

Science

FINDINGS

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"Science affects the way we think together."

Lewis Thomas

Heed the Head: Buffer Benefits Along Headwater Streams



Loretta Ellenburg

Headwater streams and riparian areas in western Oregon are home to a unique set of aquatic and streambank organisms and contribute to the health of the downstream environment.

"No river can return to its source, yet all rivers must have a beginning."

—Native American proverb

The upper watersheds of the Oregon Coast Range are laced with small streams—the headwaters of the Nestucca, Trask, Wilson, Siletz, and Willamette, to name a few of the region's rivers famed for their salmon runs. In between these networks of fingerling streams are webbings of riparian areas that host unique assemblages of aquatic and terrestrial organ-

isms. Upland from these riparian areas are productive forests of Douglas-fir and hemlock.

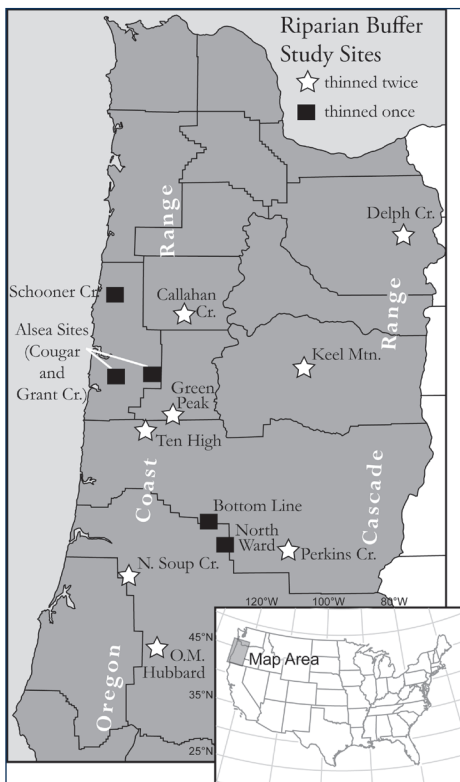
Riparian areas, where the terrestrial mingles with the aquatic, are special places. Riparian areas around headwaters are particularly important because they have strong ecological connections to uplands and provide resources to the downstream system. Small flying insects dip and dart, falter and fall into the stream, becoming a meal. A tree topples, landing in the water, forming instream habitat. The bank sloughs, delivering sediment and rock to the stream.

IN SUMMARY

Since the Northwest Forest Plan implemented riparian buffers along non-fish bearing streams in 1994, there have been questions about how wide those buffers need to be to protect aquatic and riparian resources from upland forest management activities. The Density Management and Riparian Buffer Study of western Oregon, also initiated in 1994, examines the effects of thinning and different buffer widths on aquatic and riparian vertebrates and habitats, tree growth, and vegetation along headwater streams.

Dede Olson, a research ecologist with the Pacific Northwest Research Station, leads the riparian component of the study. Olson and her colleagues found that aquatic and riparian species and habitat were retained with no-entry, 50-foot minimum variable-width buffers. Their research has characterized both aquatic and terrestrial amphibian assemblages that rely on headwater streams and near-stream riparian forest habitats. For example, they documented that terrestrial salamanders have heightened movements within 50 feet of headwater streams. By extending such buffers along headwater streams over ridgelines, landscape connectivity could be provided, enabling gene flow among populations of terrestrial salamanders.

Scientists found that thinning upslope accelerated growth of trees within the buffer within 50 feet from the thinned edge. Larger trees ultimately lead to larger pieces of down wood, which form critical habitat both on land and in streams.



At these study sites in western Oregon, scientists are characterizing headwater streams in managed forests. They are also examining the response of instream habitats and vertebrates and streambank amphibians to experimental treatments of different riparian buffer widths with upland forest thinning.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

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KEY FINDINGS

- Results from the Density Management and Riparian Buffer Study of western Oregon show that buffer width matters. The narrowest buffer (20 feet) appeared to pose a risk to amphibians 10 years after upland thinning and 1 year after a second-entry thinning. However, Dunn's salamanders (*Plethodon dunni*) and *Rhyacotriton* salamanders showed increased abundances within the 50-foot minimum variable-width buffer and 240-foot buffers (roughly the potential height of one tree at productive sites) after the two thinning entries.
- Woodland salamanders used riparian forests with 50 feet of headwater streams as habitat.
- Thinning upland of buffers accelerated tree growth within the buffer within 50 feet from the thinned edge.
- More than 80 percent of down wood in these small headwater streams came from within 50 feet of the stream channel. Most existing wood was a legacy of the earlier old-growth stand. More early decay-class wood was found in the stream reaches with the 20-foot buffer width; hence self-thinning of the dense second-growth stands in the wider buffers was not evident in the timeframe of this study.

