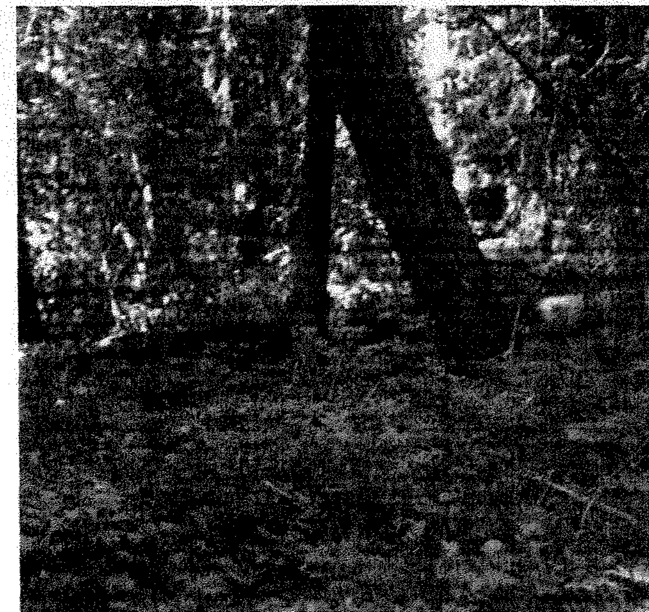

Figure 4—Plot one is located within the *Abies lasiocarpa/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase at 1,090 m elevation; trees include old-growth western larch, Douglas-fir, and western white pine; common shrubs include mountain maple and serviceberry; herbaceous understory is dominated by queencup beadlily, Hooker fairybell, and subshrub twinflower (from center toward south post).

Table 2—Plot one in the Coram Research Natrual Area. Characteristics of representative trees measured in 1990. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Abies lasiocarpa	55	21.3	20
Abies lasiocarpa	75	23.4	14
Larix occidentalis	255+	62.7	35
Larix occidentalis	283	47.7	35
Picea sp.	125	22.8	17
Pinus monticola	140	53.1	37
Pinus monticola	125	44.4	38
Pinus monticola	140	49.1	35
Pinus contorta	165	45.7	29
Pseudotsuga menziesii	113	41.6	27
Tsuga heterophylla	70	17.8	12

and lodgepole pine and 50 to 70 year old subalpine fir, western hemlock, and western white pine (table 2). The lower canopy is almost exclusively subalpine fir and spruce. The understory is relatively open except for clumps of young subalpine fir (fig. 4), possibly the result of an underburn in 1905 (Sneck 1973). Based on the understory composition and the abundance of regenerating subalpine fir and spruce, the stand classifies as a *Abies lasiocarpa/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase (Pfister and others 1977).

Trees—Larch are the largest trees in the canopy, ranging from 33 to 67 cm d.b.h., with a total basal area on the 0.1 ha plot of 1.88 m^2, (about 37 percent of the total plot basal area) (table 3). Larch are also the oldest trees on the plot, with one cored tree 283 years old (table 2). The tallest trees on the plot are western white pine. Douglas-fir is also common in the overstory, and occurs occasionally in the smaller diameter classes.

Subalpine fir and spruce represent about 43 percent of all trees on the plot in the 2.5 to 12.5 cm size classes, a clear indication of successional trend.

The presence of western white pine in nearly all diameter classes, including seedlings (table 4), suggests regular establishment. Western white pine comprises 23 percent of all the trees on the plot and about 30 percent of the total plot basal area. In the absence of white pine blister rust (*Cronartium ribicola*) and mountain pine beetle (*Dendroctonus ponderosae*), this species would likely remain an important canopy species as succession continues (Mouer 1992); seven white pine trees, however, have already died. It is likely that additional mortality caused by blister rust will occur.

Recruitment of seedlings is rare, with an average density of 0.18 seedlings per m^2 (table 4). No larch have been recruited into the stand, and only a single Douglas-fir seedling occurs in the four subplots. Four of the nine seedlings found in the four seedling subplots are subalpine fir. The remaining four are all western white pine.

Shrubs—*Spiraea betulifolia, Lonicera utahensis,* and *Vaccinium globulare* are most common in the lower shrub layer, while *Acer glabrum* and *Amelanchier alnifolia* are most common in the upper shrub layer (appendix). Total shrub cover, excluding the subshrub, *Linnaea borealis*, is about 30 percent.

Herbs—The herbaceous understory is dominated by *Clintonia uniflora, Disporum hookeri,* and the subshrub *Linnaea borealis* (appendix). Twenty-eight herbaceous species were identified within the sampled microplots on the plot. There are no species unique to plot one among the eight permanent plots sampled, but one species, *Fragaria virginiana*, is only found in this plot and plot eight.

Table 3—Plot one in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1990.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5 - 5.0	11(1)	118.3 (4.3)			4	33.3 (1.9)									15(1)	151.6
5.1 - 7.5	4	102.0 (4.3)			8	233.4 (8.5)			3(1)	101.6 (8.1)	1	22.7			16	459.7
7.6 - 12.5	9	749.4 (20.8)			10(1)	822.8 (24.5)			6(1)	501.3 (22.8)			1	110.8	26(1)	2,184.3
12.6 - 20.0	1(1)	258.6			12	2,495.9 (52.2)			3(5)	515.1 (33.0)	1	310.1	1	249.3	18(1)	3,829.0
20.1 - 30.0	2	781.8 (54.1)			2	741.5 (52.6)	1	698.5	3	1,440.2 (207.1)					8	3,662.0
30.1 - 45.0			1	874.8	2	1,537.2 (30.8)	(2)		6	6,907.5 (368.6)	2	2,339.3 (279.7)			11(2)	11,658.8
45.1 - 60.0			5	11,317.1 (463.9)			1	1,640.3	3	6,327.8 (183.8)	1	2,332.8			10	21,618.0
60.1 - 75.0			2	6,618.1 (314.5)											2	6,618.1
>75.0															0	0.0
Total	27(2)	2,010.1	8(0)	18,810.0	38(1)	5,864.1	2(2)	2,338.8	24(7)	15,793.5	5(0)	5,004.9	2(0)	360.1	106(5)	50,181.5

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Table 4—Number of seedlings by plot, species, and height class measured in 1990 on plots one, two, and four, and in 1993 on plots five through eight. Number of seedlings is for the four seedling subplots combined, a total of 50 m^2.

