

Science

FINDINGS

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“Science affects the way we think together.”

Lewis Thomas

SAVING STREAMS AT THEIR SOURCE: MANAGING FOR AMPHIBIAN DIVERSITY IN HEADWATER FORESTS



Headwaters make up more than 75 percent of the total stream network, yet regulatory protections are often weaker within headwaters owing to their lack of fish.

*“To protect your rivers,
protect your mountains.”*

—Emperor Yu of China

Forest managers have long understood the importance of protecting streams and their adjacent riparian areas. Indeed, stream buffers are the cornerstone of most strategies to safeguard forest biodiversity, water quality, and ecological integrity. And although nearly everyone agrees that stream protection is important, there is no consensus on exactly what constitutes a stream—at least in regulatory terms. Many forest policies only afford protection to streams that support fish. However, new research is expanding our perspective beyond this fish-centric view and suggesting a need for alternative

management designs for upstream headwater riparian areas.

By definition, headwater streams are small, usually less than 6 feet across. But what they lack in width they make up for in length: more than 75 percent of the total stream network is headwater streams. They are the source of much of the water, gravel, wood, and nutrients that flow through the stream network and eventually to the ocean. Owing to favorable microclimate and availability of water, headwaters provide habitat for distinct assemblages of plants and animals.

“Headwater streams and riparian areas are a nexus of biodiversity, with disproportionate numbers of species tied to this habitat,” says Dede Olson,

IN SUMMARY

Although stream protection has become a central tenet of forest management in the Pacific Northwest, it is often only the larger, fish-bearing streams that are afforded the strongest safeguards. Yet, even without fish, headwater streams and riparian areas are hotspots of biodiversity, and they are the source of much of the water, gravel, and nutrients that subsidize downstream environments. Amphibians, in particular, thrive in the relatively cool and moist microclimate created by headwater streams. In fact, more than a quarter of amphibian species in the region have life histories reliant on headwaters.

Scientists working on the Density Management and Riparian Buffer study recently completed the first phase of research into the effectiveness of riparian buffers as habitat reserves in headwater forests. They found that even when using the narrowest riparian buffer (20 feet), thinning upslope did not adversely affect headwater amphibian populations; slightly wider buffers (approximately 50 to 75 feet) defined by transitions from riparian to upslope vegetation or by streamside topography were sufficient to maintain headwater stream microclimates. In some cases, abundances of upslope, terrestrial salamanders were reduced within the region of active thinning, but these impacts were small and short-lived. This suggests that combined stream buffers and upslope thinning may effectively retain amphibian headwater habitat and communities, and could aid in establishing connectivity for terrestrially dispersing amphibians across ridgelines and adjacent headwater drainages.

a research ecologist at the PNW Research Station in Corvallis, Oregon. “Nevertheless, our knowledge of the ecology of these systems remains sparse, even though they are undergoing widespread degradation at alarming rates.”

Headwater streams are distinct from their downstream counterparts in many ways. “Tightly constraining valley walls and riparian vegetation often shade the full width of headwater streams,” explains Paul Anderson, a research forester at the PNW lab in Corvallis. “This contributes to microclimates that are unique to headwaters and that influence stream temperatures and habitat for terrestrial and aquatic organisms.”

Some headwater streams are seasonally intermittent, running dry in the heat of the summer. Others periodically flow underground into the “hyporheic zone” before resurfacing further downstream. These features, along with frequent cascades and obstacles, explain the lack of fish, which turns out to be a boon for some amphibians, such as torrent salamanders, that thrive in fishless headwaters.

