Influence of Forest Management on Headwater Stream Amphibians at Multiple Spatial Scales

Background

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 PNW headwater streams include the Pacific giant salamander (*Dicamptodon tenebrosus*), the tailed frog (*Ascaphus truei*), the southern torrent salamander (*Rhyacotriton variegatus*), and the Columbia torrent salamander (*R. kezeri*).

Several studies of headwater stream amphibians have examined species-habitat associations in managed and unmanaged forests. 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 also have been well studied at the stream-reach scale; however, the influence of broader spatial-scale patterns (such as landscape structure) on amphibians is unclear. Because management activities at broad scales can influence habitat at finer scales, identifying the effects of these activities on headwater amphibians at different spatial scales is fundamental to the development of appropriate riparian management practices.

CFER scientists Margo Stoddard and John Hayes investigated the relationships between headwater stream amphibians (Pacific giant salamanders, tailed frog adults, tailed frog tadpoles, and torrent salamanders) and habitat characteristics measured at four spatial scales (2-m sample unit, patch, sub-drainage, and drainage; Figure 1). The goals of the study were to: 1) identify and rank the importance of habitat characteristics in predicting amphibian occurrence at fine spatial scales; 2) identify and rank the importance of geophysical and management-related characteristics in predicting amphibian occurrence at three broader spatial scales; 3) examine patterns across scales; and 4) evaluate habitat models at each spatial scale that could be used to develop riparian and upslope management strategies that maintain adequate habitat for stream amphibians.

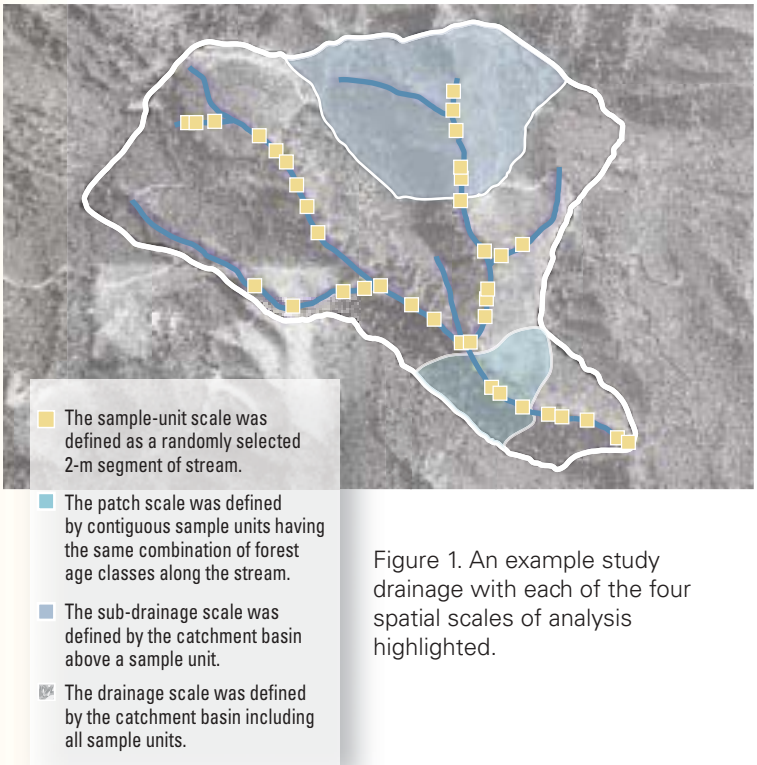

Figure 1. An example study drainage with each of the four spatial scales of analysis highlighted.

In 1998, a population of potential study sites was identified from 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 Oregon Coast Range. To assure 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 (Figure 2). Drainages in each management intensity category were then randomly selected from a list of all potential sites for a total of sixteen drainages (five intensively logged drainages, five moderately logged drainages, and six drainages subjected to low-logging intensity; Figure 3).

Figure 2. Digital orthophotographs of three of the study drainages with A) low, B) moderate, and C) high management intensities based on the percentage of forest >55 years old. Light areas on photos represent clearcut and young forest stands.

Amphibian sampling and microhabitat classification were conducted in 702 2-meter units. Each unit was carefully searched for amphibians by overturning stream substrates. Instream and streambank habitat characteristics representing geomorphic, vegetative, topographic, and physical characteristics also were measured. Macrohabitat classification was based on characteristics measured at the patch, sub-drainage, and drainage spatial scales. Variables examined at the patch scale included stand age(s) around the stream, presence of a forested band >55 years old and at least 150 ft (46 m) in width on each side of the stream, aspect, and stream gradient. Variables at the sub-drainage and drainage scales included the proportion of young (<15 years old) forest, road density, percent side-slope, aspect, and proportion of stream length bordered by forested bands >55 years old and >150 ft in width.