Species and height class	Plot 1	2	3	4	5	6	7	8
cm	---	---	---	--- *No.* ---	---	---	---	---
Abies lasiocarpa								
<5.0							5	
5.0 - 10.0	1	12		2	4			
10.0 - 30.5	1	33		1	5	1		6
30.5 - 91.0	2	3		2	1	1		5
>91.0		2		1				13
Picea sp.								
<5.0								
5.0 - 10.0								
10.0 - 30.5		1			1			
30.5 - 91.0								
>91.0		1						
Pinus monticola								
<5.0								
5.0 - 10.0	2	1						
10.0 - 30.5	1	2						
30.5 - 91.0								
>91.0	1							
Pseudotsuga menziesii								
<5.0						4	10	3
5.0 - 10.0						5	1	5
10.0 - 30.5	1				3	7	3	7
30.5 - 91.0							1	1
>91.0								
Tsuga heterophylla								
<5.0								
5.0 - 10.0								
10.0 - 30.5					1			
30.5 - 91.0					1			
>91.0				1				
Total seedlings, all species	9	55	0	7	16	18	20	40

Plot Two

Plot two is on a flat bench in the southwestern corner of the Coram Research Natural Area (table 1; fig. 2). Codominants in the 35 to 37 m high canopy are 150 to 300 year old western larch and 100 year old western white pine (table 5; fig. 5). Most larch within the stand are about 200 years old, but a few trees are in excess of 300 years. Mid and lower canopy levels are primarily subalpine fir under 70 years old and 100 to 160 year old spruce. Based on the understory composition and the abundance of recruiting subalpine fir in the lower canopy levels, the plot classifies as an *Abies lasiocarpa/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase (Pfister and others 1977).

Trees—The upper canopy of the plot is dominated by two larch (52 and 59 cm d.b.h.) and two western white pine (52 and 55 cm d.b.h.) (table 6). Larch occurs only in size classes larger than 30 cm, but western white pine occurs in nearly all size classes.

Spruce are found in all diameter classes up to 45 cm d.b.h. and comprise nearly 40 percent of the total basal area (1.56 m^2) on this plot and 36 percent of all trees. Subalpine fir is the most abundant tree, but is concentrated in the smaller diameter classes. Over half of the trees on the plot are subalpine fir in d.b.h. classes less than 20 cm. Only one 11.6 cm d.b.h. Douglas-fir occurs on the plot.

Ninety percent of the seedlings are subalpine fir (table 4), an average density of nearly one seedling per m^2. The occurrence of western white pine and spruce in nearly all d.b.h. classes, including seedlings (average density of 0.06 and 0.04 seedlings per m^2), suggests continuing establishment.

Table 5—Plot two in the Coram Research Natural Area. Characteristics of representative trees measured in 1990. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Abies lasiocarpa	60	9.6	7
Abies lasiocarpa	60	7.1	6
Abies lasiocarpa	58	12.4	9
Abies lasiocarpa	60	14.5	21
Larix occidentalis	295	60.9	37
Larix occidentalis	175	40.1	34
Picea sp.	120	28.9	26
Picea sp.	157	39.6	27
Picea sp.	131	32.2	27
Pinus contorta	120	26.1	29
Pinus monticola	93	39.8	35
Pinus monticola	111	41.6	34

Shrubs—*Amelanchier alnifolia* is the most common species in the upper shrub layer (appendix). Of note in this layer is *Taxus brevifolia*, a species that only occurs on one other plot (plot four). The lower shrub layer is dominated by *Rosa gymnocarpa, Spiraea betulifolia, Lonicera utahensis,* and *Vaccinium globulare*.

Herbs—The herbaceous layer is dominated by *Aralia nudicaulis* and *Arnica latifolia* (together totaling nearly 40 percent cover) and by the subshrubs *Linnaea borealis* (appendix). Twenty-four herbaceous species occur on the plot. Two *Lycopodium* species and a *Trifolium* species are found only on this plot.

Figure 5—Plot two is located within the *Abies lasiocarpa/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase at 1,085 m elevation; trees include old-growth western larch and western white pine in the overstory, and younger subalpine fir is abundant in the understory; common shrubs include serviceberry, wild rose, spiraea, and blue huckleberry; herbaceous understory is dominated by wild sarsaparilla, broadleaf arnica, and subshrub twinflower (from center toward west post).

Table 6—Plot two in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1990.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5 - 5.0	16	214.8 (2.9)			4(1)	48.2 (4.0)									20(1)	263.0
5.1 - 7.5	30(1)	869.3 (7.5)			10	304.2 (6.9)			1	28.7					41(1)	1,202.2
7.6 - 12.5	17(1)	1,356.2 (22.7)			13	1,101.9 (24.5)			1	62.7	1	105.7			32(1)	2,626.5
12.6 - 20.0	15(4)	2,772.2 (58.9)			11(1)	2,458.7 (48.5)			2(1)	496.2 (18.0)					28(6)	5,727.1
20.1 - 30.0	3(2)	1,222.5 (77.7)			12	6,531.1 (119.2)	1	543.3	2	766.3 (24.9)					18(2)	9,063.2
30.1 - 45.0			1	1,256.6	5	5,118.0 (309.4)	1(1)	1,472.5	2(1)	2,558.7 (56.9)					9(2)	10,405.8
45.1 - 60.0			2	6,133.5 (747.7)					2(1)	4,518.2 (152.6)					4(1)	10,651.7
60.1 - 75.0															0	0.0
>75.0																
Total	81(8)	6,435.0	3(0)	7,390.1	55(2)	15,562.1	2(1)	2,015.8	10(3)	8,430.8	1(0)	105.7	0(0)	0	152(14)	39,939.5

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Plot Four

Plot four is within a western larch cover type on a gentle (less than 5 percent) west-facing slope (table 1; fig. 3). It is the lowest elevation, the wettest and warmest of the eight plots—a *Tsuga heterophylla/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase (Pfister and others 1977). Douglas-fir, 200 plus years old, is the canopy dominant, but 300 plus year old larch, 150 to 200 year old western white pine, and a single 100 year old lodgepole pine form the 30 to 35 m high upper canopy cover (fig. 6; table 7). The mid canopy is dominated by 100 year old spruce, subalpine fir, and western hemlock.

