CFER News

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In this issue...

Research Synthesis:

Influence of Forest Management on Headwater Stream Amphibians

Amphibians are important components of headwater streams in forest ecosystems of the Pacific Northwest (PNW). They comprise the highest vertebrate biomass and density in these systems and are integral to trophic dynamics both as prey and as predators. The most commonly encountered amphibians in headwater streams in the PNW include the Pacific giant salamander (*Dicamptodon tenebrosus*), the tailed frog (*Ascaphus truei*), and torrent salamanders (*Rhyacotriton* spp.).

Several studies of headwater stream amphibians have examined species-habitat associations of streams in managed and unmanaged forest stands. Results from some of these studies suggest that logging practices at the stand scale may impact species presence and abundance by directly or indirectly altering stream and riparian habitat. Habitat associations have also been well studied at the stream reach scale. However, the influence of larger spatial scale patterns (such as landscape structure) is unclear. Identifying the effects of forest management practices on headwater amphibians at different spatial scales is fundamental to the development of appropriate riparian management practices.

As part of her graduate research under the direction of John Hayes, Margo Stoddard investigated the relationships between Pacific giant salamanders, metamorphosed tailed frogs, larval tailed frogs, and torrent salamanders, and habitat characteristics measured at four spatial scales (2-m sample unit, intermediate, sub-drainage, and drainage). Specifically, the goals of the study were to: 1) identify and rank the importance of habitat characteristics in predicting amphibian occurrence at small spatial scales; 2) identify and rank the importance of geophysical and management-related characteristics in predicting amphibian occurrence at three larger spatial scales; 3) examine patterns across scales; and 4) evaluate habitat models at each spatial scale that could be used to

Continue next page

CFER Cooperative Forest Ecosystem Research

Continued from front page

develop riparian and upslope management strategies that maintain adequate habitat for stream amphibians.

In early 1998, a population of potential study sites were identified from GIS (Geographic Information System) maps of land ownership, streams, and forest age classes. Potential study sites included all third-order drainages in the Eugene and Salem Districts of the Bureau of Land Management (BLM) on the east slope of the Coast Range mountains. To assure that a range of management conditions was represented, drainages were stratified into "low," "moderate," and "high" management intensities based on the percentage of forest >55 years old in each drainage. Drainages in each management intensity category were then randomly selected from a list of all potential sites (five intensively logged drainages, five moderately logged drainages, and six drainages subjected to low logging intensity).

Amphibian sampling and microhabitat classification was conducted in 702 two-meter lengths of stream or sample units, the smallest spatial scale examined in this study. Each segment was carefully searched for amphibians by overturning stream substrates. In addition, instream and streambank habitat characteristics representing geomorphic, vegetative, topographic, and physical characteristics were measured.

Macrohabitat classification was based on characteristics measured at the intermediate, sub-drainage, and drainage spatial scales. The intermediate spatial scale was defined according to the age class combination around one or more sample units. All contiguous sample units with the same combination of forest age classes along the stream represented an age-class combination. Explanatory variables for analysis at this spatial scale included age-class combination, presence of a forested band at least 150 ft. (46 m) in width on each side of the stream, aspect, and stream gradient. A sub-drainage was defined as the catchment basin above a given sample unit, and a drainage was defined as the catchment basin above the furthest downstream point where sampling began. Variables included at the sub-drainage and drainage scales related to the proportion of young (<15 year old) forest, road density, side-slope characteristics, aspect, and proportion of stream length bordered by forested bands (>150 ft. in width).

For each spatial scale (sample unit, intermediate, sub-drainage, and drainage), Stoddard examined all logistic regression models with four variables or fewer to determine the odds of occurrence of Pacific giant salamanders, metamorphosed tailed frogs, larval tailed frogs, and torrent salamanders in relation to habitat or forest structure characteristics. Models were ranked using Akaike's Information Criteria (AIC). Measures based on AIC help to assess the strength of individual models with the lowest value representing the most appropriate model. Akaike weights, which are estimates of the relative likelihood of each candidate model given the data, were used to assess the importance of the individual parameters.

