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Science FINDINGS

INSIDE

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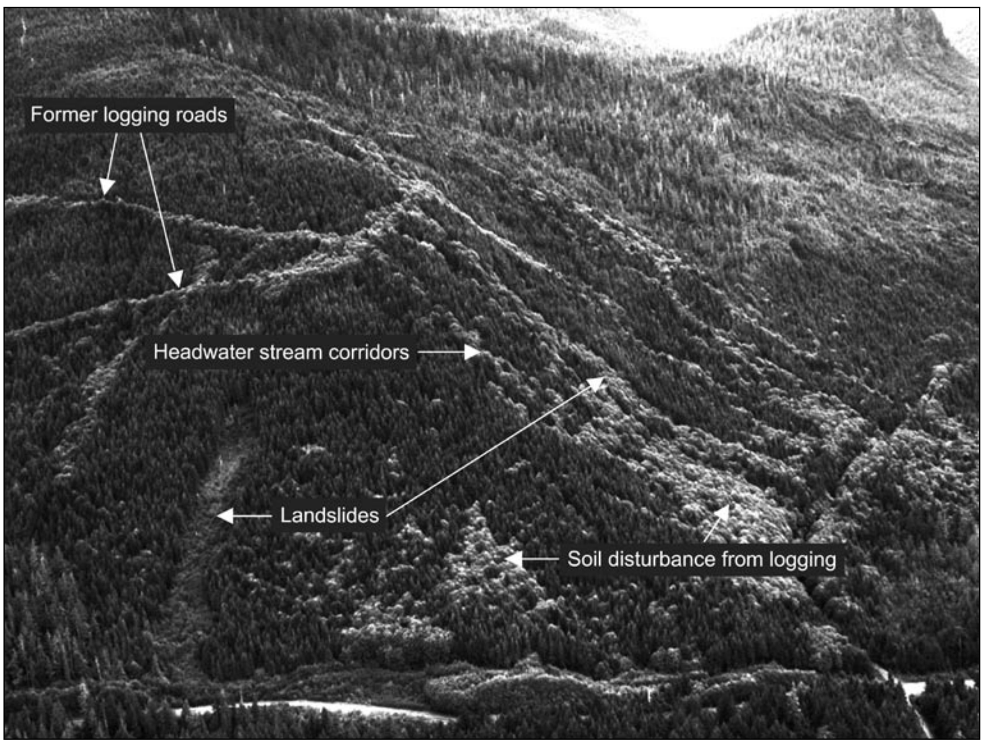
"Science affects the way we think together."

Lewis Thomas

ECOLOGICAL PAYOFFS FROM RED ALDER IN SOUTHEAST ALASKA



Red alder regenerates in soil-disturbed habitats. Red alder is the lighter-colored tree species.

"What is a weed? A plant whose virtues have not been discovered."

—Ralph Waldo Emerson (1803–1882)

In parts of southeast Alaska it is not unusual to see distinct bands of light green leafy trees marching down the hillsides in spring. The trees are red alder, contrasting with the darker colors of the hemlock/spruce/cedar forests of these northern latitudes. These bands are following streams, where erosion exposes the mineral soils the species prefers for regeneration.

For decades red alder has reliably colonized recent clearcuts, landslides, and blowdown patches for the same reason—exposed mineral soil. The species has until recently been branded a weed by southeast Alaska timber interests, based on its propensity for 'interfering with' early conifer growth. However, in the Pacific Northwest, red alder is now a highly valued crop tree with a small but thriving hardwood lumber market.

A native component of the southeastern Alaska and the Pacific Northwest landscape, and similar to other alder species found in forests throughout the world, red alder exhibits rapid

IN SUMMARY

Clearcutting has been the primary timber management practice in southeast Alaska forests since large-scale commercial forestry began in the 1950s. The dense, even-aged conifer stands that subsequently develop, however, may have undesirable consequences for some nontimber resources, most notably fish and wildlife.

