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Understory Plant Diversity in Riparian Alder-Conifer Stands After Logging in Southeast Alaska

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Abstract

Stand structure, tree height growth, and understory plant diversity were assessed in five mixed alder-conifer stands after logging in southeast Alaska. Tree species composition ranged from 7- to 91-percent alder, and basal area ranged from 30 to 55 m^2/ha. The alder exhibited rapid early height growth, but recent growth has slowed considerably. Some conifers have been suppressed, but some spruce are now nearly as tall as the overstory alders. The four stands with the most alder had high species richness of shrubs, herbs, ferns, and mosses, but the predominantly spruce stand had slightly fewer species of shrubs and ferns, and considerably fewer herbs. Mixed alder-conifer stands have maintained species-rich understories for 45 years after logging, and stands with conifers and alders of relatively equal stocking contained the largest diameter conifers. Riparian alder-conifer stands maintain plant diversity and also will provide some large-diameter conifers for large woody debris for streams.

Keywords: Riparian stands, understory plant diversity, southeast Alaska, red alder, Sitka spruce, large woody debris, stand structure.

Introduction

In southeast Alaska, new stands of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) develop in clearly defined stages (Alaback 1982, Deal and others 1991). After disturbances such as extensive windthrow or clearcut logging, natural regeneration is rapidly established. Both species are prolific seed producers (Harris 1967, 1969), and conifer regeneration is often overabundant after logging (Harris 1967, Harris and Farr 1974). The forest canopy closes when stands are 20 to 30 years old. These dense young-growth stands then enter an intense and long-lasting (50 to 100 or more years) stem-exclusion stage (Oliver and Larson 1990) that shades out virtually all understory vegetation (Alaback 1982).

Maintaining biodiversity in young stands established after clearcutting is a challenge to foresters and wildlife biologists. Efforts to maintain or reintroduce understory vegetation for wildlife forage have been mostly unsuccessful (USDA Forest Service 1991). Thinning of stands either releases advance hemlock regeneration or promotes new conifer regeneration (Deal and Farr 1994) to the general exclusion of other vegetation. Ongoing research on ways to maintain biodiversity after logging, such as alternatives to clearcutting (USDA Forest Service 1994), may prove useful, but current information on stand structures that provide understory plant diversity after logging would be extremely valuable for managers.

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Sitka spruce and red alder (*Alnus rubra* Bong.) are common associates in southeast Alaska riparian forests. Red alder may be beneficial in riparian areas after logging by increasing soil nitrogen through nitrogen fixation and providing greater stand structural diversity than pure conifer stands. Alder, however, is a relatively small-diameter tree that decomposes rapidly in streams and generally is considered inadequate to provide the large woody debris needed for anadromous fish habitat (Bisson and others 1987). Sitka spruce is common in riparian areas, but managers are concerned about whether it can compete with alder and produce large-diameter trees soon enough to provide large woody debris for streams. The objective of this study was to assess stand structures, tree growth rates, and understory plant diversity of mixed alder-conifer stands to provide information for managers who are interested in improving riparian areas for anadromous fish and wildlife habitat.

Study Area

Study sites were located in the coastal hemlock/spruce zone of southeast Alaska. This region is characterized by rugged, thickly forested islands, cool temperatures, and substantial precipitation throughout the year (Harris and others 1974). The research area was along lower Noxon Creek on Baranof Island, about 25 km north of Sitka, Alaska. Noxon Creek has a total stream length of about 20 km and drains a watershed of nearly 2600 ha. The river terrace slopes are less than 5 percent, and soils are well drained. Much of the lower 9 km of the stream was tractor logged in the mid-1940s and again in the mid-1960s (Bryant and others 1992). The former stands, before logging, were moderately productive, with timber harvest averaging about 4.0 m^3/ha. Information on species composition of former stands is unknown; however, new stands have various mixtures of red alder, Sitka spruce, and western hemlock.