Trees—The largest trees on the plot are five Douglas-fir over 55 cm d.b.h. (table 8). Three larch ranging from 46 to 54 cm d.b.h., are the next largest trees. Larch and Douglas-fir combined contribute nearly equally in basal area, forming nearly 60 percent of the plot basal area of 4.78 m^2. Larch occur only in the largest size classes, while Douglas-fir and western white pine can be found in nearly all classes.

Table 7—Plot four in the Coram Research Natural Area. Characteristics of representative trees measured in 1990. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Abies lasiocarpa	77	18.0	21
Abies lasiocarpa	53	11.2	18
Abies lasiocarpa	125	25.4	24
Larix occidentalis	315	37.1	34
Picea sp.	109	24.6	21
Picea sp.	119	36.5	30
Pinus monticola	145	25.4	24
Pinus monticola	170	41.1	35
Pinus contorta	103	28.7	30
Tsuga heterophylla	41	14.0	11
Tsuga heterophylla	188	46.2	29
Tsuga heterophylla	50	21.8	21

Figure 6—Plot four is located within the *Tsuga heterophylla/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase at 1,075 m elevation; trees include old-growth western larch and Douglas-fir in the overstory and younger subalpine fir, spruce, and western hemlock in the understory; common shrubs include mountain maple, serviceberry, and blue huckleberry; herbaceous understory is dominated by broadleaf arnica, western meadowrue, and beargrass (from center toward east post).

Shade-tolerant trees make up 84 percent of the conifers that are less than 26 cm d.b.h. (subalpine fir 48 percent, spruce 21 percent, western hemlock 15 percent) in comparison to 29 percent of the conifers that are more than 26 cm d.b.h. (subalpine fir 0 percent, spruce 24 percent, western hemlock 5 percent). Because western hemlock is the most shade-tolerant conifer growing on the plot, in the absence of disturbance it will eventually dominate the stand (Pfister and others 1977). Paper birch (*Betula papyrifera*) is common on the plot, with eight trees ranging from 9 to 22 cm d.b.h. and a total basal area of 0.12 m^2.

Seven seedlings occur in the four seedling subplots, approximately 0.14 seedlings per m^2 (table 4). All are subalpine fir, except for a 170 cm tall western hemlock.

Shrubs—Common species in the shrub layer include *Acer glabrum, Lonicera utahensis, Rubus parviflorus,* and *Rosa gymnocarpa* (appendix). One shrub species, *Shepherdia canadensis,* only occurs in this and one other plot.

Herbs—Twenty-one herbaceous species occur on plot four, none are unique (appendix). The most common are *Arnica latifolia, Clintonia uniflora, Aralia nudicaulis* and *Disporum hookeri*. The subshrubs *Linnaea borealis* is slightly less dominant in this plot compared to plots one and two (about 10 percent cover).

Table 8—Plot four in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1990.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5 - 5.0	8	108.8 (3.1)			3	35.4 (5.5)			2	34.7 (1.3)	1	11.0	3	32.7 (3.8)	17	222.6
5.1 - 7.5	10	309.1 (9.0)			1(1)	21.4			1	31.6			6	206.8 (7.9)	18(1)	568.9
7.6 - 12.5	13	994.8 (22.9)			6	408.8 (19.7)			(1)		1	101.5	1	78.9	21(1)	1,584.0
12.6 - 20.0	14(2)	2,583.9 (52.0)			4	692.9 (48.2)			1	220.4	2(1)	434.3 (64.8)	3	530.7 (49.5)	24(3)	4,462.2
20.1 - 30.0	1	510.7	2(1)	1,223.2 (3.9)	6	2,913.0 (130.1)	1	643.8	4	1,778.5 (41.5)			1	374.2	15(1)	7,443.4
30.1 - 45.0			6	6,488.1 (151.9)	5(1)	4,836.9 (202.4)			1	1,339.6	(1)				12(2)	12,664.6
45.1 - 60.0			3	6,096.0 (328.1)							3(2)	7,382.5 (64.3)	1	1,683.7	7(2)	15,162.2
60.1 - 75.0											2(1)	5,726.8 (30.6)			2(1)	5,726.8
>75.0															0	0.0
Total	46(2)	4,507.3	11(1)	13,807.3	25(2)	8,908.4	1(0)	643.8	9(1)	3,404.8	9(5)	13,656.1	15(0)	2,907.0	116(10)	47,834.7

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Plot Eight

Plot eight is located within the western larch cover type on a west-facing 27 percent slope near the eastern boundary of the Coram Research Natural Area (table 1; fig. 2). The canopy is an approximately equal mix of 200 year old Douglas-fir and 250 to 300 year old larch (table 9; fig. 7). The lower canopy layers are dominated by subalpine fir, with occasional Douglas-fir. Based on the understory composition and the presence of regenerating alpine fir, the plot would be classified as an *Abies lasiocarpa/Clintonia uniflora* habitat type, *Xerophyllum tenax* phase (Pfister and others 1977)—a slightly drier site than the lower elevation subalpine fir habitat types.

Table 9—Plot eight in the Coram Research Natural Area. Characteristics of representative trees measured in 1993. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Abies lasiocarpa	199	43.0	27
Pseudotsuga menziesii	187[a]	54.3	27
Larix occidentalis	300	65.5	39
Larix occidentalis	293	66.8	31
Abies lasiocarpa	126	15.8	11

[a]Missed center; extrapolated 13 more years.

Trees—About equal numbers of large (45 to 75 cm diameter) Douglas-fir and western larch occur on this plot (table 10). Douglas-fir is found within nearly every size class, but the smallest larch was larger than 20 cm. Douglas-fir and larch comprise 79 percent of the basal area on the plot.

Subalpine fir makes up only 11 percent of the plot basal area, but 60 percent of the total number of trees (table 10). Most of the subalpine fir is less than 20 cm, but one 200 year old tree is 43 cm d.b.h.. Spruce and lodgepole pine are also represented in the area. The single western white pine on the plot is dead, but live trees are scattered elsewhere in the stand.

Tree regeneration measured in the seedling plots was 60 percent subalpine fir and 40 percent Douglas-fir (table 4). Based on the successful regeneration and establishment of Douglas-fir in the seedling classes and in smaller diameter classes, it will probably continue to be a significant component of the stand. With prolonged absence of fire, however, increasing closure of the canopy and the associated shade will likely prevent continued establishment of Douglas-fir, resulting in an eventual loss from the stand. Lack of regenerating western larch suggests it too will be lost from the stand unless there is a disturbance such as fire.

