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The Role of Red Alder in Riparian Forest Structure along Headwater Streams in Southeastern Alaska

Abstract

We assessed the influence of red alder on tree species composition, stand density, tree size distribution, tree mortality, and potential for producing large conifers, in 38-42 yr old riparian forests along 13 headwater streams in the Maybeso and Harris watersheds on Prince of Wales Island, Alaska. Red alder ranged from 0 to 53% of the total live basal area of the stands. Tree density, basal area of live and dead trees, and mean diameter of live conifers were not significantly related to the percent of alder as a proportion of total stand live basal area within these riparian forests. The mean diameter of the 100 largest conifers per hectare (the largest trees) was similar among different sites and appeared unrelated to the amount of alder in the stands. The mean diameter of dead conifers increased slightly with increasing proportion of red alder. Most dead trees were small and died standing. Red alder was much more concentrated immediately along stream margins (within 0-1 m distance from the stream bank vs. > 1 m). The presence of red alder did not inhibit the production of large-diameter conifers, and both alder and conifers provided small woody debris for fishless headwater streams in southeastern Alaska. Red alder is an important structural component of young-growth riparian stands.

Introduction

Red alder (*Alnus rubra*) is a common species in riparian stands in southeastern Alaska and a major hardwood component of forests in the Pacific Northwest. The geographical range of red alder extends from southeastern Alaska to southern California. The species occurs within a 300-km-wide strip along the northwestern Pacific coast at elevations below 1000 m (Harrington 1990). It is a shade-intolerant, fast-growing, short-lived tree commonly found in places where heavy disturbance has exposed mineral soil, such as landslides, avalanche tracks, logging skid trails, beaches, and streams. It also is a pioneer species on land recently exposed by glacial outwash, retreat, or land uplift (Harris and Farr 1974, Harrington et al. 1994, Newton and Cole 1994).

In southeastern Alaska, red alder rarely occurs in pure stands and it is more commonly distributed as a component of young mixed stands with shade-tolerant conifers such as western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*) and western redcedar (*Thuja plicata*). These mixed stands have a heterogeneous structure where a few large diameter conifers occur in the upper canopy, numerous small diameter conifers are in the lower canopy, and alder is confined to the mid-canopy stratum (Deal et al. 2004). These stands can also have abundant natural conifer regeneration (Hanley and Hoel 1996). In contrast, in the Pacific Northwest red alder is commonly found in pure stands (stream bottoms and lower slopes) and in mixed stands with shade-intolerant Douglas-fir (*Pseudotsuga menziesii*), Sitka spruce, and western hemlock (Harrington et al. 1994). In riparian stands red alder is concentrated along stream banks, but conifers replace

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it with increasing distance from the stream (Minore and Weatherly 1994, Pabst and Spies 1999, Nierenberg and Hibbs 2000). The lack of conifer regeneration and shrub-dominated plant communities in alder riparian forests of the Oregon Coast Range have led some researchers to suggest that these stands will likely succeed to mostly treeless shrub-dominated communities (Minore and Weatherly 1994, Hibbs and Giordano 1996, Pabst and Spies 1999, Hibbs and Bower 2001). Little silvicultural information on red alder in Alaska is available and it is difficult to say if the stand development pattern of alder-western hemlock and Sitka spruce in southeastern Alaska will be similar to the observed stand development of mixed Douglas-fir-alder forests from the Pacific Northwest.

Clearcutting has been the main timber management practice in the coastal mountainous terrain of southeastern Alaska since the early 1950s (Harris 1974) and has resulted in large blocks of the old-growth forests being replaced by young, even-aged conifer forests. The dense, uniform, even-aged stands that develop after clearcutting in southeastern Alaska may have negative consequences for wildlife and fish (Wallmo and Schoen 1980, Bisson et al. 1987, Thedinga et al. 1989, Hanley 1993, Dellasala et al. 1996). Forest canopy closure occurs 25-35 yr after cutting, and these stands then enter a prolonged stem exclusion stage (Oliver and Larson 1990) that limits or nearly eliminates herbaceous colonization for next the 100-150 yr (Alaback 1982). Although canopy removal in riparian forests may initially lead to increased stream productivity, subsequent canopy closure may reduce productivity by changing streams from autotrophic to heterotrophic (Sedell and Swanson 1984, National Research Council 1996, Hetrick et al. 1998, Stone and Wallace 1998).

Forest management practices such as precommercial thinning in young-growth conifer forests have led to dense conifer regeneration but have been unsuccessful in reestablishing understory vegetation for wildlife habitat and forage (Deal and Farr 1994). Recent studies of young-growth mixed red alder-conifer stands, however, show that different successional pathways are possible (Hanley and Hoel 1996, Hanley and Barnard 1998). Mixed red alder-conifer forests provide more productive and species-rich understories than pure conifer forests in southeastern Alaska (Deal and Orlikowska 2002) and in coastal Oregon (Franklin and Pechanec 1968). These mixed stands create better habitat for deer (McComb 1994), small mammals (Hanley 1996), and birds (Sidle 1985).