Amphibians, in general, seem to flourish in headwater streams and forests. All 47 Northwestern amphibian species have stream-

KEY FINDINGS	
<ul style="list-style-type: none"> • Unique amphibian assemblages occur in headwater streams of managed forests in western Oregon, with some species having close ties to stream hydrology patterns such as spatially intermittent reaches. 	
<ul style="list-style-type: none"> • Instream and bank amphibians in headwaters of managed forests were not adversely affected by upslope thinning to 80 trees per acre when riparian buffers 20 to 450 feet wide were retained adjacent to streams. 	
<ul style="list-style-type: none"> • Abundances of terrestrial salamanders occurring from banks to uplands were reduced after thinning in some cases, and not in others. Site-specific conditions appear to be linked to their responses, where habitat features such as legacy down wood or occurrence of rocky substrates at sites may ameliorate effects of overstory removal. 	

riparian associations, and a quarter of those have life histories reliant on headwaters in particular. Because amphibians require cool, moist microclimates and often divide their life history between the stream and upslope forests, they can be quite sensitive to forest disturbances, particularly logging. According to Olson, monitoring the status of amphibian populations may be an effective barometer for estimating the impacts of forest management on ecosystem integrity. She is now involved in a study that puts that theory to the test.

Olson and Anderson are investigators in a large, multidisciplinary study that is quantifying ecosystem effects of novel types of forest management in headwater forests: The Density Management and Riparian Buffer study. They recently completed the first phase of research, which documented the efficacy of headwater riparian buffers for maintaining microclimate and amphibian populations in association with thinning projects designed to restore old-growth forests on federal lands.

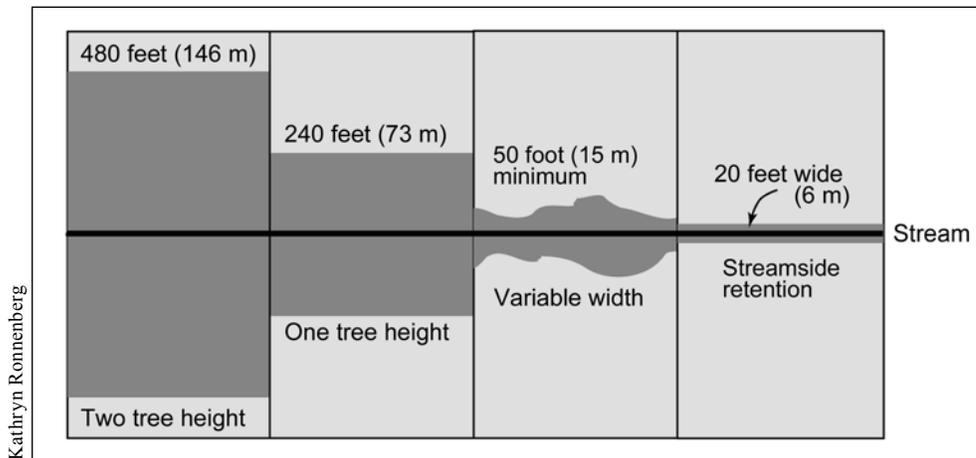
EXPEDITING OLD GROWTH

From the 1950s until the 1980s, the Forest Service and Bureau of Land Management (BLM) clearcut Douglas-fir forests at a rate unimaginable on federal lands today. This was before the spotted-owl controversy, during a time when old-growth

forests were commonly viewed as decadent and rotting. Many headwater forests were cutover during this period. Often, the streams themselves were used as flumes to transport the logs out of the forest. Today, the legacy of those harvests is evident within hundreds of

thousands of acres of young, dense, even-aged forests, all between 25 and 60 years old.

Clearly times have changed, and restoring old growth has become the management directive de jour. The challenge managers face now



Kathryn Ronnenberg

The Density Management and Riparian Buffer study was designed to test the effectiveness of different buffer widths for protecting amphibian assemblages and microclimate around headwater streams while thinning harvests were conducted upslope.

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is learning how to expedite the development of old-growth conditions from plantations. Time is obviously one key ingredient, but dense young forests left to their own devices do not readily transform into structurally diverse old growth. Aggressive thinning is seen as the pathway to restoration. Thinning opens the canopy, freeing up sunlight and other resources, which increases growth in the remaining trees while also allowing an understory canopy to establish.

The Density Management and Riparian Buffer study was designed to test the ability of thinning to produce old-growth characteristics while also minimizing ecological impacts of harvest operations. Study sites were primarily on forests managed by the BLM distributed throughout the Oregon Coast Range and Oregon Cascade Range.