Shrubs—*Acer glabrum* and *Amelanchier alnifolia* are the dominant shrubs in the upper shrub canopy, with a combined cover of approximately 30 percent (appendix). *Vaccinium globulare* is the most abundant in the lower shrub layer, with a cover of about 20 percent.

Herbs—Twenty-three herbaceous species occur in plot eight, none of them unique to the plot (appendix). Common herb species are *Arnica latifolia* and *Thalictrum occidentale*. *Xerophyllum tenax*, with about 20 percent cover, is more abundant here than on the lower elevation plots.

Table 10— Plot eight in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1993.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5 - 5.0	18	187.5 (4.6)									2	23.8 (4.4)			20	211.3
5.1 - 7.5	10	285.2 (5.9)			2	68.3 (9.8)					1	30.6			13	384.1
7.6 - 12.5	12(1)	855.0 (15.4)			1	67.0									13(1)	922.0
12.6 - 20.0	12	2,230.4 (55.4)									1	221.7			13	2,452.1
20.1 - 30.0	3	1,339.1 (156.4)	1	323.0							5	2,825.5 (91.3)			9	4,487.6
30.1 - 45.0	1	6,347.3	2	2,350.4 (197.9)			2	1,766.2 (197.9)			9(1)	8,631.7 (261.3)			14(1)	19,095.6
45.1 - 60.0			4(2)	7,382.7 (136.3)					(1)		4(1)	9,894.5 (264.9)			8(4)	17,277.2
60.1 - 75.0			3	9,892.0 (248.8)							2	7,300.6 (1,030.7)			5	17,192.6
>75.0															0	0.0
Total	56(1)	11,244.5	10(2)	19,948.1	3(0)	135.3	2(0)	1,766.2	0(1)	0	24(2)	28,928.4	0(0)	0	95(6)	62,022.5

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Figure 7—Plot eight is located within the *Abies lasiocarpa/Clintonia uniflora* habitat type, *Xerophyllum tenax* phase at 1,370 m elevation; trees include old-growth western larch and Douglas-fir in the overstory and younger subalpine fir, and occasionally Douglas-fir in the understory; common shrubs include mountain maple, serviceberry, and blue huckleberry; herbaceous understory is dominated by broadleaf arnica, western meadowrue, and beargrass (from center toward east post).

Western Larch Forest Cover Type: Young Stand

Plot Three

Plot three is just outside of the Coram Research Natural Area boundaries, but still within the Coram Experimental Forest. It was placed in the 1890 burn on a southwest-facing slope (25 percent) (table 1; fig. 2). The stand is dominated by western larch and Douglas-fir, all younger than 100 years old (table 11; fig. 8). No older trees occur on the plot. While none of the indicators can be found on the plot, adjacent vegetation outside the burn is an *Abies lasiocarpa/Clintonia uniflora/Aralia nudicaulis* habitat type (Pfister and others 1977).

Trees—Douglas-fir is dominant, with 56 percent of the total basal area of the plot (table 12). Western larch is the most abundant, 70 percent of all trees. Ages of larch and larger fir are similar, 80 to 100 years old (table 11), but larch are slower growing, with no trees over 18.4 cm d.b.h. Five Douglas-fir trees are larger than 26 cm d.b.h., the largest 37.9 cm. Total basal area in plot three is the smallest among the eight sampled plots, only 1.81 m^2, less than two-thirds the total of next smallest total (plot five). Unique to plot three is the complete lack of dead trees.

The only other common tree on the plot is paper birch, with 18 trees between 4 and 13 cm d.b.h. and a basal area total of 1.14 m^2.

Table 11—Plot three in the Coram Research Natural Area. Characteristics of representative trees measured in 1990. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Larix occidentalis	80	17.0	24
Larix occidentalis	72	5.6	30
Pseudotsuga menziesii	80	17.3	17
Pseudotsuga menziesii	80	15.0	17
Pseudotsuga menziesii	79	38.1	29
Pseudotsuga menziesii	80	37.1	30

Most of the larch and Douglas-fir are likely of similar age. Smaller trees are suppressed, not young (table 11), suggesting little recruitment. No seedlings occur on any of the seedling subplots (table 4), but a single spruce sapling 3.25 cm d.b.h. (table 12) foreshadows the successional fate of the stand displayed in older stands (plots one, two, four, and eight).

Shrubs—The upper shrub layer is dominated by *Acer glabrum*, with approximately 30 percent cover (appendix). *Linnaea borealis, Spiraea betulifolia*, and *Symphoricarpos albus* each provides approximately 20 percent.

Herbs—Only eight herbaceous species are found on plot three, much less than the 20 or more species found in older stands of this cover type in the Coram Research Natural Area (appendix). All herbaceous species occur as traces of 1 percent cover or less. Common species found in older stands, such as *Aralia nudicaulis, Clintonia uniflora*, and *Arnica latifolia*, are absent from plot three.

Figure 8—Plot three is located within the *Abies lasiocarpa/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase at 1,115 m elevation; trees include western larch, Douglas-fir, and paper birch; common shrubs include mountain maple in the overstory and twinflower, spiraea, and snowberry; herbaceous understory is composed of Hooker fairybell, woods strawberry, and western meadowrue (from center toward east post).

Table 12—Plot three in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1990.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5 - 5.0			4	60.7 (4.6)	1						5	68.9			10	138.1
5.1 - 7.5			33	1,051.5 (7.1)							2	72.1			35	1,123.6
7.6 - 12.5			42	3,525.8 (19.2)							9	767.8			51	4,293.6
12.6 - 20.0			18	3,302.7 (44.6)							16	3,392.3			34	6,695.0
20.1 - 30.0											8	3,707.2			8	3,707.2
30.1 - 45.0											2	2,203.3			2	2,203.3
45.1 - 60.0															0	0.0
60.1 - 75.0															0	0.0
>75.0															0	0.0
Total	0(0)	0	97(0)	7,940.7	1(0)	0	0(0)	0	0(0)	0	42(0)	10,211.6	0(0)	0	140(0)	18,160.8

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Spruce–Subalpine Fir Forest Cover Type

Plot Five

Plot five is located on a moist west-facing 23 percent slope in a stand of 130 to 200 year old spruce (table 1; fig. 2). The canopy is comprised of a single 300 year old larch, 10 spruce, and three Douglas-fir (table 13; fig. 9). The middle and lower canopies are a mix of subalpine fir and spruce. Based on the understory species and the abundance of subalpine fir, the habitat type for the plot is *Abies lasiocarpa/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase (Pfister and others 1977).