At each spatial scale, species-habitat association models were developed, and the importance of each habitat variable in determining species occurrence was determined. Models were ranked using Akaike's Information Criterion (AIC), and variable importance was assessed with Akaike weights (Burnham and Anderson 2002, *Model Selection and Multi-Model Inference: a Practical Information-Theoretic Approach*. Springer-Verlag. 488 pp.).

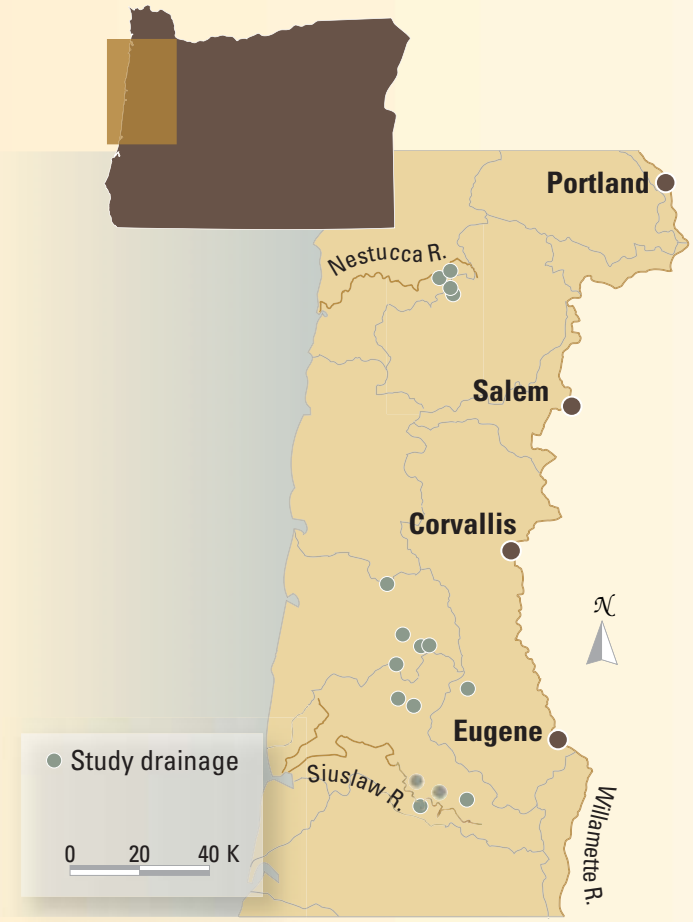

Figure 3. Location of the sixteen study drainages selected for study. Drainages were randomly selected and represent a range of management intensities.

Results

At the finest spatial scale, amphibians were most frequently found in stream segments with greater proportions of large substrates (>3.2 cm in diameter) in the streambed. At the patch and sub-drainage scales, variables related to the geophysical characteristics of streams or drainages (e.g., gradient and aspect) were important for all species or life stages except tailed frog adults. In general, at broad spatial scales, variables related to forest condition (e.g., the presence of a forested band >150 ft in width on each side of the stream or the percentage of stream length with forested bands >150 ft in width) around streams were important. Table 1 provides a summary of the variables most important in predicting occurrence at each spatial scale for each species or life stage.

Table 1. Blue boxes highlight the variables most important in predicting amphibian occurrence at all spatial scales. All relationships between characteristics and amphibian occurrence are positive.

		Species			
Spatial scale	**Habitat characteristic associated with high probability of occurrence**	**Tailed frog tadpole**	**Pacific giant salamander**	**Tailed frog adult**	**Torrent salamander**
Sample unit	Large amount of large substrate	■	■	■	■
	Large stream width	■	■		
	High elevation			■	■
	High % pool	■			
Patch	>150-ft forested band[a]		■	■	■
	Southwesterly aspect	■	■		
	Old forest on ≥1 side of stream[b]	■			
	Low stream gradient		■		
	High stream gradient				■
Sub-drainage	>150-ft forested band[a]	■	■	■	■
	Northeasterly aspect	■	■		
	High % old forest in sub-drainage			■	■
	Large area with slope <60%	■	■		
	Large sub-drainage area	■			
	Small sub-drainage area				■
	Low stream gradient		■		
Drainage	>150-ft forested band[a]	■	■	■	
	No characteristics[c]				■

[a] "Forested band" variables represent the presence of (patch scale) or high % of stream length (sub-drainage and drainage scales) with a band of >55 year-old forest >150 ft in width on each side of the stream.