Terrestrial and stream systems are tightly coupled in headwater ecosystems; therefore riparian stand condition and structure may greatly affect the physical and biological processes in headwater streams (Vannote et al. 1980). These high gradient (generally > 10°) headwater streams are located upstream of, and draining into, fish-bearing habitats (Gomi et al. 2002, Wipfli and Gregovich 2002). Riparian red alder may increase the amount of terrestrial-derived invertebrates falling prey to juvenile salmonids (Wipfli 1997, Allan et al. 2003). Headwater streams draining mixed red alder-conifer riparian forests also export more invertebrates to downstream fish-bearing habitats than do young-growth conifer sites, potentially enough to support up to four times more fish biomass (Piccolo and Wipfli 2002, Wipfli and Musslewhite 2004).

Riparian forests along headwater streams are a valuable source of woody debris for instream habitat (Harmon et al. 1986, Bisson et al. 1987). Mixed alder-conifer riparian forests are capable of producing large-diameter conifers that may eventually provide woody debris for instream habitat (Deal 1997). Headwater streams transport wood, sediment, and other channel bed material (Gomi et al. 2002). Wood that is large relative to the channel size may also become anchored in the channel and store material or contribute to scour by redirecting force of water flow (Gomi et al. 2002). Depending on the size of woody debris pieces, they can play different functional roles; large woody debris (LWD) creates physical structure (Bisson et al. 1987) whereas fine woody debris (FWD) may have more importance in biological functions (Thorp et al. 1985, Richardson 1992, Wallace et al. 1995). LWD is ≥ 0.5 m in length and ≥ 0.1 m in diameter, whereas FWD is ≥ 0.5 m in length and 0.03-0.1 m in diameter (Gomi et al. 2001). LWD anchors the location of pools and creates upstream sediment terraces that form riffles and bars (Bisson et al. 1987). Streams with naturally accumulated LWD have erratic and complex channel morphologies, and create more sustainable aquatic habitat for rearing fish and other organisms than stream channels with removed wood or wood clustered in large jams (Bryant 1980). FWD provides substrate for aquatic invertebrates (Thorp et al. 1985) and their food. Since channel width is small in headwater streams, FWD also stores sediment and alters channel morphology (Bilby and Ward 1989, Gomi et al. 2001).

For the past several decades, red alder was often considered an undesirable species by forest managers, and was removed during timber stand improvement (TSI) to release the more economically valuable conifer species (Morse 1967, Tarrant 1978, Hibbs et al. 1994). This view began to change, however, when the economic value of red alder was recognized (Waggener 1978, Plank et al. 1990, Plank and Willits 1994).

Our research was focused on the role of red alder in riparian areas and the effect of red alder on forest stand structure in this important management zone. It was a part of a multidisciplinary research initiative that evaluated the role of red alder in achieving multiple resource objectives in managed young-growth ecosystems in southeastern Alaska. Information on other components of the initiative can be found in the published study plan (Wipfli et al. 2002). Our specific study had three objectives. First, we examined how the presence of red alder related to stand density and tree size distribution in mixed red alder-conifer stands along headwater streams. Second, we assessed the potential of young-growth riparian stands that contain red alder for developing large diameter trees. Third, we evaluated how red alder influenced the recruitment of woody debris by quantifying the density, sizes, and types of dead trees along headwater streams across a range of red alder density (0-53% of basal area). Overall, we were interested in the effect of alder on forest structure in mixed young-growth red alder-conifer riparian stands in southeastern Alaska.

Methods

Study Area

Study sites were located in the Maybeso and Harris drainages, Prince of Wales Island, southeastern Alaska (Figure 1). The climate of this area is maritime—cool and moist with annual precipitation of 2670 mm, and an average annual temperature of 5.7°C (Western Regional Climate Center 2002). Both Maybeso Creek and Harris River are located in broad glacial valleys that contain volcanic bedrocks with some conglomerate and dioritic outcrops (Nowacki et al. 2001). Maybeso Creek drains a watershed of ~46 km^2 and Harris River of 108 km^2. Soils are well drained, and moderately to highly productive for forest growth. Among soil types the most common are Tolstoi/Karta, Tolstoi/Rock outcrop and Tonowek/Tuxekan (Deal et al. 2004). The old-growth forest of the Maybeso Valley was extensively logged beginning in 1953, when large clearcuts were used to produce wood for the first pulp mills in the region (Harris 1974). Prior to logging, forests were primarily composed of western hemlock and Sitka spruce, with less common species of western redcedar, Alaska-cedar (*Chamaecyparis nootkatensis*), and mountain hemlock (*Tsuga mertensiana*). Among the understory species of the old-growth forest the most common were blueberry and huckleberry (*Vaccinium* spp.), rusty menziesia (*Menziesia ferruginea*), salmonberry (*Rubus spectabilis*), devil's club (*Oplopanax horridus*), lady fern (*Athyrium filix-femina*), single delight (*Moneses uniflora*), fern-leaved goldthread (*Coptis asplenifolia*), bunchberry (*Cornus canadensis*), and foamflower (*Tiarella trifoliata*) (Alaback 1982, Hanley and Hoel 1996). The young-growth stands that developed after clearcutting contain Sitka spruce, western hemlock, and western redcedar. Also, considerable amounts of red alder occur in these young-growth stands because of the extent of soil disturbance created by both natural disturbance and the yarding methods of that time.