Trees—Nearly 40 percent of all trees are spruce, occurring in all but the largest two diameter classes (table 14). About 63 percent of the plot basal area is provided by spruce (1.92 m^2). The largest tree on the plot is a 267 year old larch, with a d.b.h. of 69.7 cm and a height of 44 m, contributing about 13 percent of the total basal area of the plot. This is the only larch occurring on the plot, although larch occurs in up to 30 percent canopy cover in some parts of this stand.

Other canopy species include Douglas-fir and paper birch. Ten paper birch, ranging in d.b.h. from 12 to 55 cm, contribute a basal area of 0.82 m^2 within the plot. Douglas-fir occurs in nearly all size classes, with the largest tree 48.5 cm d.b.h. Half of all plot trees are subalpine fir. Except for one 32 cm d.b.h. tree, nearly all of the subalpine fir are under 13 cm d.b.h.

Seedling composition is 63 percent subalpine fir, 19 percent Douglas-fir, 13 percent western hemlock, and 5 percent spruce (table 4). Most of the seedlings range from 6 to 30 cm. The tallest seedling is a 70 cm tall western hemlock.

Table 13—Plot five in the Coram Research Natural Area. Characteristics of representative trees measured in 1993. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Abies lasiocarpa	57	12.5	16
Larix occidentalis	274	69.7	44
Picea sp.	140	18.0	20
Picea sp.	78	26.4	23
Picea sp.	146	44.0	37
Picea sp.	191	54.6	27
Pseudotsuga menziesii	139	48.5	30

Figure 9—Plot five is located within the *Abies lasiocarpa/Clintonia uniflora* habitat type, *Aralia nudicaulis* phase at 1,100 m elevation; trees are mostly spruce with a few old-growth western larch in the overstory and subalpine fir and Douglas-fir; common shrubs include mountain maple, serviceberry, Utah honeysuckle, and snowberry; herbaceous understory is dominated by broadleaf arnica, wild sarsaparilla, and Hooker fairybell (from center toward east post).

Shrubs—Shrub cover is primarily *Acer glabrum*, with *Amelanchier alnifolia, Lonicera utahensis*, and *Symphoricarpos albus* also common (appendix). Subshrubs, such as *Linnaea borealis* and *Chimaphila umbellata*, provide up to 10 percent cover. One shrub, *Ribes lacustre*, only occurs on this plot and is indicative of the moist conditions.

Herbs—The most common herbaceous species are *Arnica latifolia, Aralia nudicaulis*, and *Disporum hookeri*, each with about 20 percent cover (appendix). This plot has the highest diversity of species—49 in all—of which 17 occur only on this plot. Several of these, such as *Scirpus microcarpus, Glyceria elata, Lycopus asper*, and *Senecio triangularis*, are indicative of the wet conditions found at the west end of the plot.

Table 14—Plot five in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1993.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5-5.0	8(1)	108.4 (6.0)			1(1)	5.3					1	5.4			10(2)	119.1
5.1-7.5	7	200.1 (7.8)			1	32.1					1	22.7			9	254.9
7.6-12.5	10(1)	655.4 (21.7)			3	247.1 (28.4)					1(1)	100.2			14(2)	1,002.7
12.6-20.0	5	926.1 (83.0)			7(2)	1,177.2 (51.9)					(1)				12(3)	2,103.3
20.1-30.0	2	781.8 (54.1)			4(1)	1,844.4 (84.4)					(1)				6(2)	2,626.2
30.1-45.0	1	800.7			5	5,474.6 (284.0)					2	2,491.3 (181.6)			8	8,766.6
45.1-60.0					5	10,403.1 (341.1)					1	1,849.6			6	12,252.7
60.1-75.0			1	3,817.8											1	3,817.8
>75.0															0	0.0
Total	33(2)	3,472.5	1(0)	3,817.8	26(4)	19,183.8	0(0)	0	0(0)	0	6(3)	4,469.2	0(0)	0	66(9)	30,943.3

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Interior Douglas-fir Forest Cover Type

Plot Six

Plot six is above an ephemeral drainage on a 49 percent southwest-facing slope (table 1; fig. 2). The upper canopy is dominated by a mix of 300 year old Douglas-fir and larch (table 15; fig. 10). Douglas-fir is the most common species in the lower and middle canopies as well. Based on the presence of regenerating Douglas-fir, the lack of healthy subalpine fir, and understory components, the habitat type is a *Psuedotsuga menziesii/Linnaea borealis* habitat type, *Symphoricarpos albus* phase (Pfister and others 1977).

Trees—The largest tree on the plot is a Douglas-fir, with a d.b.h. of 75 cm (table 16). Total plot basal area for Douglas-fir is 3.43 m^2, about 80 percent of the total plot basal area for all species. Douglas-fir is the most common species on the plot, comprising 83 percent of the conifers and spanning all size classes. The other species on the plot are four canopy larch, two spruce, and two lodgepole pine. Subalpine fir is present, but limited to two low-vigor small trees.

Douglas-fir also dominates seedling class (table 4). Of 18 seedlings occurring in the four seedling subplots, 16 are Douglas-fir and two are subalpine fir.

Table 15—Plot six in the Coram Research Natural Area. Characteristics of representative trees measured in 1993. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Larix occidentalis	328	47.5	38
Pseudotsuga menziesii	122	22.6	18
Pseudotsuga menziesii	111	32.5	22
Pseudotsuga menziesii	134	38.8	28
Pseudotsuga menziesii	317	51.0	31

Shrubs—Common shrub species are *Acer glabrum, Symphoricarpos albus,* and *Amelanchier alnifolia* (appendix). Subshrub cover, including species such as *Linnaea borealis* and *Chimaphila umbellata*, is about 15 percent.