Red alder is frequently established in these young-growth conifer stands and appears to provide different forest structural attributes and improved biodiversity that may mitigate some negative effects of harvesting. However, to date, it has been unclear what the ecological functions of red alder are in these ecosystems. Understanding the ecological role of alder in young stands will help aid restoration and management of young forest ecosystems.

Recent findings from the PNW Research Station in Alaska, funded by the Station's Wood Compatibility Initiative, suggest that red alder may leave a legacy of more open stand conditions, increase forest understory plant and wildlife biodiversity and abundance, and enhance productivity and biological function of headwater streams.

early height growth, and for the first 20 to 30 years of its life, can dominate other conifer trees established following both natural and human-caused disturbances.

"When you see the extent of these bands, and their coverage across the landscape, you begin to understand how they produce such a remarkable amount of food for fish, and productivity for stream and forest in general," says Mark Wipfli, an associate professor at the University of Alaska, Fairbanks, and formerly a research aquatic ecologist at the PNW Research Station. "It is a real eye-opener now to learn about the benefits coming from this poorly understood tree species."

The very abundance of the species on the landscape led Wipfli and other researchers to wonder about the ecological implications of such vegetation. Upon investigating the state of knowledge about red alder, they found a significant gap in the scientific literature, so they developed a primary set of questions to guide subsequent research: Does red alder affect understory development, tree growth, and timber production? How does it influence food and habitat for fish and wildlife? How does red alder function in stream and riparian habitats? Does it influence forest ecosystem diversity and productivity?

KEY FINDINGS

- Red alder is dynamic in young-growth stands, exhibiting rapid early height growth. As it becomes overtopped by conifers as early as 20 to 25 years, it may leave a legacy of more open stand conditions characteristic of mature forests.
- Mixed red alder-conifer stands provide more heterogeneous structures than pure conifer stands with different tree sizes, multiple canopy layers, and similar numbers of large-diameter conifers.
- Red alder increases forest understory plant biodiversity and abundance, providing more cover and browse for deer and other wildlife such as songbirds and terrestrial invertebrates.
- Headwater streams with riparian red alder appear to be more productive, providing more food (invertebrates) for fish and birds.
- Red alder seems to provide critical biological function (food) to forested ecosystems, whereas conifer species provide more physical function (habitat), especially in streams.

With Bob Deal, a research silviculturist with the Station's Portland, Oregon, lab, and others, Wipfli coordinated the ensuing research into the ecosystem role of this common and little known species.

FOLLOWING THE CLEARCUTS

Clearcutting has been the primary timber management practice in forests of southeastern Alaska since commercial timber harvesting began in the 1950s. Conifer forests in southeast Alaska have no trouble at all regenerating after harvest, and rarely need artificial planting, Deal explains. In fact, they're rather too good at it, resulting in dense forests that quickly shade out other understory species that might provide browse or cover for wildlife.

"The dense, uniform, even-aged stands that develop after clearcutting have many negative consequences for wildlife and fish," says Wipfli. "Forest canopy closure generally occurs 25 to 35 years after cutting and is followed by a nearly complete elimination of understory vegetation for 100 years or longer."

From this point, there's a cascade of effects relating back to clearcutting. The resulting even-aged conifer forests have simple, uniform stand structures, lack the diverse structures of mature forests, and are poorly suited for many wildlife species.

When the canopy closes over small streams, the nature of the food web changes, affecting overall aquatic productivity. Removal of streamside timber can, in some cases, reduce the amount and size of large wood in a stream, with resultant loss of bird and fish habitat. Changes in forest structure brought about by clearcutting may, in some circumstances, also alter supply, storage, and transport of woody debris and sediment through processes such as landslides, windsnap and blowdown, and bank erosion.

"Consequently, there is increasing interest in developing forest management practices that maintain or enhance biodiversity and assure long-term sustainability of forest products, wildlife, and aquatic resources," says Deal.

