The Distribution, Habitat Preferences, and Life Histories of the Stream Dwelling Amphibians in the Lower Klamath Watershed: General Patterns and Implications for Watershed Conservation

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KLAMATH – SISKIYOU BIOGEOGRAPHY

The Lower Klamath River and its tributaries flow through a mountainous landscape in southern Oregon and Northern California that has often been labeled the Klamath-Siskiyou region by biogeographers (Bury and Pearl 1999, Welsh and Lind 2002, World Wildlife Fund 2001). This region includes the biotic communities of the Siskiyou Mountains, Marble mountains, southern Cascades, and northern California Coast, and therefore represents a diverse array of habitat types varied in elevation and precipitation. With this diverse set of habitats comes an even more diverse assemblage of amphibian species. The amphibian (and reptile) communities of Oregon and California tend to overlap within the Klamath-Siskiyou region, while species that are widespread over the west are present as well. These three species groups come together to form the most diverse herpetofaunal assemblage in the entire Pacific Northwest (Bury and Pearl 1999), thereby contributing to the area's reputation as a biodiversity 'hotspot' (World Wildlife Fund 2001).

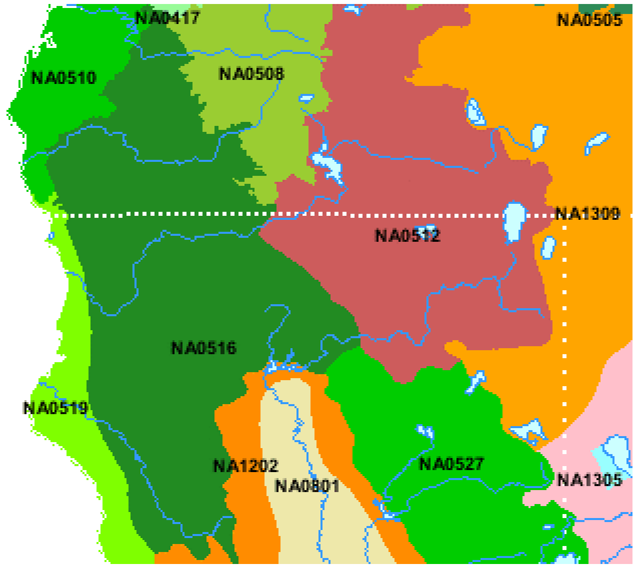

Figure1: Map of northern California and southern Oregon, Klamath-Siskiyou region is dark green (NA0516). (From World Wildlife Fund 2001).

Most of these species have co-evolved with the forests of the Pacific Northwest since the time of the dinosaurs. Many of them appear to have changed little since that time. The amphibian genus' *Ascaphus*, *Dicamptodon*, *Rhyacotriton*, and *Plethodon*, which are endemic to the Pacific Northwest, "may be among the most conservative living derivatives of an ancient North American Mesozoic terrestrial vertebrate fauna…(Welsh 1990)." Not surprisingly, these species have become well adapted to very narrow ecological niches within the ancient forest community that they have evolved in for so long. Although the extant amphibians of the Klamath-Siskiyou region represent many different life histories and habitat preferences, we will focus here on the five amphibian species that must dwell in streams for a significant portion of their life cycles: the southern torrent salamander (*Rhyacotriton variegatus*), the tailed frog (*Ascaphus truei*), pacific giant salamander (*Dicamptodon tenebrosus*), the roughskin newt (*Taricha granulosa*), and the foothill yellow-legged frog (*Rana boylei*).