Methods

During August 1992, five 0.05-ha plots were established in riparian stands along the river terrace of lower Noxon Creek. Stands were selected to encompass the range of tree species composition from predominantly red alder to various alder-conifer mixtures to mostly Sitka spruce. Stands were naturally regenerated, unthinned, and free of alder girdling. A 20- by 25-m plot was established within each stand, beginning at the forest edge of Noxon Creek and extending 20 m deep into the stand.

Tree species and crown class were identified, and diameter at breast height (d.b.h.; 1.3 m) was measured for all trees with d.b.h. greater than 5 cm. Total tree height and height to live crown were measured for 15 to 20 trees per plot, selected at random from across the range of tree diameters. Increment cores were taken at breast height from all trees measured for height and were used to determine tree age and diameter growth. Tree ages were taken from all plots, and tree heights were measured from all plots except plot 4. The four largest diameter trees (two alders and two spruces per plot) were selected for destructive sampling to reconstruct height growth.

Within each plot, 20 understory vegetation subplots were installed within a grid, with four parallel transects each with five sampling points placed at 5-m intervals. Tree seedlings, shrubs, herbs, ferns, mosses, lichens, and liverworts were identified to species on each subplot. A 1- by 1-m frame graduated every 0.1 m was used to demarcate the subplot, and cover class for each plant species was visually estimated.

Table 1—Overstory stand structure and understory species richness for 5 stands at Noxon Creek

		Overstory stand													
		Trees			Basal area			Largest trees (top 40/ha)				Understory plants			
Stand	Age[a]	Alder	Spruce	Hemlock	Alder	Spruce	Hemlock	Alder d.b.h.	Spuce d.b.h.	Alder height	Spruce height	Shrubs	Herbs	Ferns	Mosses[b]
		No. of stems/ha			*m²/ha*			*Mm*	*Mm*	*m*	*m*	*No. of species*			
1	45	820	60	20	32.98	0.53	3.41	448	123	24.1	7.6	4	17	5	8
2	45	560	160	20	27.46	1.63	.37	404	156	21.8	11.3	3	16	4	7
3	45	400	340	180	17.26	19.11	2.60	370	524	21.4	15.8	7	17	5	9
4	45	280	760	180	17.58	24.97	1.84	403	488	—	—	6	12	5	10
5	26	260	2,960	660	5.67	43.33	6.24	209	251	15.0	18.0	3	6	3	9

[a] Stand age is breast height (1.3 m) age.
[b] Includes all mosses, lichens, and liverworts.

Results

Overstory Stand

Stand composition and structure varied greatly among stands. Species composition (stems/ha) ranged from 7 to 91 percent alder, and most conifers were spruce (table 1). The basal areas of stands 1 and 2 were 89 to 93 percent alder, stands 3 and 4 were 40 to 44 percent alder, and stand 5 was 10 percent alder. The first four stands (alder stands) were all 45 years old and were lightly stocked with only about 30 to 45 m^2/ha. Stand 5 (spruce stand), although only 26 years old, had a basal area of over 55 m^2/ha and was heavily stocked with small spruce and hemlock.

In stands of the same age (stands 1-4), the heights and diameters of the largest alders were similar, but the size of the largest spruces differed greatly (table 1). The diameters of the largest alders ranged from 37.0 to 44.8 cm, and the height of the tallest trees ranged from 21.4 to 24.1 m. Conversely, the diameters of the largest spruces ranged from 12.3 to 52.4 cm, and the height of the tallest trees ranged from 7.6 to 15.8 m. The tallest alders in these stands were consistently taller than the tallest spruces. The largest diameter trees were usually alder; however, the largest trees found in stands 3 and 4 were spruce. The spruce stand was a young, dense, mostly conifer stand, and dominant trees were all about the same diameter and height.