Site Selection

Our research was conducted in 38-42 yr old mixed red alder-conifer stands along 13 small headwater streams. Site selection criteria for streams were: year-round surface flow, high gradient (>10°), small stream size (< 4 m bankfull width), flow into downstream fish-bearing habitat, no intermediate management activities (e.g., no thinning, or alder girdling), and wide range of density of red alder in the adjacent riparian forests. Mean stream flow at the transition zone (the zone between fish-bearing and fishless sections of stream) ranged from 0.9 to 116.2 $L \cdot s^{-1}$, and bankfull width from 0.7 to 3.4 m (Table 1). All streams had 300-m reaches sampled in the downstream-most portion of the fishless zone starting at the stream sampling station (used for sampling transport of prey and detritus downstream) and extending 300 m upstream.

Data Collection and Analyses

During August 2000, 4-7 pairs (depending on stream accessibility and geomorphology) of nested

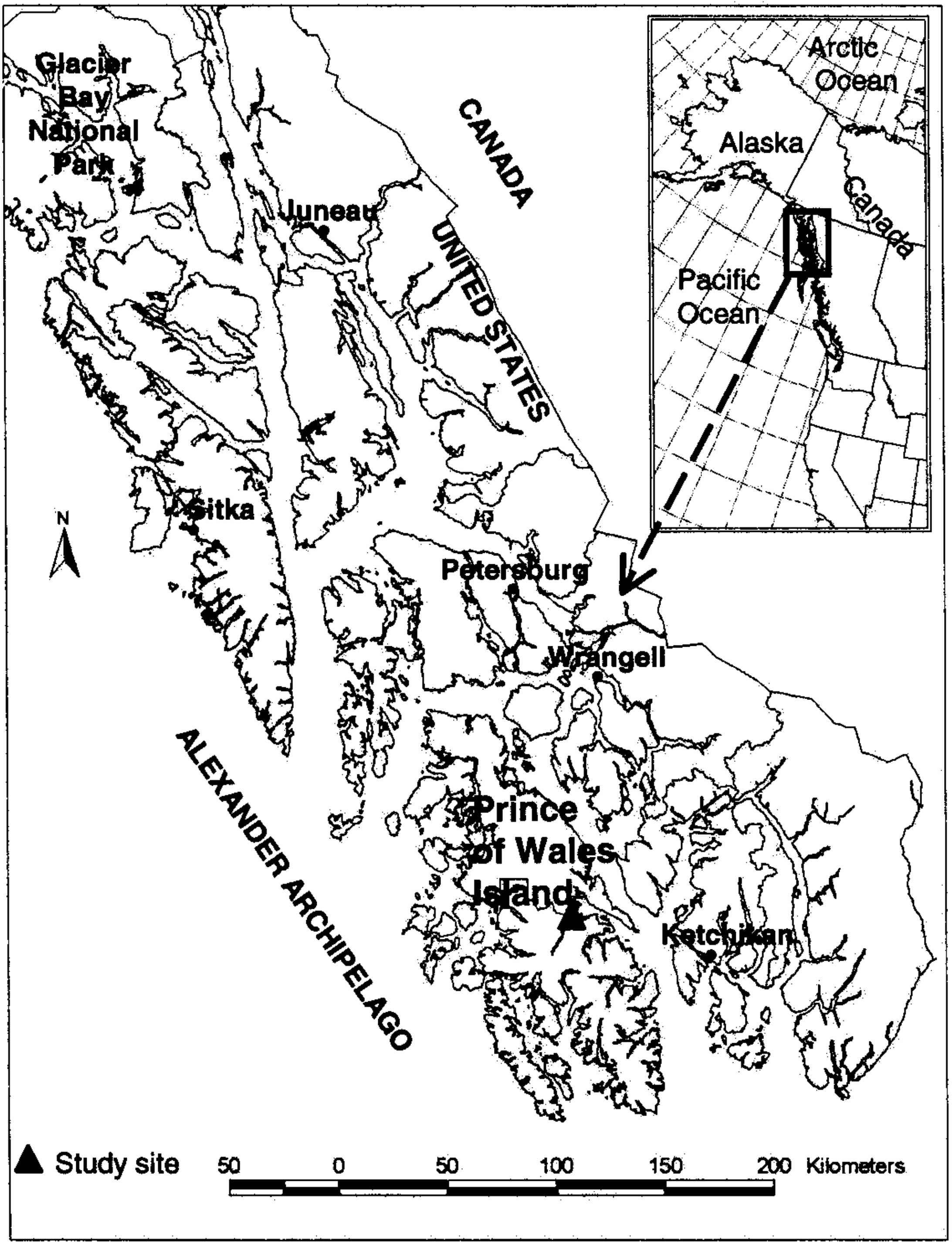

Figure 1. Map of study site location, Prince of Wales Island, southeastern Alaska.