"Managing for healthy riparian areas in headwaters provides many downstream benefits" says Dede Olson, a research ecologist with the U.S. Forest Service Pacific Northwest Research Station. "Downstream productivity, water temperature, and instream habitat are tied to the health of the headwater stream-riparian system."

Headwater streams in western Oregon are small, often no more than a few feet wide. They may be discontinuous, flowing underground for a short distance before reemerging at the surface. They also may be seasonal, drying in summers when rains wane. This lack of continuous water and the assumption that they didn't have fish meant that prior to the Northwest Forest Plan, they weren't classified as streams warranting protection on federal lands. Logging occurred across many of them.

The aquatic conservation strategy of the Northwest Forest Plan, implemented in 1994, calls for a protected buffer zone between all streams and upland forest management activities on federal land within the Plan area. The widths of these riparian reserves varies; they were designed to be at least 300 feet (equivalent to the minimum potential height of two trees at that site) along fish-bearing streams and 150 feet (minimum one site-potential tree height) along non-fish bearing and intermittent streams. These widths are termed "interim," open to change as our knowledge advances, especially relative to site-specific conditions. In this regard, adaptive management is at the heart of riparian reserve designs.

"The concept behind riparian buffers is to maintain and restore aquatic and riparian con-

ditions and ecological integrity on the landscape," Olson explains.

The buffer widths were based on the best science at the time, but were largely untested. Headwater watersheds in western Oregon are generally considered prime timberland. With the buffers now extending stream-riparian protections into headwaters, questions were raised about how wide buffers need to be to retain aquatic conservation strategy objectives around those small streams. Furthermore, relative to forest management, how might riparian buffers adapt with upland harvest practices—would buffers be the same for a selective harvest versus a regeneration harvest?

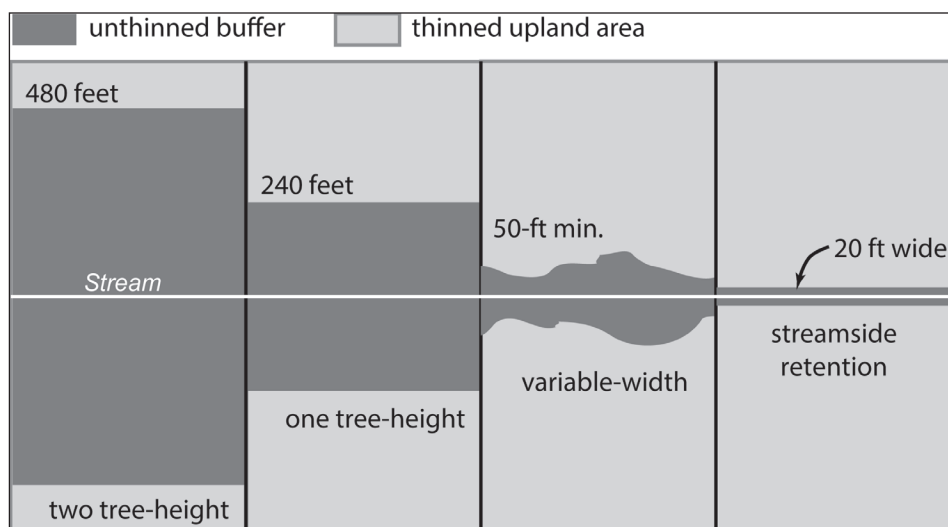
To answer these questions, scientists with the Forest Service, Bureau of Land Management, Geological Survey, and Oregon State University initiated the Density Management and Riparian Buffer Study of western Oregon (DMS) in 1994. They projected that much of the federal forest landscape in western Oregon would be ready for commercial thinning in about 20 years (2014). With this in mind, study objectives focused on learning about thinning with riparian buffers. Similarly, with the Northwest Forest Plan's emphasis on late-successional forest, the DMS initiated experiments designed to learn how to restore or accelerate development of old-forest conditions. Specifically, the integrated study addresses the effects of thinning and buffers on multiple resources such as aquatic and riparian vertebrates, tree growth, and vegetation. It was designed as an operational-scale experiment, which means the treatment sizes were equivalent to what land managers might really use for a project. The study is ongoing, and a wealth of knowledge is emerging from its various components.

IS THIS A STREAM?

Olson leads the aquatic vertebrates and habitats component of the DMS. She designed riparian buffer widths for implementation across 13 study sites in headwater areas of the Oregon Coast and Cascade Ranges. The sites were selected as representative of federally managed timber land. Initially, the study sites were dominated by second-growth 30- to 80-year-old Douglas-fir and hemlock.