At the smallest spatial scale, occurrences of all amphibian taxa were negatively associated with decreasing substrate size. At the intermediate and sub-drainage scales, variables related to the geophysical characteristics of streams or drainages (i.e., gradient and aspect) were important for all species or life stages except metamorphosed tailed frogs. At large spatial scales, variables related to forest condition (i.e., the presence of a forested band ≥150 ft. in width on each side of the stream, or the percentage of stream length with a forested band ≥150 ft in width) around streams were important in predicting amphibian occurrence (Table 1).

At all spatial scales, the combined influences of habitat structure and geophysical location were important in determining amphibian occurrence. In most cases, the importance of these variables could be related to known life-history requirements including cover, lack of sedimentation, thermal requirements, and habitat for foraging, movement, or dispersal. These requirements and activities that affect these requirements should be considered when maintaining amphibian habitat as a management goal. For example, forest management activities that increase sedimentation or stream temperatures should be minimized around small streams in which metamorphosed tailed frogs may congregate to breed and torrent salamanders are likely to occur. One approach that has been suggested to achieve this is to retain blocks of land around small headwaters. Conservation approaches for tailed frogs should also consider differences in habitat requirements among life stages. Stream width and aspect of the stream or sub-drainage could help identify where tadpoles would likely persist if logging upslope occurred. Similar requirements regarding forested riparian areas and stream aspect were observed for Pacific giant salamanders. Forested habitat could be maintained along streams in which tadpoles and Pacific giant salamanders are likely to occur (relatively wide with northerly aspects), protecting stream habitat and providing corridors in which metamorphosed amphibians may forage or along which they may move.

In addition to corroborating previous research findings on amphibian habitat relationships (e.g., substrate composition, stream width, elevation), this study provides new insights on linkages between amphibian responses across spatial scales and also demonstrates that landscape scale variables (e.g., the presence of a forested band or the percentage of forested stream length) can be used to assess management approaches for stream amphibian communities. Furthermore, these findings will facilitate determination of conservation emphasis areas or less sensitive sites for management. To increase our understanding of ecological relationships across scales, however, the influences of broad-scale variables on amphibian responses at finer spatial scales should be investigated further. ❑

Margo Stoddard received her Master of Science degree from Oregon State University in June of this year. A publication based on her thesis research results is under preparation.

John P. Hayes is program coordinator and a wildlife ecologist for the CFER program. He also serves as an associate professor in the Department of Forest Science at Oregon State University.

Table 1. Summary of most important variables in predicting species occurrence at all spatial scales. Variables are listed in order of decreasing importance weights. Odds of finding each species increased as variable values increased, except for "gradient" (Pacific giant salamanders only) and "young forest," which were negatively associated with odds of occurrence. The variable "aspect" represents a continuous measure ranging from south-westerly (warmer) slopes to north-easterly (cooler) slopes.

Species	**Scale**			
	Sample Unit	**Intermediate**	**Sub-drainage**	**Drainage**
Pacific giant salamanders	Large substrate Width	Forest≥150 ft Gradient Aspect	Forest≥150 ft Slope>60% Aspect Gradient	Forest≥150 ft
Larval tailed frogs	Large substrate Width Pool habitat	Old forest Aspect	Area Forest≥150 ft Aspect Slope>60%	Forest≥150 ft
Metamorphosed tailed frogs	Large substrate Elevation	Forest≥150 ft	Forest≥150 ft Young forest	Forest≥150 ft
Torrent salamanders	Elevation Large substrate	Gradient Forest≥150 ft	Area Forest≥150 ft Young forest	Null

UP CLOSE:

Functional role of large wood

Stream systems exist in a dynamic environment, where disturbance events, such as landslides and debris flows, create and maintain complexity within the drainage network. The natural cycles of disturbance and reorganization result in periods of high wood and sediment loading and periods of low wood and sediment loading to channels, thus creating a diverse array of habitat types and availability over time. The associated spatial and temporal pattern of large wood inputs to streams is important because it effects channel morphology, the routing and storage of water and sediment, and provides structure and complexity associated with habitat for numerous aquatic and terrestrial organisms.