[b] Represents presence of old forest on ≥1 side of stream.

[c] A null model including only an intercept term was ranked as the best model for predicting torrent salamander occurrence at the drainage scale.

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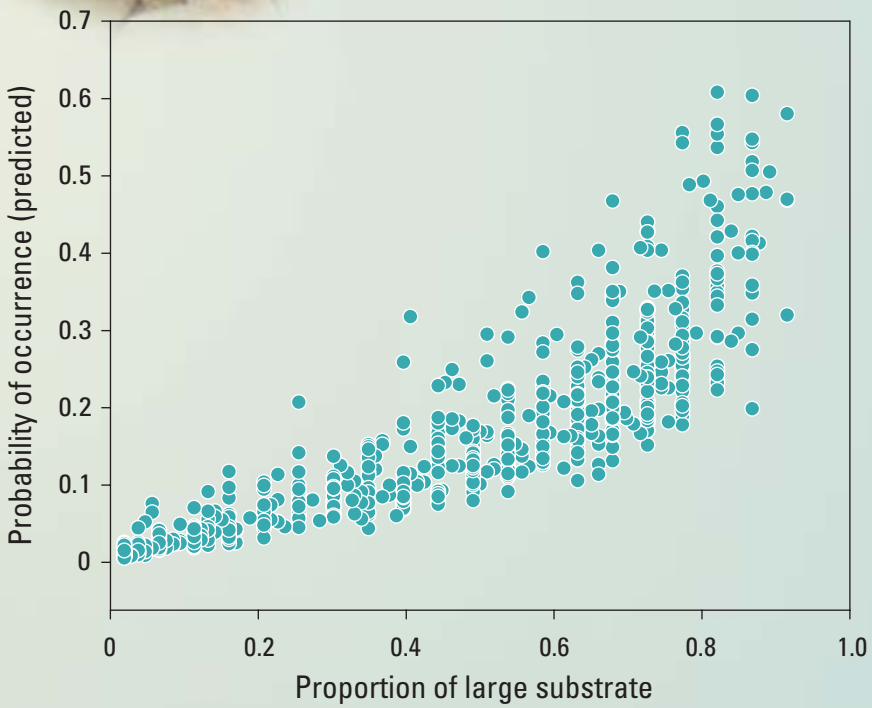
Because forested riparian habitat was a key characteristic for predicting occurrence of stream amphibians at broader spatial scales, the influence of forest band width was examined in greater depth. The researchers found that the relative odds of finding amphibians in streams generally increased with band width (Figure 4). For example, odds of finding a tailed frog tadpole in a stream surrounded by forested bands >150 ft wide were approximately 5 times greater than in a stream surrounded by forested habitat <50 ft wide (odds ratio = 0.205). The response of Pacific giant salamanders was similar to that of tailed frog tadpoles. For tailed frog adults and torrent salamanders, only a small number of observations were recorded, and this may have obscured biologically important differences among band widths for these taxa.

Case Study: Habitat Associations for Tailed Frog Tadpoles at Multiple Spatial Scales