Olson's team first surveyed the sites to gather baseline information. "I wanted to be able to characterize the aquatic-riparian habitats and fauna, to add some specificity to headwater values in managed forest stands, and apply that knowledge to the somewhat vague aquatic conservation strategy objectives," she explains. Early results from 106 headwater streams across 12 of the 13 sites found that most of the streams were discontinuous rather than seasonal. They found 15 species of fish and amphibians, including nine species of salamanders.

Salamanders can be stream dwellers, bank dwellers, or upland terrestrial creatures and are seen as biodiversity indicators to the health of the system. "Salamanders are central to the food web," explains Olson. "They collect energy from streams and then transfer aquatic nutrients to the terrestrial system as they venture upland. If they are eaten by a bird or shrew, then that transfers energy to the terrestrial food web. Many salamanders return to water for breeding. When they deposit their



This schematic illustrates the four different buffer widths used in Density Management and Riparian Buffer Study experiments.

eggs, they bring terrestrial nutrients back to the water. They are really critical to the energy flow in a forest. Others have found that salamanders may even have a role in carbon sequestration due to the quantity of invertebrates they eat that break down leaf litter."

Of the 15 species recorded, many have strong associations to features specific to small headwater streams. Torrent salamanders (*Rhyacotriton* spp.), for example, emerged as a focal taxon. "Torrent salamanders, which are species of concern in Oregon and Washington, are associated with the upper-

most intermittent streams, for example. You don't see them in big water," Olson says. She recognized the taxon as a potential indicator of change to both physical habitat conditions of streams and its biotic community.

"Historically, streams and stream habitat have been looked at from a fish-centered point of view," she continues. "Our work has helped characterize what is a headwater stream, especially beyond the point of continuous water, what stream habitat attributes are associated with headwater species, and how forest management may affect those species and habitats."

TESTING DIFFERENT BUFFER WIDTHS

Over the years, the upland stands were thinned as part of the DMS experiments, and resurveys were conducted to monitor responses of selected attributes. The initial thinning harvest reduced overstory tree densities to about 80 trees per acre. Twelve years later, a second thinning brought the stands to about 30 trees per acre, approximating the overstory tree density of the largest trees in old-growth stands in the area. It has been about 5 years since the second thinning, and Olson is synthesizing her findings from the past 20 years.

Olson's component of DMS has assessed the effects of these harvest treatments in combination with four different no-entry buffer widths on headwater stream habitats and stream and riparian organisms. Measuring from stream center, the narrowest buffer is about 20 feet on either side of the stream. It's followed by the 50-foot minimum variable-width buffer; "variable width" provides flexibility so the buffer can be expanded to include seeps, steep slopes, unique vegetation, or other distinct



Loretta Ellenburg

This site illustrates a 50-foot minimum buffer where the upland forest has been thinned twice in the past 20 years.

microhabitats that are site specific. The third buffer is about 240 feet (roughly the height that the tallest tree species could grow at a

productive site), the current interim riparian reserve requirement for these fishless streams. The fourth buffer is 480 feet, equivalent to

two site-potential tree heights. At each site, all riparian buffer treatments were paired with streams in an untreated control unit that received no upland thinning.

After documenting prethinning conditions, Olson's next objective was to see what effect, if any, buffers had on headwater stream habitats and instream and streambank communities after upland thinning. With her partners, she has analyzed 45 stream reaches at eight study sites in years 1, 2, 5, and 10 after the first thinning and through year 1 after the second thinning.

All species noted initially were present through the two thinning harvests, but Olson's team has documented a significant decrease in counts of two taxa within the narrowest buffer (20 feet). Ten years after the first thinning, fewer bank-dwelling Dunn's salamanders (*Plethodon dunni*) were seen in reaches with that narrowest buffer. One year after the second thinning, the decrease in numbers of bank-dwelling Dunn's salamanders persisted. Torrent salamander numbers also declined in streams with the 20-foot buffer, whereas counts of both Dunn's and torrent salamanders *increased* after timber harvests in streams with the 50-foot minimum buffer and the 240-foot buffer. No changes to the stream channels



Matt Kluber

Upland salamander species such as this ensatina (Ensatina eschscholtzii) use riparian corridors to move about the landscape.

in terms of width or depth of pools, or substrate composition were noted with any of the buffer widths.

Olson and her colleagues also examined the habitat associations and movements of

woodland salamanders along these buffered streams. They found that some terrestrial salamanders were highly associated with riparian forests within 50 feet of small streams. That's where the terrestrial salamanders were most often found. "I think these riparian buffers are very much an I-5 corridor of movement," says Olson. "This added function as a potential connectivity corridor is another reason to support near-stream zones as important habitat for nonaquatic salamanders, and consideration for riparian reserve benefits."