Herbs—*Disporum hookeri* is the most common herbaceous species, with a cover of approximately 20 percent (appendix). Other common forb species include *Adenocaulon bicolor, Thalictrum occidentale,* and *Clintonia uniflora. Calamagrostis rubescens* is a common graminoid, with a cover of about 20 percent, much more abundant than on other plots.

Figure 10—Plot six is located within the *Pseudotsuga menziesii/Linnaea borealis* habitat type, *Symphoricarpos albus* phase at 1,190 m elevation; trees include old-growth Douglas-fir and western larch in the overstory and mostly Douglas-fir in smaller size classes; common shrubs include mountain maple, snowberry, serviceberry, twinflower, and prince's pine; herbaceous understory is dominated by Hooker fairybell, western meadowrue, trail plant, queen cup beadlily, and pinegrass (from center toward east post).

Table 16—Plot six in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1993.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5-5.0	1	15.0									2	23.0 (7.1)			3	38.0
5.1-7.5	1	31.4									1	37.2			2	68.6
7.6-12.5					2	177.6 (46.2)					7(1)	684.6 (28.1)			9(1)	862.2
12.6-20.0											10(1)	2,351.2 (48.2)			10(1)	2,351.2
20.1-30.0							2	1,068.1 (191.2)			12(1)	6,012.2 (136.8)			14(1)	7,080.3
30.1-45.0			1	1,519.5							8	8,600.7 (255.0)			9	10,120.2
45.1-60.0			3	6,640.9 (404.1)							5	8,724.3 (170.8)			8	15,365.2
60.1-75.0											2	7,869.9 (653.4)			2	7,869.9
>75.0															0	0.0
Total	2(0)	46.4	4(0)	8,160.4	2(0)	177.6	2(0)	1,068.1	0(0)	0	47(3)	34,303.1	0(0)	0	57(3)	43,755.6

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Plot Seven

Plot seven is near the eastern boundary of the Coram Research Natural Area in the SAF interior Douglas-fir cover type (table 1; fig. 2). The plot is positioned on a 22 percent southwest-facing slope about 40 m below Emery Ridge. The upper canopy is 200 year old Douglas-fir (table 17; fig. 11). Douglas-fir also dominates the mid canopy, but subalpine fir is the most common in the lower canopy. Based on the presence of this regenerating alpine fir, the plot is classified as an *Abies lasiocarpa/Clintonia uniflora* habitat type, *Xerophyllum tenax* phase (Pfister and others 1977).

Trees—The plot is dominated by larch–Douglas-fir; all remaining tree species on the plot are 24 cm d.b.h. or less except for a single 39 cm d.b.h. lodgepole pine (table 18). Most of the plot basal area, 81 percent, is Douglas-fir (3.81 m^2), and the largest tree on the plot is a 61 cm d.b.h. Douglas-fir. Subalpine fir is the most abundant species, comprising 73 of the 122 live trees on the plot (60 percent). The stand in which this plot is located is composed primarily of Douglas-fir and subalpine fir, with a minor component of lodgepole pine and spruce. Western larch is absent from the plot, although it occurs with up to 10 percent cover within the stand.

Plot seven has the highest number of dead trees compared to the other seven plots (17 trees within the 0.1 ha plot). About half of these are small subalpine fir; the remaining are Douglas-fir, distributed among five diameter classes. Seedling recruitment is 75 percent Douglas-fir (about 0.3 seedlings per m^2 averaged over the four subplots) and 25 percent subalpine fir (table 4). Four of the subalpine fir seedlings occur in a single plot, and none are over 5 cm tall. Most seedlings of both species in the four subplots occur on nurse logs.

Figure 11—Plot seven is located within the *Abies lasiocarpa/Clintonia uniflora* habitat type, *Xerophyllum tenax* phase at 1,355 m elevation; Douglas-fir is in upper and mid-canopy, but subalpine fir predominates in the understory; common shrubs include blue huckleberry, mountain maple, serviceberry, ninebark, and Utah honeysuckle; herbaceous understory is mostly beargrass and broadleaf arnica (from center toward west post).

Table 17—Plot seven in the Coram Research Natural Area. Characteristics of representative trees measured in 1993. Age is based on ring counts of cores at d.b.h.

Species	Age	D.b.h.	Height
	Year	*cm*	*m*
Pseudotsuga menziesii	201	42.6	27
Abies lasiocarpa	85	18.3	11
Pseudotsuga menziesii	174	50.2	26
Pseudotsuga menziesii	229[a]	42.8	26
Pseudotsuga menziesii	210	31.5	22

[a]Missed center; extrapolated 7 additional years to measured years.

Shrubs—Common shrub species are *Acer glabrum, Lonicera utahensis, Rosa gymnocarpa,* and *Amelanchier alnifolia* (appendix). *Vaccinium globulare* is abundant, with a cover of approximately 20 percent. *Physocarpus malvaceus*, which only occurs on this and plot three, is indicative of the slightly drier conditions on this site.

Herbs—*Xerophyllum tenax*, with a cover of 30 percent, is more abundant on this plot than on any other. Other herbaceous species occur in trace amounts, except for *Arnica latifolia*, with a cover value of 3 percent (appendix).

Table 18—Plot seven in the Coram Research Natural Area. Number of live and dead trees and total basal area (cm^2) of live trees by species and d.b.h. class (cm) measured in 1993.

	ABLA		LAOC		PIEN		PICO		PIMO		PSME		TSHE		Total	
Diameter class	Live (dead)	Basal area (s.d.)[a]	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)	Live (dead)	Basal area (s.d.)
cm																
2.5-5.0	10(3)	127.9 (4.0)													10(3)	127.9
5.1-7.5	12(1)	344.8 (7.2)									(1)				12(2)	344.8
7.6-12.5	29(4)	2,205.7 (23.0)			1	76.6					2(1)	284.3 (18.8)			32(5)	2,566.6
12.6-20.0	19(1)	3,739.5 (63.6)									8	1,824.3 (49.9)			27(1)	5,563.8
20.1-30.0	3	1,244.2 (30.1)									14(2)	7,085.5 (119.9)			17(2)	8,329.7
30.1-45.0							1	1,220.2			19(4)	20,007.0 (263.4)			20(4)	21,227.0
45.1-60.0											3	6,092.5 (111.8)			3	6,092.5
60.1-75.0											1	2,892.4			1	2,892.4
>75.0															0	0.0
Total	73(9)	7,662.1	0(0)	0	1(0)	76.6	1(0)	1,220.2	0(0)	0	47(8)	38,186.0	0(0)	0	122(17)	47,145.0

[a]Standard deviation of the average basal area is included as a measure of the variability of trees within each class.