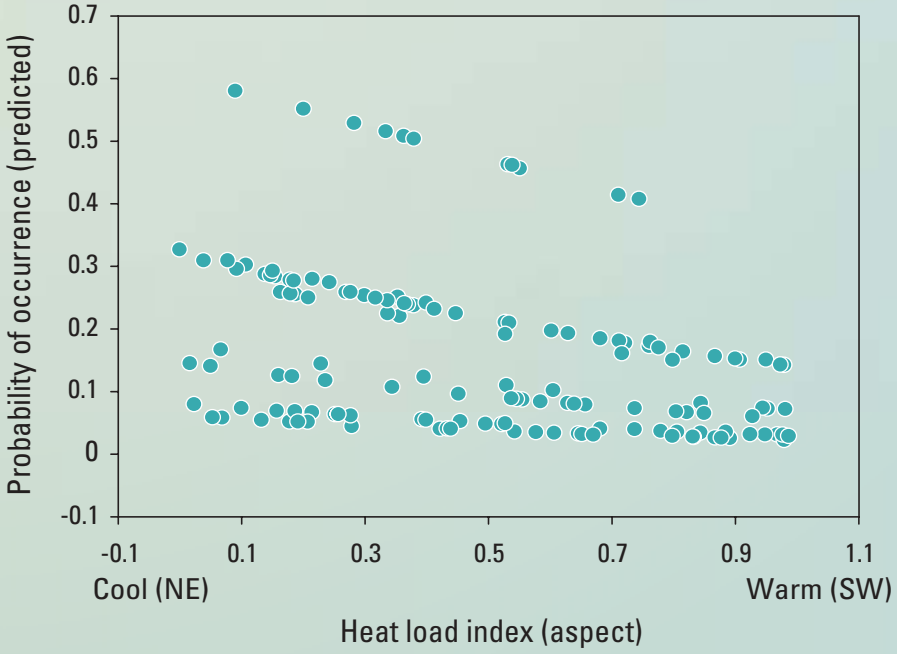
Sample-unit Scale

The top graph shows the probability of finding a tailed frog tadpole relative to a change in the amount of large substrate in a sample unit. As the proportion of large (pebble, cobble, boulder) substrate increased from 0.2 to 0.5, the predicted probability of occurrence increased from 0.06 to 0.14 and increased to 0.30 when the proportion of large substrates increased from 0.50 to 0.80. The graph was based on a best approximating model, which included stream width and % pool habitat.



Patch Scale

The bottom graph shows the probability of finding a tailed frog tadpole relative to a change in heat load index (aspect) in a patch. The odds of finding a tailed frog tadpole were 61% lower in a southwesterly facing stream than in a northeasterly facing stream. The graph was based on a best approximating model, which included a categorical variable representing the combination of stand ages (i.e., patch) on each side of the stream.



Sub-drainage and Drainage Scales

The proportion of stream length with forested bands >150 ft (46 m) wide was one of the most important variables in habitat models for tailed frog tadpoles (No graph provided).