Knowing that salamander populations exist across the forest landscape, Olson has pondered how these tiny animals might move between drainages that have no connecting streams. For terrestrial salamanders in the Coast Range to get to another watershed, they must go up and over ridgelines. This dispersal ability is important to allow gene flow among different populations. She points out that a one-tree height riparian reserve isn't usually sufficient to provide over-ridge connectivity for salamanders. Yet, using those riparian reserve networks as jumping-off points, the shortest distances over ridgelines are at headwaters. For animals like salamanders, down wood serves as refugia for and could be used as stepping stones to an adjacent drainage.

WANTED: LARGE TREES

Large trees eventually become large pieces of downed wood, which is critical habitat for many species both in and out of the stream. Along the bank and upslope, large logs create microhabitat and travel routes for small organisms. In streams, down wood creates habitat for fish and structure for other aquatic life. Given the importance of recruiting large down wood in riparian areas, a key management question for forests where the riparian areas were previously harvested is how to accelerate tree growth and hasten the creation of conditions characteristic of older forests. One piece of this is growing large trees that will someday be large down wood.

With partners Kenny Ruzicka and Klaus Puettmann of Oregon State University, the scientists found that thinning upland of riparian buffers increased the growth of trees within the no-entry buffers, to a distance of 50-feet from the upland-buffer edge.

If a management goal is to increase the growth rate of trees in the riparian area while minimizing disturbance effects, this kind of information is very relevant.

"You might consider thinning inside the



Loretta Ellenburg

Large trees eventually produce pieces of large down wood, which store carbon and water and provide habitat used by a variety of organisms including Oregon slender salamanders (Batrachoseps wrighti), shown guarding eggs above. Scientists tested how tree growth in headwater riparian buffers could be accelerated with upland thinning.

interim riparian reserve, for example, to make more light or nutrients available to remaining trees to accelerate their growth,” Olson says. “Yet if you take trees by thinning, you may affect the microclimate, litterfall, and disturb the substrate, so there are reasons why you’d want to stay out of the near-stream zone as well. If that’s a priority, a 50-foot no-entry zone along these small streams can still lead to accelerated tree growth to accelerate the development of future large trees and large down wood.”

With Julia Burton of Oregon State University, Olson and Puettmann examined instream wood. They found most of it was fairly decayed and clearly a legacy of the previous old-forest stand. Streams with 20-foot buffers, had more small wood showing early stages of decay, but because most of the total wood


LAND MANAGEMENT IMPLICATIONS


- Retaining a no-entry zone 50-foot minimum variable-width buffer along each side of the headwater streams benefits sensitive salamander species that can serve as biodiversity indicators for riparian and aquatic systems.
- Thinning upland of riparian buffers accelerated tree growth within buffers to a distance of 50 feet from the buffer edge, supporting the role of thinning to within 50 feet of the stream to accelerate riparian forest restoration.
- These findings support thinning within a portion of the interim riparian reserves of the Northwest Forest Plan to facilitate ecological restoration in the riparian area along headwater streams in western Oregon.

volume was in late-decay stages, there was no overall effect of buffers on instream wood volume. Again, 50 feet appears to be a significant

distance for aquatic-riparian conditions: more than 80 percent of the wood came from source trees within 50 feet of streams.

KEEPING ALL THE PIECES

“It’s really a multistate system,” Olson says, “And if you want to keep all the states, you need to consider all the parts and then identify how to keep all the pieces. If you don’t, it may become a much more simplified system.

“Now we know that the idea of a stream continuum, where you would find different fish species as waters increase in size, is a concept that runs both directions, with amphibian diversity dominating headwaters.” There are different species at different points along a stream, and these are parts of the aquatic-riparian conditions to consider for protection.

I think we now have several lines of support from our animal, habitat, and vegetation data that a 50-foot minimum buffer around headwater streams in western Oregon maintains many of the parts of the stream and riparian function with upland thinning.”

Olson points out, “We studied small streams, with thinning. We don’t know what would happen if you were to have a 50-foot buffer with upslope clearcutting.” She makes two more caveats: the length of the study area along each stream was relatively short—about 750 feet. “It would be more informative if

we could study longer stream reaches with a single buffer width,” she says. “Secondly, our results do not have inference to larger reaches downstream that are used by fish.”

“There is room for more work, but this gets us thinking about how to manage headwater riparian areas,” Olson says. “I don’t think we are trying to re-create historical conditions. I think we are trying to retain and improve what we have now.”

*“There are no extra pieces
in the universe...”*

—Deepak Chopra

FOR FURTHER READING

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SCIENTIST PROFILES



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