Habitat Components

Certain habitat components are unique to or characteristic of the Klamath-Siskiyou bioregion and the greater Pacific Northwest. Based on the broad scale observations of Moyle and Mount (2003) the stream habitats of the Lower Klamath

Watershed, and the Klamath-Siskiyou region in general, have been shaped by the conditions associated with old growth coniferous forests, rugged topography, and geographically varied precipitation patterns. Old growth coniferous forests maintain cool, moist microhabitats and sheltering structure. By preventing excessive runoff and erosion they maintain clear streams with low sediment loads. They also contribute to the structure of streams with large woody debris and riparian vegetation. The large trees and shrubs provide thick canopy cover and ample shade to keep streams cool in the warmer months. The rugged topography of the region is characterized by high gradient streams. Steep slopes coupled with abundant precipitation create fast moving headwaters throughout much of the region. These swift streams cascade over rocks and large woody debris and contain very little fine sediment in their natural state. However, alluvial lowlands like the Scott Valley provide space for meandering low gradient streams as well. Precipitation varies greatly over the Lower Klamath watershed. Coastal mountain areas are extremely wet while the eastern end of the region, where the Scott River lies, can be more arid. Distinct forest communities and amphibian assemblages result from this variation.

Habitat components come together to produce unique stream environments that harbor a community of amphibians, each with evolved traits that allow it to grow and reproduce within a section of stream. Amphibian species, each with a different life history and evolved traits, will tend to congregate in areas with preferred habitat characteristics. Furthermore, the antagonistic or symbiotic interactions between these species will affect their distribution. The result is a kind of species spectrum that can be observed over the length of a single stream. This spectrum is highly dependant on exact stream habitat conditions. The smallest changes, especially those caused by human activities, can drastically change the species spectrum. In an idealized undisturbed stream of the western Lower Klamath watershed, the following amphibian species would be encountered in the order described if one were to walk along the stream from the highest first-order headwaters to the main stem of the adjoining river.

SPECIES SUMMARY

Southern Torrent Salamander (*Rhyacotriton variegatus)*:

Rhyacotriton is the only genus in the family Rhyacotritonidae; a family unique to the Pacific Northwest (Pough et al. 2001). Torrent salamanders have reduced lungs and gills (Pough et al. 2001) and are extremely sensitive to desiccation (Nussbaum et al. 1983). These traits are not a hindrance because they dwell only in fast, well-oxygenated, perennial headwater streams.

Figure 2. Photos of *R. variegatus* by G. Nafis

Life Cycle

Adult female southern torrent salamanders lay their eggs hidden in streams most often during the spring after a prolonged mating season that may last for several months (Nussbaum et al. 1983). The larvae are completely aquatic and the adults will only emerge from the stream to feed along the moist edges (Nussbaum et al. 1983, Stebbins 1972). Both life stages feed on various stream dwelling invertebrates (Stebbins 1972).

Habitat

As the name might suggest, torrent salamanders specialize in inhabiting very steep, fast headwaters streams in wet, mountainous areas below 1469m (Welsh and Lind 1996). *R. variegatus* has the southernmost distribution of the torrent salamanders, ranging from Mendocino county, California to southern Oregon along the coast ranges with only a small number reaching eastward to the western Cascade mountains (Stebbins 1985). Welsh and Lind (1996) reported that this species is associated with very specific habitat types consisting of "cold, clear, headwater to low-order streams with loose, coarse substrates (low sedimentation), in humid forest habitats with large conifers, abundant moss, and >80% canopy closure." Their results showed some support for the common hypothesis torrent salamanders are often preyed upon by *D. tenebrosus* and therefore may be segregated to areas higher up in the watershed. While torrent salamanders are an important part of the amphibian fauna in the moist western part of the Lower Klamath watershed, they are probably not present in the drier Scott and Shasta watersheds due to their need for humid microhabitats.

Tailed Frog (*Ascaphus truei*):

The tailed frog is the only species in its family and is considered a very ancient offshoot of the frog (Anura) order. According to Welsh (1990) (citing Estes and Reig 1973 and Savage 1973) the family Ascaphidae is the oldest known fossil frog lineage dating from the Jurassic period in Patagonia and may have inhabited the area that is now North America during this period as well. The tailed frog has undoubtedly inhabited the old growth coniferous forests of the Pacific Northwest for a very long time. This relict species is morphologically well adapted to living in fast moving headwater streams. The most distinctive feature is the 'tail', which is present only on males. According to Pough et al. (2001) the organ is actually a kind of phallus allowing this species to employ internal fertilization. Although most frogs fertilize externally, use of internal fertilization is more effective in fast moving water. The tadpoles use unusual oral sucker discs to climb and maintain position on rocks in cascading waters.