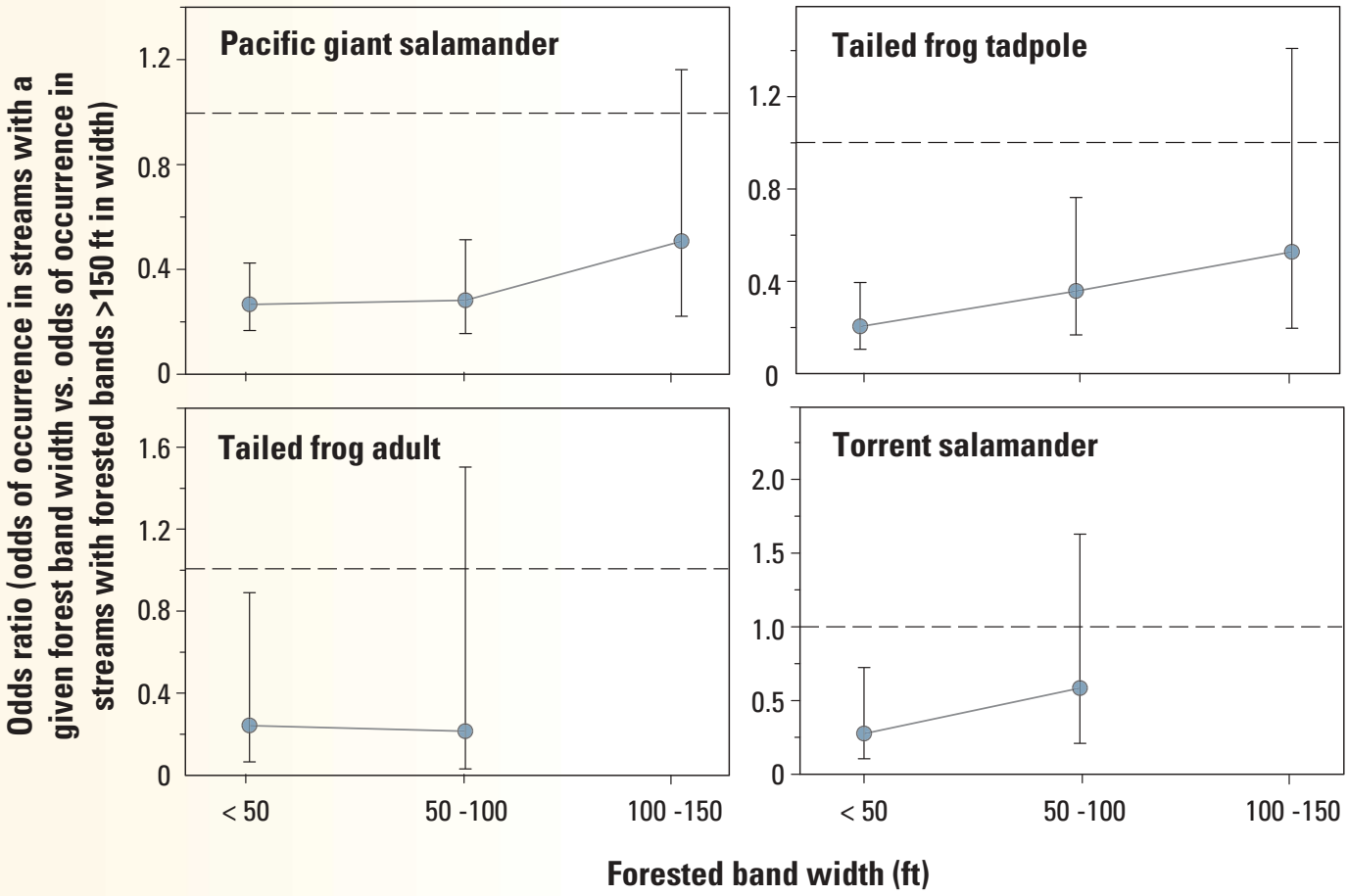


Figure 4. Relationships between forested band width and odds ratios for stream amphibians. Points represent ratio of odds of finding each species in a stream (patch scale) bordered by forested bands of various widths compared to odds of occurrence in streams with forested bands >150 ft in width (± 95% confidence intervals). The dashed line (odds ratio = 1) represents the point at which odds of occurrence do not differ. Odds ratios for torrent salamanders and tailed frog adults were calculated using data from only two band width age classes because these species did not occur in stands having 100-150 ft forested bands.

Management Implications

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, cool temperatures, and habitat for foraging, movement, or dispersal. Because disturbance of riparian and upslope habitat at broad scales may affect amphibian habitat at finer scales by influencing stream temperature, microclimate, and sediment input, these life-history requirements and activities that affect these requirements should be considered when maintaining amphibian habitat is a management goal. For example, activities that increase sedimentation should be minimized adjacent to small, high elevation streams where tailed frog adults may congregate to breed and where torrent salamanders are likely to occur. One approach that has been suggested to achieve this is to retain blocks of land around small headwaters. Some consideration should be given to providing corridors in which metamorphosed amphibians, such as juvenile and tailed frog adults, may forage or disperse. Conservation priority for Pacific giant salamanders and tailed frog tadpoles should be given to maintaining forested habitat along streams in which these taxa are likely to occur (relatively wide headwater streams with northeasterly aspects). Results from this study suggest forested bands at least 150 ft in width will help maintain populations of some species. However, further research on the influence of forest band width is needed, particularly for tailed frog adults and torrent salamanders.

This study provides new insights into linkages between amphibian responses across spatial scales. Results also demonstrate that landscape-scale variables (e.g., the presence of forested bands or the percentage of forested stream length) can be used to assess management approaches for stream amphibian communities. These findings will facilitate determination of conservation-emphasis areas for species protection or less sensitive sites for forest resource management.

KEY RESULTS

- Large substrate in the streambed is a key habitat component for stream amphibians at fine spatial scales.
- Occurrence of stream amphibians was high in streams with northeasterly facing aspects, suggesting this variable can be useful in determining areas of conservation emphasis.
- The presence of forested habitat adjacent to streams and the amount of forested stream length in drainages were important in predicting occurrence of stream amphibians at broad spatial scales.
- Landscape-scale variables can be used to assess management approaches and habitat suitability for stream amphibians.

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Scientists who Contributed to this Factsheet

Margo Stoddard received her Master of Science degree from Oregon State University in June of 2001. During her time with CFER, Margo served as a research assistant in wildlife ecology and was involved in research examining multi- and cross-scale relationships between stream amphibian occurrence and habitat structure in managed landscapes.

Dr. John P. Hayes is program coordinator and a wildlife ecologist for the CFER program. He also is a professor in the Department of Forest Science at Oregon State University. His research interests include the influence of forest management on wildlife populations, the influence of spatial scale on habitat selection, and the ecology and management of bats.

For Further Reading

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