TABLE 1. Physical and biological characteristics of headwater streams and adjacent riparian forest on Prince of Wales Island, Alaska, 2000. Sites are listed with an increasing proportion of red alder in adjacent forest.

	Stream			Riparian Stands						
						Species composition				
						(% of total stand basal area)				
Site	Channel slope gradient[1] (deg.)	Bankfull width[2] (m)	Stream flow (L·s^{-1})[3]	Total basal area (m^2·ha^{-1})	Tree density (stems·ha^{-1})	Red alder	Sitka spruce	Western redcedar	Hemlock[4]	Diameter of largest conifers (cm)[5]
Lost Bob	19.5	0.7	7.4	40.9	3371	0	35	12	53	30
Upper Good Example	13.6	0.9	3.0	47.4	4543	2	50	24	24	32
Cedar 2	18.8	1.7	4.5	64.1	3350	4	30	16	50	37
Upper Morning	14.5	1.1	4.7	60.1	3654	4	26	29	41	35
Creature Creek	15.2	1.1	36.0	47.6	2557	10	46	22	22	38
Gomi	26.1	1.0	5.5	52.0	2662	25	34	5	36	36
Mile 22	18.3	1.2	1.5	52.0	1643	29	26	0	45	34
Big Spruce	26.3	0.9	0.9	70.1	2700	32	50	2	16	43
Cedar 1	19.3	1.6	16.0	54.5	3886	35	20	10	35	28
Broken Bridge West	22.5	1.5	3.9	54.4	2644	39	44	5	12	38
Cotton	27.2*	3.4	116.2	68.9	3400	43	24	10	23	31
Broken Bridge East	10.7*	2.2	24.0	49.5	2643	47	44	3	6	36
Brushy	15.5	0.9	1.4	59.1	1600	53	4	1	42	42

[1] Channel slope gradient of entire stream; *channel slope gradient measured on 25% of stream length only.

[2] Bankfull width – the dominant channel forming flow (Dunne and Leopold 1978).

[3] Mean stream flow at transition zone.

[4] Western and mountain hemlock.

[5] Mean diameter of the 100 largest conifers per hectare.

fixed-area plots, one of each pair on the left bank and one on the right, were established along each 300-m stream reach (Wipfli et al. 2002). Aspects varied across sites, with no pattern closely associated with alder-conifer mixtures, or alder regeneration. Each fixed-area included a small (5-m^2), a medium (25-m^2), and a large (50-m^2) nested plot. Each plot measured 5 m along the stream bank and 1 m (small plot), 5 m (medium plot), and 10 m (large plot) into the riparian forest. Within each small plot, all trees were recorded; all trees with a dbh $\geq$ 3 cm (dbh - diameter at 1.3 m) had dbh measured and all trees with either dbh < 3 cm or height 1 m $\leq$ h < 1.3 m were tallied. Within each medium plot, all trees with dbh $\geq$ 3 cm had dbh measured. Within each large plot all trees with dbh $\geq$ 15 cm had dbh measured. Tree species, tree status (live or dead), and dbh were measured for all trees on each fixed-area plot. Additionally, the type of mortality was recorded as: tipped up root system (uprooted), or roots in place but bole intact (standing), bole broken above 3 m (broken), and broken at root collar (down). Tree sampling was dictated by size classes of woody debris (Gomi et al. 2001): fine organic debris (< 3 cm diameter), fine woody debris (3.0 to < 10 cm diameter), and large woody debris ($\geq$ 10 cm diameter), because we were interested in estimating the potential woody debris recruitment from the riparian stands.

Tree data for all 13 riparian habitats were combined by stream reach (left and right bank plots were merged for each measuring point) to assess stand density, species composition, tree mortality, diameter distribution, and the proportion of alder basal area in each stand. Correlation analyses were used to determine the relationship of the proportion of alder basal area to the total basal area of live and dead trees, live and dead tree density, mean diameter of conifers and mean diameter of largest conifers for the riparian stands. Analysis of variance (ANOVA) and Scheffé's test were used to test for a distance-from-stream (0-1 m, 1-5 m, 5-10 m) effect on the amount of alder along streams (SAS 1990). This test was also used to determine a difference in amount (basal area) of alder among 0-1 m, 1-5 m, and 5-10 m zones. The level of significance was set at P=0.05.