“The thinning in our study was originally viewed as aggressive,” says Anderson. “Our objective was to open the canopy enough to allow sufficient light to spur tree regeneration and so that it stayed open until those trees become established. Twenty years ago, thinning from 200 trees per acre down to 100 would have been considered a heavy thinning. For our objectives we thinned to 80 trees per acre—and that might not even be enough. It’ll only be 8 to 10 years before the overstory canopy closes back up.”

Loggers left the largest trees and thinned the rest in a nonuniform pattern. Canopy cover was no less than 40 percent after harvest. They also cut several ¼- to 1-acre patches



Thinning was used to lower the density of second-growth forests from over 200 trees per acre down to about 80. This will accelerate growth in the remaining Douglas-fir trees and promote new understory canopy.

and left several ¼- to 1-acre retention islands, all in an effort to maximize forest stand heterogeneity.

The study was designed to test four riparian buffer widths wherein no cutting was allowed. The buffers corresponded to the range of current federal and state forest practices and

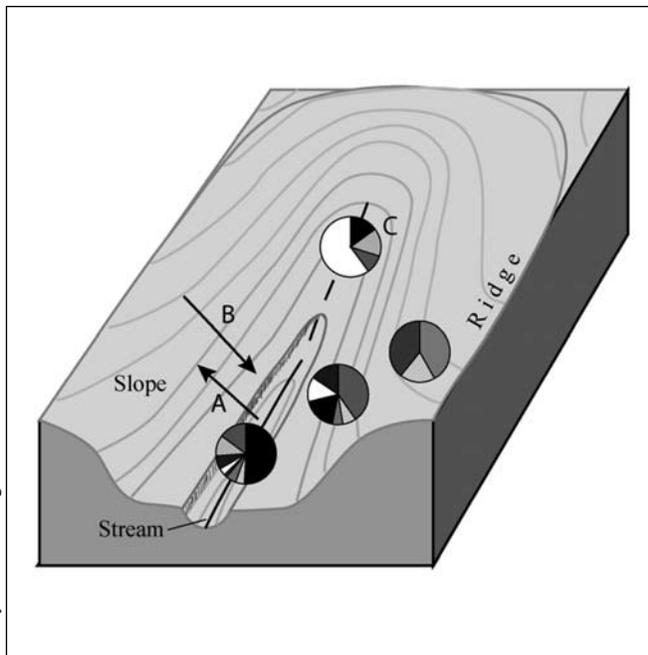
ranged from 20 to 475 feet, on each side of the stream. One treatment had variable buffer widths depending on site-specific boundaries between riparian and upslope topography and vegetation; this strategy mimics recent practices on federally owned headwater forests.

WORKING IN THE ZONE

Olson and several colleagues sampled amphibian abundances and diversity along 68 headwater streams throughout 11 thinning sites—carefully searching under cover items such as rocks and logs in streambeds and along streambanks, and in upland transects at a couple of case study sites. They sampled one year before and two consecutive years after the thinning. “They are cryptic animals and we survey during the wet spring when they are most active at the ground surface,” explains Olson. “Some amphibians go subsurface in the summer, and may or may not emerge again in the fall when it rains.”

The headwaters lived up to their reputation as amphibian hot spots. All told, the researchers captured and released more than 3,000 individuals representing 13 amphibian species. The coastal giant salamander, Dunn’s salamander, western red-backed salamander, and torrent salamander were, by far, the most frequent captures.

Kathryn Ronnenberg



Headwater stream drainages showed differences in amphibian assemblages, both with streamflow regime and distance into uplands, as shown by pie diagrams with different wedges representing the relative abundance of different species. In this diagram, “A” indicates the area of the “stream effect” where microclimates are affected by streams, and “B” indicates the upland edge effect from forest management activities. “C” indicates a different amphibian assemblage occurring in spatially intermittent streams, compared to perennially flowing water downstream, where torrent salamanders (white edge) are frequently found.

“I was disappointed that we didn’t find more tailed frogs,” says Olson. “They are listed as a sensitive species in the region and don’t seem to do as well in these managed forests.”