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Credit: Bob Deal

Biologically simplified, 40-year-old, even-aged conifer ecosystem (A), and a mixed red alder–conifer ecosystem of the same age (B) showing the more diverse stand structure and abundant understory.

RED ALDER TO THE RESCUE?

Which brings us back to red alder. Red alder is the most common hardwood tree in the Pacific Northwest, extending from southern California to southeast Alaska. It is a short-lived, shade-intolerant pioneer with rapid juvenile growth and the ability to fix atmospheric nitrogen. The soil disturbance generated by logging, log landings, skid trails, or avalanche paths exposes mineral soil, inviting the deciduous species to put down roots to form both pure and mixed stands.

"Other recent studies of young-growth stands of red alder mixed with conifers indicate that the presence of alder may mitigate some of the negative impacts of clearcutting in southeast Alaska," he says. "Mixed alder-conifer stands have species-rich, highly productive understory vegetation with biomass similar to that of old-growth stands of the region, and habitat quality for small mammals in these mixed stands may be equal to that of old-growth forests."

Although inclusion of alder will not mitigate all wildlife habitat problems, it may provide more benefits than would thinning of even-aged conifer stands, Deal points out. Attempts to establish understory herbs and shrubs through thinning often lead to yet more conifer regeneration, with little new herbaceous colonization.

The results in riparian areas are particularly notable. "Riparian forests with some red alder appear to produce more prey for fishes than conifer riparian forests," Wipfli says. "This is significant because over half of the prey biomass ingested by juvenile salmonids in southeast Alaska is terrestrial and originates from adjacent riparian vegetation." If similar processes occur in upland forests, he adds, the presence of red alder may contribute to an increase in invertebrate production, providing more food for animals such as birds, bats, small mammals, and fish, in turn affecting their abundance and production.

The irony now is that harvest methods since the 1970s have focused on reducing soil disturbance, and the resulting decrease in red alder coverage after harvest is a known pattern in southeast Alaska.

It's one thing to recognize that a "weed" species might have something more to offer than its poor reputation suggests, it's another to find out what that something might be. A number of recent studies, including several by Wipfli, Deal and others, have begun to fill in the many holes in understanding of red alder's ecosystem role.

FILLING THE KNOWLEDGE GAP

Among the studies three themes emerged: the influence of red alder on specific ecosystem components, the flow and use of wood among habitats, and the influence of red alder on ecosystem linkages and processes.

"We hypothesized that red alder increases the abundance and diversity of understory plants, which in turn influences aquatic and terrestrial invertebrate communities in terms of abundance and species richness, and the bird and fish communities that feed on those prey," Wipfli explains. "We also predicted that dead wood, especially red alder, serves important biological functions affecting invertebrate communities in riparian and aquatic habitats."

The investigations tracked interactions in seven major resource areas: geomorphic processes, wood production, understory vegetation, avian ecology, terrestrial invertebrates, aquatic and riparian ecology, and fish ecology. The researchers believe this series of investigations is the first to concurrently cover stream, riparian, and nonriparian habitats in southeast Alaska. To date, they note, most information about red alder in the region is speculative or based on data from other regions.

Among findings from the studies: these mixed red alder-conifer stands provided more variable structures than pure conifer stands with different tree sizes, multiple tree canopy layers, and similar numbers of large-diameter conifers. Understory plant diversity and abundance were significantly higher in these mixed alder-conifer forests, and most of the increase in understory biomass was in vascular plants important for deer forage and other small wildlife species. Further, mixed red alder-conifer stands potentially provide more food for songbirds, more and safer nest sites, and reduced susceptibility to nest predation, based on work by Toni DeSanto, an avian ecologist with the PNW Research Station in Juneau, Alaska.

Credit: Rick Edwards

Headwater stream draining an upland forest where it has already transitioned into a lower gradient, fish-bearing reach.