Results

Species composition of mixed red alder-conifer riparian forests along these headwater streams ranged from 0 to 53 % red alder as a proportion of total stand basal area (Table 1). The remaining species were conifers with western hemlock and Sitka spruce the most abundant. The total stand basal area of live trees ranged from 40.9 to 70.1 m^2·ha^{-1} and varied greatly among sampled stands (Table 1). There was no significant relationship between increasing amount of red alder in the stand and the total stand basal area of live trees. The total basal area of dead trees in these stands ranged from 0.1 to 7.6 m^2·ha^{-1}, and was also highly variable among these riparian forests. There was no significant relationship between the total basal area of dead trees, and the amount of alder within these stands.

One predominantly alder stand (Brushy) was lightly stocked with only about 1600 stems·ha^{-1}, and the greatest tree densities were in stands with the greatest proportion of conifers (Table 1). The relationship between live tree density and amount of alder in these stands was not significant. A nonsignificant trend also occurred for increasing density of dead trees across the alder gradient. The concentration of dead stems was quite variable (57 to 1800 stems·ha^{-1}).

The greatest number of live alder trees occurred in the 7.51-12.5-cm diameter class (midpoint 10 cm) (Figure 2a). The diameter distribution of live conifer trees was strongly skewed to small size classes with greatest number in the smallest diameter class (2.51-7.5 cm). The diameter distribution of dead trees was also heavily skewed towards the smallest diameter classes (Figure 2b). We found few larger-diameter dead trees.

Mean diameters of live conifers ranged from 9 to 18 cm among the riparian forests, but this variation was not related to the amount of alder within these forests stands. The mean diameter of the 100 largest conifer trees·ha^{-1} ranged from 28 to 43 cm (Table 1) and there was also no significant relationship between mean diameter of largest conifers and amount of red alder. The mean diameter of dead trees ranged from 4 to 8 cm, and it increased significantly with increasing amount of alder (P=0.04).

Most dead trees were small diameter conifers (Table 2). Of dead trees, the majority died standing with mean percentage for this tree mortality type ranging from 42.5±25.3 to 91.1±4.0 (Figure 3). Dead standing was the most common type of dead tree among all species and size classes. The relatively rare large dead conifer class was the only group of trees where dead standing did not total > 65% of the types of dead trees. The least common type of tree mortality was uprooted with mean percentage < 0.5±0.3 (Figure 3).

TABLE 2. Mean ± SE density of dead trees (stems·ha^{-1}). Small trees have diameter 3.0-<10.0 cm and large trees have diameter ≥ 10.0 cm.

	Mean ± SE	Range
Alder		
Small	298 ± 141	0 – 1743
Large	37 ± 15	0 – 150
Conifer		
Small	314 ± 79	29 – 933
Large	18 ± 13	0 – 167
All trees		
Small	612 ± 130	29 – 1771
Large	55 ± 25	0 – 317

Red alder was significantly more concentrated along the streams (P=0.004). The greatest amount of alder (proportion of stand basal area) was within the 0-1 m distance from the stream bank (55.6 % ± 11.8), and alder proportion decreased with distance from the stream (Figure 4). The significant difference in amount of alder between the 0-1 m and the 5-10 m zones was greater than significant difference between the 0-1 m and the 1-5 m zones. There was no significant difference in amount of alder between the 1-5 m and the 5-10 m zones. Decreasing amount of alder was correlated with increases in conifer species (0-1m zone 44.4 % ± 11.8, 1-5 m zone = 75.8 % ± 5.0, 5-10 m zone 82.3 % ± 4.6).

Discussion

One of the major objectives of forest management in riparian zones is the production and maintenance of large-diameter trees along streams because these trees provide an important source of large woody debris recruitment for stream