The good news is that the harvesting operations had little impact on amphibian populations. “Instream- and bank-dwelling amphibians were not adversely affected by the thinning upslope,” says Olson. “In some cases, abundances of upslope, terrestrial salamanders were reduced within the region of the active thinning, but these reductions were small and short-lived.”

“Overall, I think the thinning was a rather benign disturbance from an amphibian point of view,” she adds.

William Leonard



Southern torrent salamanders were associated with spatially intermittent headwater streams, and are a species of concern in the region.

COOL AND MOIST

In riparian areas, open water surfaces, moist soils, and abundant vegetation contribute to the formation of unique microclimatic conditions that extend laterally from streams,” explains Anderson. “The streams create a distinct local environment through influences on air temperature and humidity. This is what we call the stream effect, and it can have a pronounced effect on riparian plants and wildlife.”

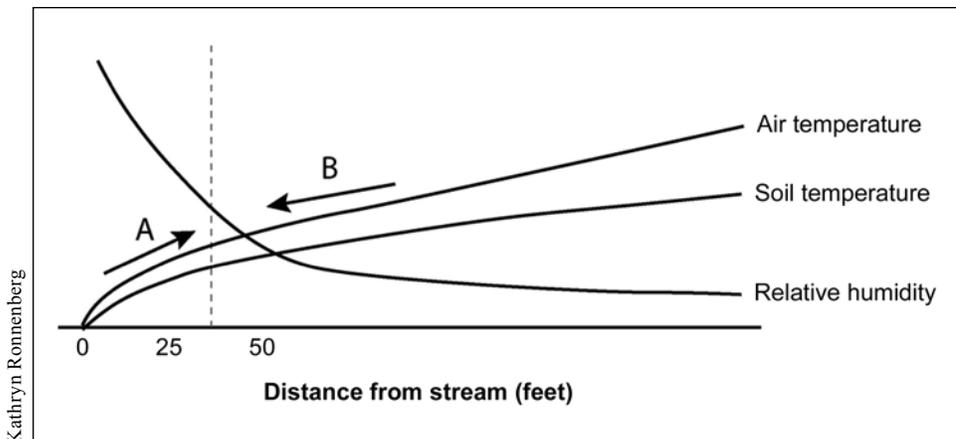
“The Density Management study allowed us to examine the stream effect within headwater systems, where it has received less attention,” says Anderson, who tested whether riparian buffers of varying width could effectively maintain the stream effect, even in the face of aggressive thinning immediately upslope.

Using electronic data loggers, researchers recorded temperature and relative humidity along transects from stream center upslope

into the thinned stands, patch openings, and unthinned forest. As expected, temperature increased with distance from the stream, whether or not there was thinning upslope. The stream effect was greatest within 30 feet of the stream; beyond that, temperatures increased at a lesser rate. Relative humidity followed the same general pattern but decreased with distance from stream.

Thinning increased temperature and reduced humidity upslope within the harvest area, but with variable-width or wider buffers, the harvest had only subtle influence on the microclimate around the stream. In fact, the average air temperature at stream center was less than 1 degree greater than in unthinned stands. According to Olson, that’s well within the tolerance of most amphibians.

“The changes we saw represent the absolute maximum effect on microclimate. We took our measurements at the hottest time of day during the warmest summer months. The microclimatic influence of these thinnings during spring, when amphibians are surface active, would likely be much less.”



Kathryn Ronnenberg

Retention of the “stream effect” on microclimate may be a consideration of headwater stream-riparian management. In this diagram, “A” indicates the area of the “stream effect” where microclimates are affected by streams. “B” indicates the edge effect from upland thinning outside of riparian buffers on streams. The vertical dashed line shows where the steep gradient of the stream effect begins to moderate.

WRITER’S PROFILE

Jonathan Thompson is an ecologist and science writer. He lives in Corvallis, Oregon.

RESERVE DESIGN

All the thinning treatments included in this study thus far incorporated a riparian buffer, and even the narrowest of these—just 20 feet across—effectively protected amphibian populations. The next phase of research will evaluate the impact of thinning across the headwater streams themselves. “We certainly wouldn’t have moved on to phase two, had we gotten different results in phase one,” says Olson.