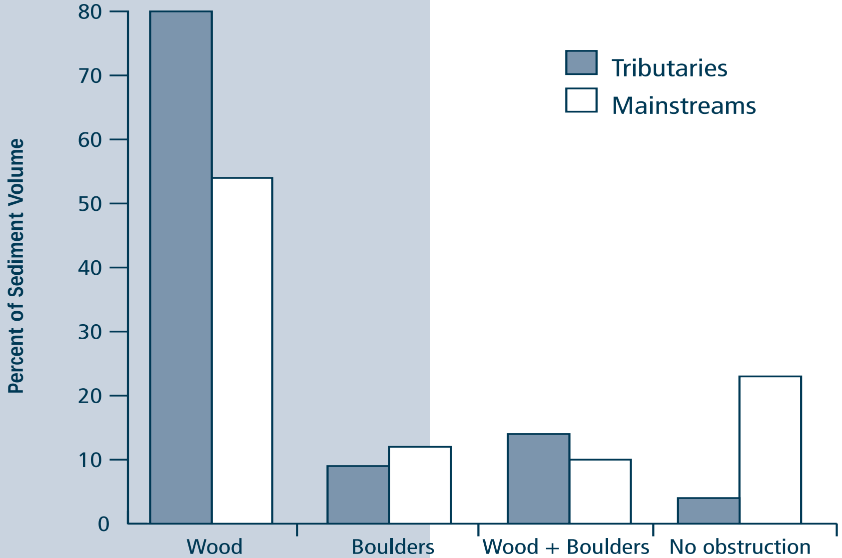
Identifying patterns of large wood recruitment and redistribution and understanding the broad spectrum of its functions is crucial for developing management strategies that provide for and maintain adequate levels of large wood inputs to streams. As part of her Ph.D. research under the direction of Dr. Robert Gresswell, Christine May is examining the geomorphic function of large wood in headwater streams in the Oregon Coast Range. Of particular interest is how the physical obstruction created by large wood influences sediment storage, and how wood interacts with streamflow and sediment at different locations in a basin.

During 1999-2000, May and her field crew measured the volume of large wood and sediment throughout Skate and Bear Creek drainages in the central Oregon Coast Range. The proportion of the streambed covered by wood-controlled sediment storage areas was measured to determine the relative importance of large wood in storing sediment. The size and orientation of wood that was storing sediment was also recorded.

May found that large wood was the focal point for sediment accumulation in steep headwater streams. Wood provided a physical obstruction to sediment transport, and 73% of the sediment in tributaries that were susceptible to debris flows was stored directly behind wood (Figure 1). Small wood (pieces < 2 m in length and < 20 cm average diameter) stored 14% of the sediment in the tributaries, and large wood stored 59%. Only 4% of the sediment was stored in the absence of wood and boulders. Large wood was also a major component of sediment storage in the mainstem of Skate Creek (54%); however, < 0.5% of the sediment in the mainstem was stored by small wood. In contrast to the tributaries, the mainstem had low-gradient reaches with relatively thin layers of gravel over bedrock that ranged from 1-5% slope. These low-gradient reaches were capable of storing sediment in the absence of wood or boulders.

May also found that the sediment storage capacity of channels that had

Figure 1. Sediment storage by wood and boulders in the channel network of Skate Creek. Numbers represent the percent of sediment stored.



been scoured to bedrock by a debris flow increased as wood was recruited to the channel, initiating a series of positive feedbacks. Sediment that was stored behind wood in the channel increased the streambed roughness, decreased the local slope of the channel, and further reduced the capacity for sediment transport. As a greater proportion of the streambed was covered by sediment, roughness continued to increase and more of the water began to flow subsurface, further decreasing surface water velocities. In addition, vegetation became established and root networks were able to hold the sediment in place.