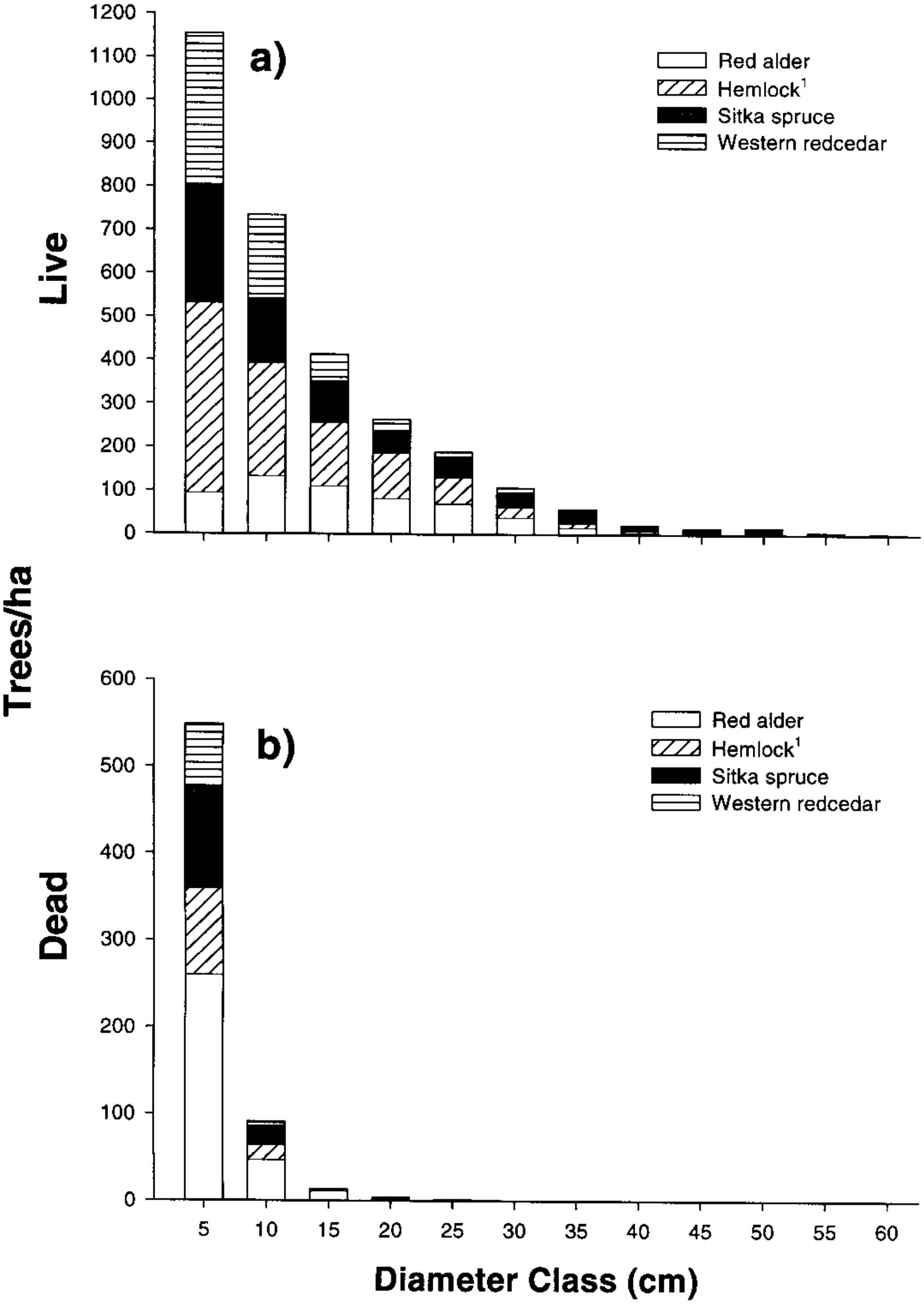

Figure 2. Tree diameter distribution of live (a) and dead trees (b) in stands along headwater streams for all of the 13 sites combined. 1- Category hemlock consists of western and mountain hemlock.

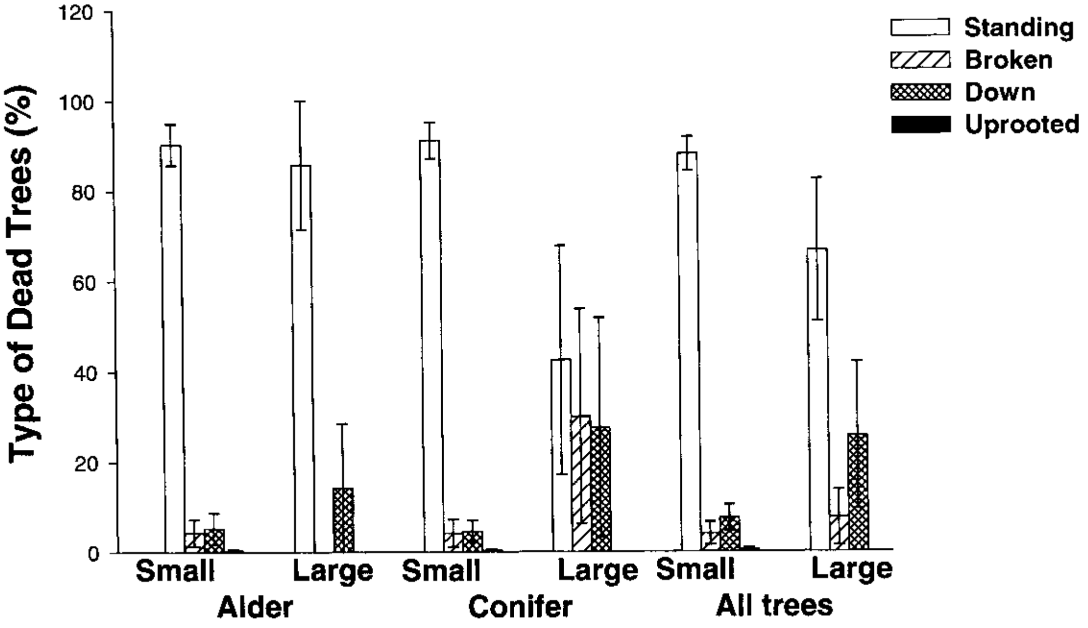

Figure 3. Mean percentage (±SE) for types of dead trees sampled along headwater streams in mixed red alder-conifer young-growth stands in southeastern Alaska. Type of tree mortality was recorded as: roots in place but bole intact (standing), bole broken above 3 m (broken), broken at root collar (down), and tipped up root system (uprooted). Small trees are 3.00 to 9.99 cm dbh, large trees are 10.00 cm dbh or greater.