Spruce and alder in the alder stands had very different height growth patterns. The alder exhibited rapid early height growth and were about 4 to 6 m tall at age 10, 10 to 15 m tall at age 30, and 17 to 21 m tall at age 45 (fig. 1). Alder height growth has slowed considerably during the last 15 years. The spruce showed variable height growth. Some spruce were suppressed and only 1 to 3 m tall. Some of the larger spruce have shown steady growth and are now nearly as tall as the overstory alders (fig. 1).

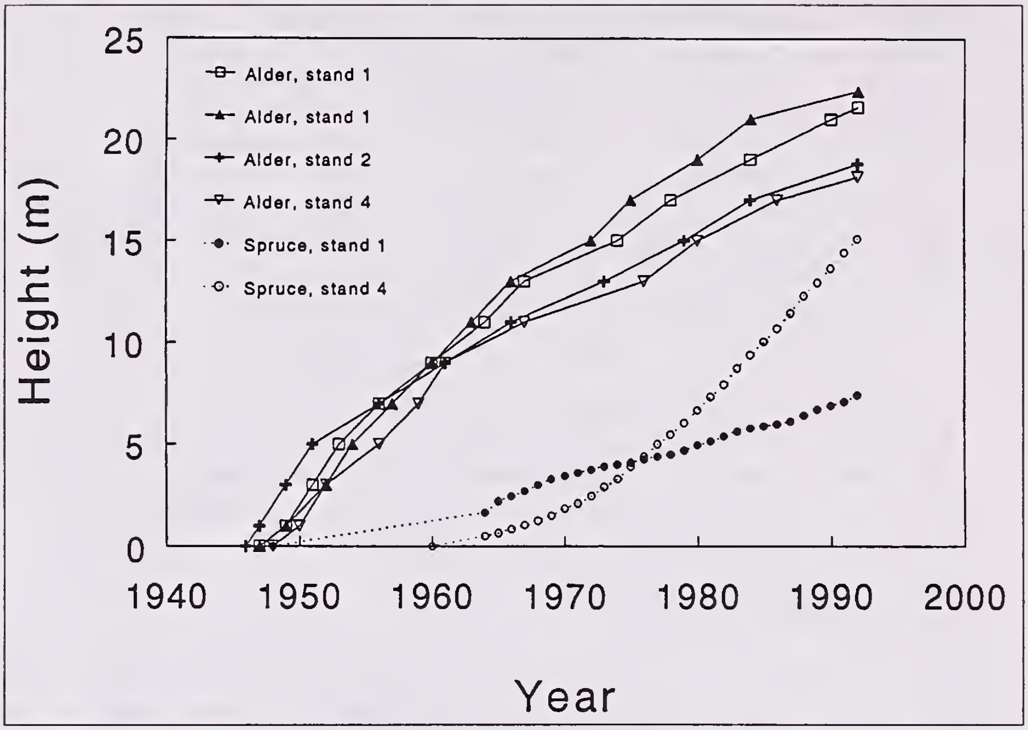

Figure 1— Reconstructed height growth patterns for destructively sampled alder and spruce trees found in the alder stands (stands 1-4) at Noxon Creek.

Understory Plants

Seven species of shrubs were found in the study area. The most common shrubs were *Oplopanax horridum* (Smith) Miq., *Ribes bracteosum* Dougl., and *Rubus spectabilis* Pursh. Tree seedlings were sparse with some *Tsuga heterophylla* and *Picea sitchensis*, and very few *Alnus rubra* present. Six fern species were found. *Athyrium filix-femina* (L.) Roth. and *Gymnocarpium dryopteris* (L.) Newm. were present in all stands. Twelve mosses, lichens, and liverworts were identified. The most common genera of mosses were *Hylocomium, Pleuroziopsis, Plagiomnium, Pogonatum,* and *Rhytidiadelphus.* Twenty-six herb species were found on the study area, and the percentage cover was compared for the 10 most common herbs (fig. 2).