Discussion

In 1992, Region 1 of the Forest Service published a guide to "Old-Growth Forest Types of the Northern Region" (Green and others 1992). Based on timber stand exam plots, minimum and average characteristics of stands of 150 years or older (for most habitat types) were presented. Table 19 compares data from the eight Coram Research Natural Area plots to these standards.

All stands except for plot three, placed within a young forest burned in 1890, classify as old growth based on age alone. For most plots, the number of trees exceeding the minimum large tree standard are more than the minimum number given in the guide. The exception is plot seven.

All old-growth plots except plot six also contain many more snags than the range measured in the timber stand exam plots. Numbers of snags found in

Table 19—Comparison of tree age and number of live trees and snags per hectare on permanent plots in the Coram Research Natural Area, measured in 1990 (plots one through four) and 1993 (plots five through eight), with minimum standards set for old-growth forest types by the Northern Region, Forest Service (Green and others 1992) on comparable sites.

	Age		Number of trees[a]		Number of snags[b]	
Plot	Plot	Minimum standards	Plot	Minimum standards	Plot	Range
			- - - - - - - - *ha*	- - - - - - - -		
One	200+	150	50	25	20	2.5-7.5
Two	200+	150	30	25	40	2.5-7.5
Three	100	150	0	25	0	2.5-7.5
Four	200+	150	50	25	60	2.5-7.5
Five	240+	150	30	25	10	2.5-7.5
Six	300+	150	40	20	10	0.0-17.5
Seven	200+	150	10	25	60	2.5-7.5
Eight	200+	150	80	25	50	2.5-7.5

[a]The standard is the number of trees >53 cm d.b.h. per hectare.
[b]Snags are defined as standing dead trees of >23 cm d.b.h. This characteristic is not used as a minimum criteria, but is given as the range of occurrence within the data set used by Green and others (1992).

the Coram Research Natural Area plots range to 60 snags per ha, compared to the average range in the stand exam plots of 2.5 to 7.5 snags per ha.

Differences in old-growth characteristics of the Research Natural Area compared to the regional guide are most likely explained by the advanced age of the Coram Research Natural Area stands, which are 200 years old or more. Characteristics identified by the regional guide are based on the average of hundreds of stands located throughout northern Idaho and Montana, many of which are less than 200 years old.

The old-growth stands in the Research Natural Area are more structurally diverse than expected. Most of the large larch and a few of the Douglas-fir occurring on the plots appear to have originated approximately 300 years ago, suggesting a stand-replacing fire. Some of the white pine and many of the large Douglas-fir appear to have originated around 1800, suggesting a fairly severe fire that killed many of the western larch and Douglas-fir that had originated with the previous fire. Between 1800 and 1900, the establishment of lodgepole pine and western white pine suggests some ground fire with occasional canopy opening. Since 1900, however, there has been an absence of fire, allowing the establishment of shade-tolerant subalpine fir and spruce.

The size class distribution of conifer species on most of the plots indicates that the old-growth stands are undergoing rapid structural and compositional change. In the absence of fire, stands featuring fire-dependent seral old growth will become gradually more dominated by shade-tolerant species, primarily subalpine fir, and more prone to catastrophic, stand-replacing fire. This natural change presents a challenge to managers. The Coram Research Natural Area was established to protect examples of old-growth western larch and Douglas-fir within the Research Natural Area system on Region 1 Forest Service lands (Wellner 1988). Managers have two options: (1) take management action to maintain the elements for which this area was designated through the use of prescribed fire, or (2) allow successional changes to occur without intervention. If the latter choice is made, managers also must decide whether natural fires will be suppressed or allowed to burn within the natural area.

Both the intervention approach and the nonintervention approach will require a re-evaluation of objectives for management within the Research Natural Area because the current objectives of allowing natural processes to occur and maintaining stands of old growth are conflicting in the face of successional processes and the risk of catastrophic fire.

Western larch and Douglas-fir stands can be maintained by prescribed fire (Kilgore and Curtis 1987). Underburning kills the fire-sensitive subalpine fir (Fischer and Bradley 1987), but most mature Douglas-fir and western larch survive and thrive under post-underburn conditions (Reinhardt and Ryan 1988). In stands where shade-tolerant species are tall, or their densities high, potentially creating ladder fuels, large individuals of the species targeted for elimination may need to be manually cut and removed (Arno, personal communication). Such ladder-fuel conditions are common in the Coram Research Natural Area, thus prescribed burning would require intensive management actions (Norum 1977).

Without management intervention, the objective for which the research natural area was designated (preserving examples of old-growth western larch and Douglas-fir stands) will not be met. In the absence of prescribed burning, shade-tolerant species will continue to increase, resulting in a gradual loss of the desired component as old trees die. If succession is interrupted by a natural fire, there is a risk that it may be stand replacing rather than remaining a nonlethal underburn because of the current and projected stand structure. Although this would initiate recruitment of larch and Douglas-fir, the old trees for which the Coram Research Natural Area was designated would be lost.

At the root of this difficult management decision is the function of natural areas and the definition of natural. Traditionally, natural areas are managed with a minimum of human intervention. Ecologists and managers are increasingly acknowledging that such areas are not representative of purely natural conditions because they are affected by human activities (such as fire suppression) that occur outside area boundaries (Shrader-Frechette and McCoy 1995). Maintaining fire-dependent old growth will require management intervention, such as the use of prescribed fire. But questions remain. Is this stand structure the natural state? Is the hands-off approach allowing processes of succession and potential stand-replacing fire to occur natural for the Coram Research Natural Area? Is the use of underburning natural, even if it requires cutting and removal of shade-tolerant species?

Complicating the issue is the uncertainty of how human fire suppression has altered the natural fire regime. According to Sneck (1977), the number and size of fires in the Coram Experimental Forest has not dramatically changed in the last century, and has actually increased slightly since the initiation of fire suppression. In similar moist forests in Glacier National Park, Barrett and others (1991) concluded that fire suppression had not produced an alteration in the natural fire regime. Fire frequency on drier sites, however, dramatically declined after 1935 (Barrett and others 1991; Lunan and Habeck 1973). These sites are primarily lodgepole and ponderosa pine forests that classify as a Douglas-fir habitat type (Pfister and others 1977).