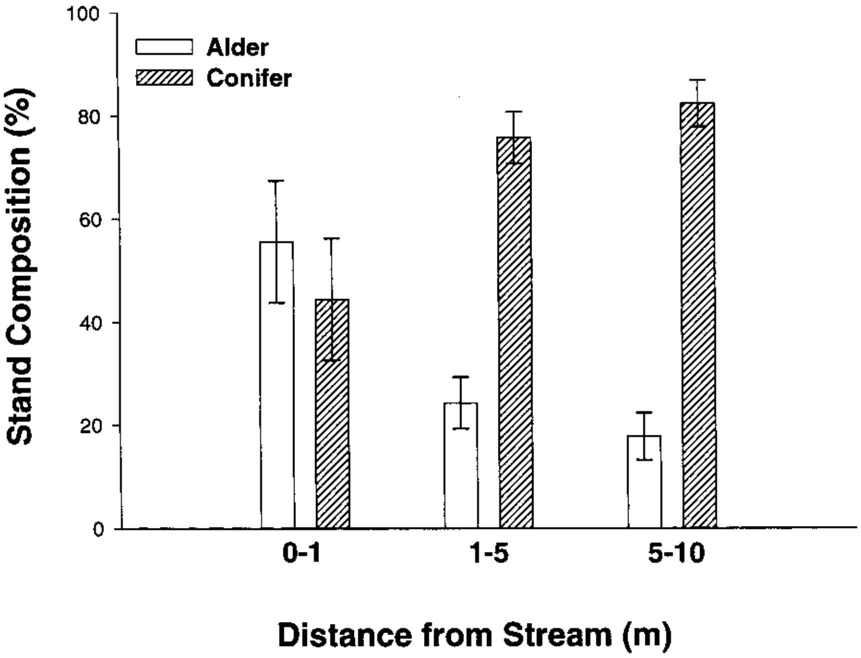

Figure 4. Composition of stands (±SE) along headwater streams at 0-1 m, 1-5 m, and 5-10 m forest plot areas perpendicular and immediately adjacent to stream for live trees with diameter at breast height 15 cm and greater.

structure (Bryant 1980, Bisson et al. 1987). These trees will provide potential woody debris for instream channels that is critical for maintaining stream stability, reducing sediments, and providing habitat for fish and other aquatic organisms (Bisson et al. 1987). In the young riparian forests that developed after clearcutting in southeastern Alaska, conifers historically were favored by resource managers and red alder was removed to encourage the development of large diameter conifer trees (Franklin et al. 1981). In our study, mean diameter of the 100 largest conifers per hectare (the largest trees) was similar among different sites and was unrelated to the amount of alder in the stand (Table 1). Eliminating alder during TSI from these 38-42 yr old riparian forests would probably have little effect on the growth of the large diameter trees. This finding is important because it appears that red alder does not suppress the growth of the largest conifers. The conifers in these stands are shade tolerant. Mixed red alder-conifer stands are less dense than pure conifer stands, so that the response of large trees to alder removal is less pronounced. If management goals are to create large trees in the shortest amount of time, then thinning competing conifers may be more effective than thinning surrounding red alder trees. Moreover, a study from the Pacific Northwest of a Douglas-fir plantation interplanted with red alder shows that retention of red alder improved growth of nearby conifers on nitrogen deficient sites (Miller et al. 1993).

The presence of red alder did not influence the type or size of dead trees. Whether alder or conifer, nearly all dead trees in this study were small. Standing dead was the most frequent type of dead tree indicating that most trees are dying from suppression in these dense forests. Biotic agents apparently caused little tree mortality. The small number of trees that were uprooted were probably killed by the forces of wind or gravity with predisposition of saturated soils or heavy snow or ice accumulations on the trees. Porcupines would be expected to be the main mortality agent killing larger trees of these ages in some portions of southeastern Alaska (Eglitis and Hennon 1997), but porcupines do not exist on Prince of Wales Island where our study was conducted. The fungus *Armillaria* sp. was found in several dead red alders that had broken off near the ground level in our study area and the activity of this fungus may become more important as stands age.