The four alder stands had similar numbers of species of shrubs, herbs, ferns, and mosses with 3 to 7 shrubs, 12 to 17 herbs, 4 to 5 ferns, and 7 to 10 mosses (table 1). The spruce stand had slightly fewer shrubs (3) and ferns (3), about the same number of mosses (9), and considerably fewer herbs (6) than the alder stands. Most understory plant species had much higher percentage cover in the alder stands than in the spruce stand. The number of herbs found on the spruce stand was less than the numbers of herbs on the alder stands, but the small sample size of five stands gave a nonsignificant result ($p = 0.11$, chi-square test for differences among groups). Also, only 4 of the 10 most common herbs were found on the spruce stand. The percentage cover of the 10 most common herbs also was consistently lower for the spruce stand than for the alder stands (fig. 2).

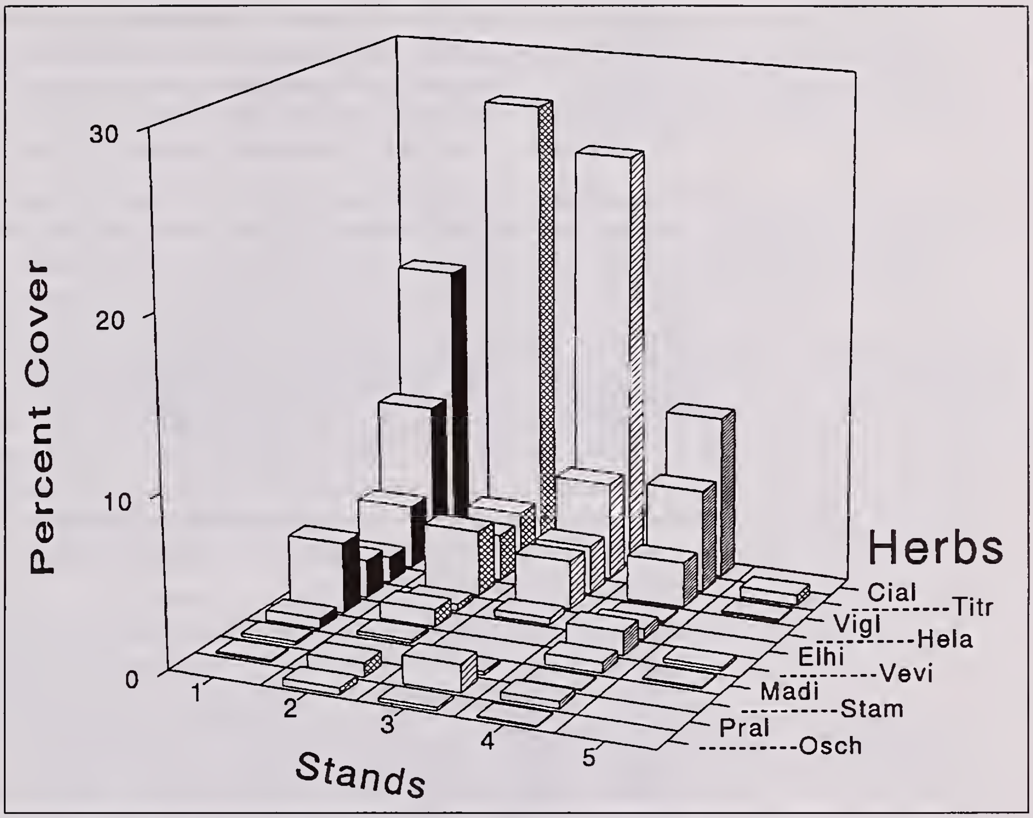

Figure 2—The mean percentage cover for the 10 most common herb species found in the five stands at Noxon Creek. Herb species are Cial—*Circaea alpina* L., Elmi—*Elymus hirsutus* Presl, Hela—*Heracleum lanatum* Michx., Madi—*Maianthemum dilatatum* (Wood.) Nels. & Macbr., Osch—*Osmorhiza chilensis* H. & A., Pral—*Prenanthes alata* (Hook.) D. Dietr., Stam—*Streptopus amplexifolius* Michx., Titr—*Tiarella trifoliata* L., Vevi—*Veratrum viride* Ait., and Vigl—*Viola glabella* Nutt.