RED ALDER AND STREAM PRODUCTIVITY

Little is yet known about the influence of plant communities developing along upland riparian areas on stream productivity and downstream fish, according to Wipfli, but red alder could have a variety of impacts, such as changes in light penetration and litter inputs. "These effects could lead to changes in aquatic productivity and input of terrestrial invertebrates to streams. Some riparian tree species contribute more invertebrate mass to streams than others, and red alder appears to support relatively high levels of prey for fish."

Red alder and other vegetation types along streams can also have major influences on stream riparian soil nutrient levels, he says. The nitrogen fixed by red alder can affect soils for many years, and can be moved by hyporheic activity into adjacent streams. In addition, because red alder decays faster than conifers and is a desirable source for invertebrates, it is likely to affect the detritus and invertebrates exported from headwaters to downstream habitats.

Wipfli and Deal's study sites encompassed a range of red alder abundance in two adjoining watersheds on Prince of Wales Island, southeastern Alaska. Two distinct types of sites were selected: nonriparian where the focus was to evaluate the influence of red alder on vegetation, birds, and invertebrates; and stream-riparian, where the focus was the effect of red alder on vegetation, stream nutrients, organic detritus, invertebrates, woody debris, and fish.

"The proportion of red alder was the independent variable common to all aspects of sampling," Deal says. "One of our goals was to construct an empirical model to show how resources might differ along the continuum of red alder dominance. This information could then be used by managers as a predictive tool for selecting the proportion of red alder to be managed in association with single or multiple resource objectives, at the stand, stream reach, or watershed scale."

RED ALDER AND WOODY DEBRIS

Total wood production decreased significantly with increasing proportion of red alder basal area, according to Deal. In contrast, tree density did not differ with red alder composition, and the largest conifer trees in mixed stands were likely to achieve the same size as in pure conifer stands. He describes a very different forest structure in the mixed alder-conifer stands than in pure conifer forests that have more uniform size distributions: these mixed alder-conifer stands created a multilayered forest canopy with a few dominant overstory conifers, a midcanopy level of red alder, and a lower canopy level of small-diameter conifers. Also, most dead trees died standing regardless of size or species.

A significant ecological downside of alder is the lesser volume of large woody debris it provides to the system, being shorter lived and decaying faster than conifers.

The number of red alder, large woody debris pieces in streams increased with increasing proportion of red alder in the riparian stand, according to findings by Takashi Gomi, a post-doctoral researcher with the University of British Columbia. However, significant relationships between the volume of large woody debris and sediment stored behind these pieces and the proportion of red alder in riparian zones were not found.

Because of the faster decay, and the fact it is a desirable food source for invertebrates, red alder likely affects the volume of detritus and invertebrates exported from headwaters to downstream habitats. However, again red alder appeared to have no direct relationship with salmonid densities. The limiting factor on salmonid populations in these streams, according to Wipfli, is more likely to be amount and quality of habitat.

WRITER'S PROFILE

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In the end, there's a balance to be considered in how red alder affects the ecosystem.

"An increase in red alder in riparian forest canopies may have both positive and negative impacts on aquatic communities," Wipfli points out. "Higher aquatic productivity and more food for fish and wildlife may be outweighed by loss of fish habitat resulting from decreased large woody debris inputs, wood longevity, and increased sediment loading from fewer large conifers."

LAND MANAGEMENT IMPLICATIONS

- Red alder can be managed to help mitigate some of the potential effects of forest clearcutting, increasing habitat quality for wildlife, stream productivity, and food for fishes, amphibians, songbirds, and other invertivores.
- Growing red alder in patches, rather than dispersed in stands where it must compete directly with neighboring conifers, may extend its ecological function for decades.
- Findings have broad implications for multiple resource objectives (forests, wildlife, fishes) and are applicable across the broad geographic regions worldwide where other alder species with similar ecological properties are found.