Fire is natural in western larch/Douglas-fir stands, but succession is also natural in the absence of fire. Introducing fire through prescribed burning, and arresting or reversing succession would require intensive activity, including cutting and removing ladder fuels. Is such human management intervention acceptable in research natural areas? Should the elements for which research natural areas are designated be maintained, even if requiring intensive management, or should human's influence be minimal and changes simply allowed to take place? For the Coram Research Natural Area, the question must be explicitly framed and answered because the lack of a decision is a decision to allow the gradual replacement of the western larch and most Douglas-fir stands and may set the stage for future stand-replacing fire.

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Appendix: Understory Flora of the Old-Growth Forests of the Coram Research Natural Area

Cover classes (aerial cover) of forbs, graminoids, vines, and woody species for each plot at the Coram Research Natural Area. Codes are t = trace (less than 1 percent), c = common (1 to 5 percent), 1 = 6 to 15 percent, 2 = 16 to 25 percent, 3 = 26 to 35 percent.

Species	Plot 1	2	3	4	5	6	7	8	Plots containing the species
	Cover classes								*Percent*
Forbs									
Adenocaulon bicolor	c			t	t	t	t	t	75
Angelica arguta					t				13
Aralia nudicaulis	c	2		c	2	t			63
Arnica latifolia	t	2		2	2		c	c	75
Asarum caudatum					t				13
Aster conspicuus			t	t	t	t	t	t	75
Astragalus canadensis					t				13
Athyrium felix-femina					t				13
Clintonia uniflora	1	1		1	c	c	t	t	88
Corallorhiza maculata		t			t	t			38
Disporum hookeri	1	t	t	1	2	2	t	t	100
Epilobium glandulosum					t				13
Equisetum arvense					t				13
Fragaria vesca	t		t	t	t	c	t		75
Fragaria virginiana	c							t	25
Galium triflorum		t		t	t	t			50
Geum macrophyllum					t				13
Goodyera oblongifolia	t	t	t	t	t	t	t	t	100
Habenaria orbiculata					t	t			25
Hieracium albiflorum	t	t	t		t	t	t	t	88
Listera caurina		t			t				25
Lycopus asper					t				13
Mitella stauropetela					t				13
Monotropa uniflora	t				t		t	t	50
Osmorhiza chilensis	t	c	t	t	t	t	t	t	100
Pedicularis racemosa	t			t	t	t	t	t	75
Prunella vulgaris					t				13
Pteridium aquilinum	t	c			t				38
Pyrola asarifolia	t	t		t	t				50
Pyrola secunda	t	t		t	t	t	t	t	88
Rannunculus sp.					t				13
Sanicula marilandica					t				13
Senecio pseudaureus					t				13
Senecio triangularis					t				13
Smilacina racemosa						t	t	t	38
Smilacina stellata	c	c		c	t	t		t	75
Thalictrum occidentale	t	t	t	t	t	c	t	c	100
Tiarella trifoliata	t	1		t	t				50
Trifolium sp.		t							13
Trillium ovatum	t				t	t			38
Veratrum californicum	t				t				25
Viola orbiculata	t	t		t	t	t	t	t	88

Species	Plot 1	2	3	4	5	6	7	8	Plots containing the species
	Cover classes								Percent
Graminoids									
Agrostis alba					t				13
Bromus vulgaris	t				t	t	t	t	63
Calamagrostis rubescens					t	2	t	t	50
Carex geyerii							1	t	25
Carex sp.	t					t		t	38
Elymus glaucus					t			t	25
Festuca occidentalis					t		t	t	38
Glyceria elata					t				13
Melica subulata	t	t		t					38
Scirpus microcarpus					t				13
Xerophyllum tenax	t	t		t	1	t	3	2	88
Subshrubs and vines									
Berberis repens	t		1	c	c	t	t	c	88
Chimaphila umbellata	c	t	t	t	c	t	t	t	100
Clematis sp.					t	t			25
Cornus canadensis	c	c		c	c				50
Linnaea borealis	2	2	2	1	c	1	c	c	100
Lycopodium complanatum		t							13
Lycopodium annotinum		t							13
Pachistima myrsinites	t	t	t	t	t	t	t	t	100
Shrubs									
Acer glabrum	c		3	1	2	2	1	2	88
Alnus sinuata					t			t	25
Amelanchier alnifolia	c	t	c	c	c	1	c	1	100
Cornus stolonifera				t	t				25
Holodiscus discolor	t	t		t		t		c	63
Juniperus communis			t						13
Lonicera utahensis	1	c		1	t	t	c	t	88
Menziesia ferruginea		t		t	t			t	50
Physocarpus malvaceus			c				c		25
Ribes lacustre					t				13
Ribes viscossisimum	t								13
Rosa gymnocarpa	1	c	1	c	c	c	c	c	100
Rosa sp.								t	13
Rubus parviflorus	c	t		c	t	t	t	t	88
Shepherdia canadensis				t					13
Sorbus scopulina	t					t			25
Spiraea betulifolia	c	c	2	c	t	2	t	t	100
Symphoricarpos albus	t		2	t	c	2	t		75
Taxus brevifolia		t		t					25
Vaccinium cespitosum					t				13
Vaccinium globulare	c	c		c	t	t	2	2	88
Vaccinium scoparium		t							13
Total number of species occurring in the plot	41	36	18	37	66	38	33	38	

Elzinga, Caryl L.; Shearer, Raymond C. 1997. Vegetation structure in old-growth stands in the Coram Research Natural Area in northwestern Montana. Gen. Tech. Rep. INT-GTR-364. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 22 p.

Forest stand structure, understory composition, and tree seedling composition are described for eight permanent tenth-hectare plots established in Engelmann spruce/subalpine fir, western larch, and interior Douglas-fir forest cover types in northwestern Montana. Sites have been protected as examples of old-growth stands since the establishment of the Coram Research Natural Area in 1937. Plot data clearly illustrate a successional trend toward shade-tolerant conifers, placing old-growth stands at risk of loss from succession or catastrophic fire. Management issues associated with use of prescribed fire to maintain old-growth characteristics in natural areas are discussed.

Keywords: research natural area, vegetation structure, old growth, western larch, Douglas-fir

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

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