Understanding the full range of impacts associated with thinning will help forest policymakers develop more effective regulations for managing headwater riparian forest. Whereas protection standards for fish-bearing streams are relatively consistent and robust across all ownerships, protections for non-fish-bearing streams differ widely.

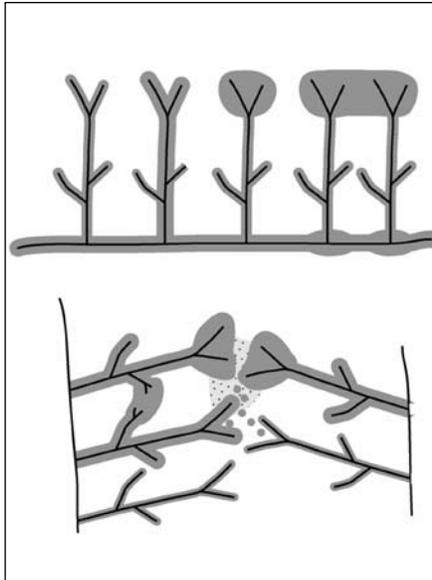
Since 1994, when the region’s federal forests came under the jurisdiction of the Northwest Forest Plan, fishless headwater streams have been protected by a buffer one tree height wide, although narrower buffers are often used after site-specific conditions have been assessed. On state and private lands in Oregon and Washington, small headwater streams have no required buffers at all.

Although Olson and Anderson hesitate to make specific management recommendations, they have outlined some features of a headwater protection strategy that they believe are important. “A reserve system should be designed to retain all habitats used by target species of amphibians, recognizing their complex life histories that bridge aquatic and terrestrial habitats. These include a mix of riparian and upslope management approaches to address the breeding, foraging, overwintering, and dispersal functions of these animals,” says Olson.

“Connectivity of habitat, both longitudinally along streams and laterally away from streams into uplands, is also important for long-term persistence of headwater amphibian species and assemblages,” she adds. “Amphibians are surprisingly mobile, and in order for populations to persist over the long term, there needs to be linkages connecting adjacent headwater streams. This means extending some of the buffers protecting adjacent headwater streams up to the ridgeline where they would connect.”

Reserve designs that explicitly incorporate landscape connectivity in headwater forests result in what Olson calls the “spaghetti and meatballs design.” On a map, it’s easy to see why: long, narrow buffer strips run parallel to the streams (the spaghetti) protecting instream- and bank-dwelling species while also preserving the “stream effect” on microclimate. Near the ridgeline, or adjacent

LAND MANAGEMENT IMPLICATIONS
<ul style="list-style-type: none">• Stream buffers in thinned stands may effectively retain amphibian headwater habitat and communities, and could aid in connecting amphibian habitat across ridgelines and adjacent headwater drainages.
<ul style="list-style-type: none">• Retention of legacy down wood and active management for recruitment of down wood in managed stands may be beneficial to ground-dwelling terrestrial salamanders.
<ul style="list-style-type: none">• Riparian buffers of various widths can be used to moderate changes to riparian and above-stream microclimates when timber harvest occurs in adjacent headwater forests.



Kathryn Ronnenberg

Headwater reserve designs for riparian management to retain amphibian communities include a “spaghetti and meatball” approach, with stream buffers of different widths as spaghetti and patch reserves in different configurations as meatballs to provide connectivity among streams over ridgelines.

to the streams, protected patches (the meatballs) may connect habitat and allow individuals to move across the landscape.

According to the researchers, more research is needed into different strategies for protecting headwater forests in the face of thinning and other types of forest management. For now, simply acknowledging that small, non-fish-bearing streams are an important ecological resource deserving protection is a big step in the right direction.

“Water is the most critical resource issue of our lifetime and our children’s lifetime. The health of our waters is the principal measure of how we live on the land.”

—Luna Leopold

FOR FURTHER READING

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SCIENTIST PROFILES



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PAUL ANDERSON is a supervisory research forester with the Resource Management and Productivity Program at the USDA Forest Service, Pacific Northwest Research

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