DEVELOPING MANAGEMENT TOOLS

Two successional trajectories for young, regenerating forests appear to follow clearcuts or other disturbance. Pure or nearly pure conifer forests (with low soil disturbance) develop a sparse and nondiverse plant understory, which in turn leads to little wildlife browse and sparse foliage for herbivorous invertebrates, Wipfli says.

"Nearly pure conifer forests also provide less nitrogen and light for stream producers and consumers, which can lead to fewer aquatic invertebrates in the associated headwater streams, ultimately providing less food for birds and downstream fish. They also provide fewer nesting sites for songbirds and support lower songbird density."

The alternative trajectory, with more red alder, leads to the benefits to the stream outlined above. In addition, the more rapid life cycle of red alder offers greater opportunity for complexity in forest structure to develop. For example, younger alder start to die off around 35 years, when conifers overtop them. Being deciduous, they allow more light penetration to the forest floor for a longer period. And gaps created where one or more large red alders have died between age 60 and 100 years, leave conifer stands more open; these gaps could also allow invasion of new trees, thereby creating a new canopy.

This kind of complexity, according to Paul Hennon, Forest Service research forest pathologist with State and Private Forestry of the Alaska Region in Juneau, Alaska, can occur decades earlier in mixed stands than in pure conifer stands where overstory death of conifers may not begin until around age 150 years. "The longer term benefit of red alder may be that its death accelerates the transition to a mature forest structure."

Larger red alders provide an intermediate source of woody debris for streams, and the species provides both nitrogen and high-quality organic matter for decomposers and invertebrates. Thus red alder increases food abundance in its immediate vicinity and in downstream reaches.

How might resource managers respond to these data?

"We're getting a great deal of interest from managers on the Tongass and other parts of southeast Alaska on this work," Wipfli says. "They're looking for opportunities to increase red alder reproduction, they're establishing some red alder planting trials to check against our restrospective study, and they're looking for ways to keep streams productive."

Further research questions abound. How much alder is good from an ecosystem management perspective? Should we be planting alder now that logging methods are less likely to disturb mineral soil? What are the long-term successional dynamics between alder and conifers? And, is there a timber market for red alder in southeastern Alaska?

Wipfli cautions against hailing red alder as the salvation species. "We shouldn't go overboard into thinking of it as a quick fix," he says. "Although it does mitigate a number of the effects of clearcutting, there are some things it can't address, such as loss of large woody debris, as well as erosion and sedimentation."

Nonetheless, the widespread occurrence of alder throughout the Pacific Northwest and around the world suggests that these results may offer insights into numerous other ecosystems, the researchers say. The "weed" is coming of age.

FOR FURTHER READING

Deal, R.L.; Hennon, P.E.; Orlikowska, E.H.; D'Amore, D.V. [In press]. *Stand dynamics of mixed red alder-conifer forests of southeast Alaska*. Canadian Journal of Forest Research.

Johnson, A.C.; Edwards, R.T. 2002. *Physical and chemical processes in headwater channels with red alder.* In: Johnson, A.C.; Haynes, R.W.; Monserud, R.A., eds. Congruent management of multiple resources: Proceedings from the wood compatibility workshop. Gen. Tech. Rep. PNW-GTR-563. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 101–108.

Orlikowska, E.H.; Deal, R.L.; Hennon, P.E.; Wipfli, M.S. [In press]. *The role of red alder in riparian forest structure along headwater streams in southeastern Alaska.* Northwest Science.

Wipfli, M.S. [and others]. 2003. *Compatible management of red alder-conifer ecosystems in southeast Alaska.* In: Monserud, R.A. [and others], eds. Compatible forest management. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Wipfli, M.S.; Musslewhite, J. [In press]. *Density of red alder (Alnus rubra) in headwaters influences invertebrate and organic matter subsidies to downstream fish habitats in Alaska.* Hydrobiologia.

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