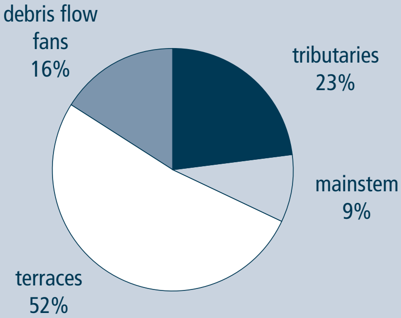
As part of the field measurements, a total length of 6860 m was surveyed in the channel network of Skate Creek, and a total volume of 21,950 m^3 of sediment was estimated to be stored in this portion of the network. The majority of sediment was stored in tributaries (Figure 2), which also comprised 69% of the channel length investigated. Alluvium in the mainstem streambed accounted for a relatively small proportion of the sediment. In addition to the channel network, 47,560 m^3 of sediment was stored in terraces and debris flow fans along the mainstem of Skate Creek. These valley floor landforms along the mainstem contained 2.2 times more sediment than the entire channel network; however, the residence time for this sediment is typically longer than that stored in the channel network.

Results from May's research suggests that small headwater streams have the potential to store large quantities of wood and sediment that can be episodically transported by debris flows. After wood and sediment are scoured from these small streams, recruitment of wood from streamside and upslope forests can replenish the channel in the interval between debris flow events. These small mountain streams are an important link between hillslope and fluvial processes, and between terrestrial and aquatic ecosystems. Policy and management historically placed less emphasis on small, often ephemeral, tributary channels and their associated riparian habitats because they do not directly provide habitat for fish. In recent years, however, it has become increasingly apparent that to maintain complex aquatic habitat, the physical and biological linkages among streams, riparian zones, and uplands throughout a watershed must also be considered. May cautions, however, that if forest management does not include plans for the continued function of these small streams, subsequent debris flows may be lacking large wood. Additionally, if these low-order streams are depleted of present or future sources of large wood, the sediment storage capacity of the basin will be drastically reduced. Without the input of wood, channels that have been scoured to bedrock by a debris flow may persist in a bedrock state for a greater length of time. Because there is no sediment storage in bedrock channels, these channels become a conveyor of sediment delivered from the adjacent hillslopes. This continual sediment transport would represent a major shift in processes, with headwater streams becoming a chronic source of sediment to downstream areas instead of an episodic source. ❑

Christine May is a Ph.D. candidate in the Department of Fisheries and Wildlife at Oregon State University. She plans to compete her dissertation by December 2001.

Dr. Robert Gresswell is an aquatic ecologist with the USGS Forest and Rangeland Ecosystem Science Center and a scientist on the CFER research team.

Figure 2. Sediment storage components of the drainage network of Skate Creek.



ANNOUNCEMENTS

Personnel Update

Dr. Dan Edge, who has served as a principal investigator for the CFER program since its establishment, has been selected to chair Oregon State University's Department of Fisheries and Wildlife. Due to his new responsibilities, Dan will be transitioning out of his position with CFER, but will continue to have graduate students involved in the program for the next several years.

Jennifer Weikel ended her appointment with CFER to accept a position as a Wildlife Ecologist for Pacific Wildlife Research Inc., a consulting firm based out of Corvallis, OR. During her time with CFER, Jennifer served as a research assistant in wildlife ecology and was involved in research examining effects of commercial thinning young Douglas-fir stands on songbirds. Jennifer's current work involves providing a variety of services including conducting wildlife surveys and providing analytical guidance for a variety of clients.

Awards and Honors

David Waldien, a Ph.D. student with Dr. John Hayes in the Department of Fisheries and Wildlife at Oregon State University, was selected as one of the recipients of the 2001 University Club Foundation, Inc. Graduate Fellowship Award. The purpose of the Award is to recognize and encourage scholarship, demonstrated leadership, and potential societal contributions by outstanding graduate scholars. Four scholarships were granted from a total of 12 nominations submitted by the major academic institutions in the state. We are pleased and proud that Dave was one of the recipients for this prestigious award. The award carries a $5,000 stipend.

Christine May, a Ph.D. student with Dr. Robert Gresswell in the Department of Fisheries and Wildlife at Oregon State University, was awarded the Richard A. Herbert Memorial Education Scholarship by the national chapter of the American Water Resources Association (AWRA). AWRA is the pre-eminent multidisciplinary association for information exchange, professional development, and education about water resources and related issues. The award is based on outstanding academic and research performance, including the quality of the student's research and its relevance to water resources. The award carries a $1,000 stipend.