Recruited woody debris was generally small (<10 cm diameter), lacked an attached root system, and often partially decayed before entering the stream. As such, these pieces of wood together with alder leaves may be providing a biological function by supporting terrestrial invertebrates (Richardson 1992, Wallace et al. 1995), but they will not be as effective as pieces of large wood (>10 cm diameter) in creating pools and storing sediment. Large woody debris from the original old-growth forest is still performing these functions in some streams, as wood decay in this environment is slow (Bilby et al. 1999). Although canopy-level trees are not currently dying along headwater streams, these large diameter trees could be recruited as large woody debris in the future. Decades later as stand development progresses, some of these large young-growth trees will begin to die, enter the stream, and provide the physical functions similar to the legacy wood, derived from pre-harvesting old-growth forest.

Species composition, stand density, and live and dead tree diameter distribution of forests along these headwater streams were similar to non-riparian upland stands in Maybeso Creek and Harris River watersheds (Deal and Orlikowska 2002). Comparing non-riparian upland and riparian forests, we found a wide range of stand composition and densities among sites, but riparian forests were generally similar to non-riparian upland forests at the same site (Deal et al. 2004). We found a significant increase in the amount of alder in the 1-m-wide zone immediately adjacent to the streams. A similar trend in alder spatial distribution was found in the coastal mountains of Oregon where this species was located closer to the streams versus farther away (Minore and Weatherly 1994, Nierenberg and Hibbs 2000). In unmanaged riparian forests in three river basins in the coastal mountains of Oregon, basal area of hardwood was relatively constant with distance from the stream, whereas basal area of conifers increased (Pabst and Spies 1999). In our study the stand structures of forests along headwater streams and in non-riparian stands were similar, excluding the clumped nature of red alder immediately along the streams. The distribution of alder in both riparian and non-riparian forests appeared to be closely related to previous logging techniques and occurrence of natural disturbances.

Our results may have some applications in headwater riparian forest management in the U.S.

Pacific Northwest and in British Columbia, although these may be limited by differences in physical and biological conditions such as precipitation, temperature regimes, and plant communities. Forest regulations with regard to stream buffers and harvest techniques vary by state, province, and on federal lands (Ministry of Forests 1995, USDA Forest Service 1997, Washington State Department of Natural Resources 1999, Alaska Department of Natural Resources 2000, USDA Forest Service and USDI Bureau of Land Management 2000, Young 2000, Oregon Department of Forestry 2003). Many small streams receive some buffer protection, although the ability of these buffers to maintain the ecological integrity of the watersheds has been a subject of debate (Young 2000, Hibbs and Bower 2001).

We found little difference in stand structure between riparian and non-riparian upland stands, but clearcutting to the stream bank may substantially alter the physical integrity of streams. Among other effects, it changes streamflow, and increases temperature and sediment load (National Research Council 1996, Stone and Wallace 1998, Young 2000).

Red alder clumped along stream margins may provide some important ecological consequences for stream communities. Because red alder contains more nitrogen and decomposes more quickly than conifers, it will provide higher quality allochthonous inputs for stream invertebrates (detritivores) than the conifers (Cummins et al. 1989, McComb 1994). Alder is also expected to support more terrestrial invertebrates than conifers, which in turn fall prey to stream fishes (Wipfli 1997, Allan et al. 2003). Red alder occurring along riparian zones and throughout watersheds also elevates stream nitrate levels (Compton et al. 2003). This, in conjunction with more sunlight penetration through alder versus conifer canopies should increase stream primary production (Hetrick et al. 1998). All of these factors will likely influence stream community structure, biodiversity, and food web productivity.

Red alder increases understory plant diversity and abundance (Franklin and Pechanec 1968, Hanley and Hoel 1996, Deal 1997, Deal and Orlikowska 2002) and food abundance for salmonids (Wipfli 1997, Piccolo and Wipfli 2002, Allan et al. 2003). Conifers may have better wood quality properties with tighter rings and smaller knots when they originate as an understory tree and then emerge from beneath the alder overstory (Newton and Cole 1994). There has been some concern that inclusion of alder may lead to reduced wood production (Deal et al. 2004), and other investigations are underway to assess the compatibility and tradeoffs of red alder and conifer forests across a broad range of terrestrial and aquatic resources (Wipfli et al. 2002).

Our results show that including red alder in young-growth stands did not lead to loss in wood production of these stands. Additionally, red alder may benefit other components of the forest ecosystem such as bird (Sidle 1985), small mammal (Hanley 1996), and deer habitat (Hanley and Barnard 1998), and it may also provide some large woody debris in the future (Deal 1997) for fish habitat and fine woody debris for food and substrate for aquatic invertebrates (Richardson 1992). These findings should provide information on the ecological role of red alder in forested headwaters that in turn should help guide upland forest management in southeastern Alaska and other parts of the Pacific Northwest. Red alder may serve as an important tool in sustainable and compatible resource management that will help to achieve better habitat for fish and wildlife and at the same time not impair the timber resource.

We acknowledge that this is an observational, retrospective study and our results could be driven by some unexplained variables that are not related to alder composition in these riparian stands. Our results should be viewed as preliminary relationships that can be tested rigorously under more carefully controlled conditions.

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