Discussion

The alder stands contained lightly stocked mixtures of alder, spruce, and hemlock. Typical well-stocked hemlock/spruce stands in southeast Alaska at similar sites and ages have basal areas of 50 to 70 m^2/ha,[1] or nearly twice the density of these alder stands. These lightly stocked alder stands had high plant diversity in the understory and exceptionally high herb-species richness compared with typical, heavily stocked conifer stands of the same age. Alaback (1982) reported that understory biomass in hemlock/spruce stands peaked at a stand age of 15 to 25 years, and rapidly declined once the canopy closed. After canopy closure, these stands enter an intense stem-exclusion stage (Oliver and Larson 1990), with the least diverse understories occurring in stands between 40 and 150 years of age (Alaback 1982). The alder stands in this study were about the same age as typical 40- to 50-year-old hemlock/spruce stands that regenerate after clearcutting. Young-growth hemlock/spruce stands of this age are in their most intense period of stem exclusion and contain the least diverse

[1] Farr, W.A. 1976. The effects of stand density on growth and yield of hemlock-spruce stands in coastal Alaska. Revised study plan. On file with: Forestry Sciences Laboratory, 2270 Sherwood Lane, Suite 2A, Juneau, AK 99801.

plant understories. These alder stands, however, currently provide abundant and diverse understory plant communities, a rare condition in young-growth stands in southeast Alaska. High plant species richness in alder stands also has been reported in coastal Oregon (Franklin and Pechanec 1968), and more comparative work among different regions and stand structures is needed to clarify the underlying causes.

Different alder-conifer mixtures in the alder stands provided favorable conditions for understory plant development; however, relatively light stocking for conifers may be critical to maintain plant understories. The spruce stand, although almost 20 years younger than the alder stands, already had more basal area than any of the alder stands. Stocking was comparable to typical hemlock/spruce stands of the same age throughout the region. The densely stocked spruce stand has already entered the stem-exclusion stage, and increased competition and decreased understory plant diversity is expected during the next few decades. Although the spruce stand was somewhat younger, it already had less understory vegetation than the alder stands, and the differences in understory plant diversity among stand types is expected to become greater with time. The most intense period of the stem-exclusion stage for the spruce stand is still to come, and plant diversity likely will continue to decrease as the spruce stand matures.

Large-diameter conifers provide large woody debris in streams, which is necessary to sustain rearing habitat for fish and other aquatic organisms (Bisson and others 1987, Franklin and others 1981). The lightly stocked alder stands contained spruce of relatively large diameter, including the largest diameter trees in the study area. Diameter growth is expected to increase even more if the spruce can emerge from beneath the overstory alder canopy. Some of the largest spruces are now nearly as tall as the dominant alders, and limited data suggest that the tallest spruces will reach the upper canopy in 10 to 20 years. Stand species composition appears to be critical to the development of large conifers. Stands with stocking greater than 75 percent alder, contained suppressed spruce and hemlock with relatively small diameters. The spruce stand was densely stocked and had excessive numbers of small-diameter trees. Stands with conifers and alders of relatively equal stocking and basal area, however, contained the largest diameter conifers. These equal-stocking stands may be the best for producing large-diameter conifers in the shortest time. If producing large-diameter conifers is desirable for large woody debris inputs in forested streams, then creating relatively open alder-conifer stands may be the most desirable management strategy in riparian areas.

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English Equivalents

When you know:	Multiply by:	To find:
Centimeters (cm)	0.394	Inches
Meters (m)	3.281	Feet
Hectares (ha)	2.471	Acres
Kilometers (km)	0.621	Miles
Square meters per hectare (m^2/ha)	4.355	Square feet per acre
Cubic meters per hectare (m^3/ha)	14.292	Cubic feet per acre

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