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New Center Director

for USGS Forest and Rangeland Ecosystem Science Center

CFER welcomes Dr. Ronald E. Kirby as the new Center Director for the USGS Forest and Rangeland Ecosystem Science Center (FRESC). FRESC, a primary cooperator and supporter of the CFER program, is one of 17 Centers in the Biological Resources Division of the U.S. Geological Survey. The Center provides the primary financial support for CFER, as well as research support.

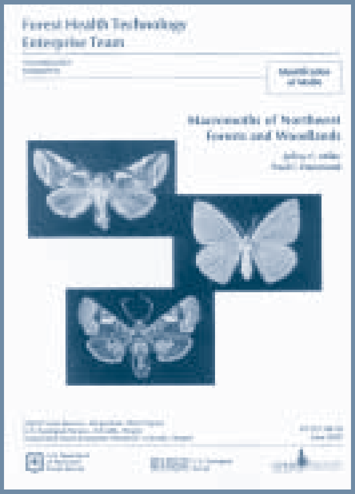
Ron accepted the position as the new Center Director in January of this year, and moved to Corvallis, Oregon in June. He succeeds Dr. Michael Collopy, who left the USGS to become Chair of the Department of Environmental and Resource Sciences, University of Nevada, Reno.

Ron brings a wealth of knowledge and experience to his new position with FRESC. He was an Angier B. Duke and National Merit Scholar at Duke University, Durham, NC, where he received a bachelor's degree in Zoology in 1969. He received a master's degree in Zoology and Wildlife Management from Southern Illinois University, Carbondale, in 1973 and his Ph.D. from the Department of Ecology and Behavioral Biology of the University of Minnesota, St. Paul, in 1976. He served as a research scientist at the Patuxent Wildlife Research Center, Laurel, Maryland, from 1976 to 1980, where he investigated winter ecology of Arctic-nesting geese and other waterfowl. In 1980, he accepted an invitation from the Wildlife Resources Program of the U.S. Fish and Wildlife Service to develop a "Research Coordinator" position for the Division of Refuge Management. He was responsible for identifying nationwide research needs and disbursing a budget of in excess of $3 million annually. In 1983, Ron became a founding member of a new research entity in the U.S. Fish and Wildlife Service, the Office of Information Transfer (OIT), Fort Collins, Colorado. He held positions on staff, as Section Chief, and as Acting Chief of this Office through 1990.

Most recently, Ron served as Assistant Director (1991-1992) and Center Director (1993-2001) for the Northern Prairie Wildlife Research Center. The Center, located near Jamestown, North Dakota, is the USGS Biological Resources Division's premiere research center for study of the breeding ecology of migratory birds and their habitat—especially waterfowl—in the mid-portion of the Continent.

Ron's personal research interests include waterfowl, especially Arctic-nesting geese, American black ducks, mallards, and wood ducks; salt marshes; and the integration of current agricultural and other land management practices with wildlife concerns on public and private lands. His current research includes investigation of the effect of hybridization on sex ratios of dabbling ducks, extent and consequences of marsh mass removal in salt marsh mosquito control operations, and identification of subadult geese.

The CFER program looks forward to working closely with Ron in partnership with state and federal researchers and resource managers to provide our cooperators with the information needed to evaluate and implement current and proposed forest ecosystem strategies and practices in the Pacific Northwest. ❑



Moth Field Guide Available

"Macromoths of Northwest Forests and Woodlands", a field guide written by Jeff Miller and Paul C. Hammond, provides diagnostic narratives and accompanying photographs for 251 species of moths and includes a discussion of over 300 additional moth species.

The USDA Forest Service's Forest Health Technology Enterprise Team published the guide, with support from the USGS Forest and Rangeland Ecosystem Science Center and the CFER program. Requests for the guide can be directed to the CFER office (phone: 541-737-7612).

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Credits

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Send your comments, article ideas, and requests to be added to our mailing list to:

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