Figure 3. Photo of *A. truei* by David Canatella

Figure 4. Photo of *A. truei* by Brad Moon

Life Cycle

Tailed frogs are highly aquatic and dwell in streams year round, only emerging from the streambed to forage on land in times of high humidity or rain (Nussbaum et al. 1983). Accordingly they are chiefly nocturnal (Stebbins 1973). Tailed frogs only breed every other year in most areas and mate and lays eggs underwater (Nussbaum et al. 1983). Perhaps due to their underwater courtship, they do not vocalize on land (Stebbins 1973, Nussbaum et al. 1983). According to Stebbins (1972) the tadpoles feed on diatoms and pollen in the stream for 2-3 years until transforming. As adults they feed on a variety of invertebrates that dwell in or near the stream.

Habitat

The tailed frog ranges from Mendocino county California to southern British Columbia and east to the crest of the Cascade Mountains, with some populations in the Rocky Mountains of western Idaho and Montana as well (Stebbins 1985, Nussbaum et al. 1983). Despite this relatively broad geographic range it only inhabits stream reaches of a very specific type and therefore is often distributed in isolated populations (Stebbins 1985). Thorough research has been dedicated to determining the precise parameters of its habitat preferences.

Research has indicated a strong positive correlation between stream gradient and tailed frog abundance (Welsh and Lind 2002, Diller and Wallace 1999). Welsh and Lind (2002) discovered a positive correlation between tailed frog abundance and forest age, rainfall, and water velocity with a negative correlation between abundance and water temperature. The tadpoles prefer riffle and cascade microhabitats where they are safe from predators like *D. tenebrosus,* while adults will inhabit small pools as well (Diller and Wallace 1999, Welsh and Lind 2002). The habitat of the tailed frog overlaps significantly with that of *D. tenebrosus,* which may contribute to predator-prey interactions. However some habitat preferences are different between the two species indicating a different response to similar evolutionary pressures (Welsh and Lind 2002). In the Klamath watershed tailed frogs likely to be locally abundant in the western with a strong eastward decline in abundance. The Scott River watershed may contain some individuals on the western headwaters.

Pacific Giant Salamander (*Dicamptodon tenebrosus)*:

These are the largest members of the Klamath-Siskiyou stream amphibian assemblage and are the only amphibian species that is a significant predator on other small vertebrates in the stream community (Bury and Pearl 1999). Adults may grow as large as 17cm long (Stebbins 1985)! The family Dicamptodontidae is unique to the Pacific Northwest (Pough et al. 2001).

Figure 5. Photo of *D. tenebrosus* by William Flaxington

Figure 6. Photo of larval *D. tenebrosus* by Henk Wallays

Life Cycle

According to Nussbaum et al. (1983) adults mate during the spring and fall in stream cavities where the female lays a large clutch of eggs and guards them until they hatch. Larvae dwell in the stream and feed by night on invertebrates, tadpoles, and even small fish. Most larvae transform in 18-24 months but some reach sexual maturity in the larval aquatic form and will remain in the stream. Adults frequent moist forest microhabitats on land and are notorious predators feeding on invertebrates, amphibians, reptiles, and small mammals.

Habitat

D. tenebrosus ranges from northwestern California to southern British Columbia and east to western Idaho (Stebbins 1985). The species appears to have less specialized habitat requirements than tailed frogs and torrent salamanders. Welsh and Lind (2002) reported a strong preference for areas harboring *A. truei* and proposed that predatory behavior may be responsible. Otherwise they found few other strong habitat correlates, indicating that while *D. tenebrosus* inhabits similar habitats to *A. truei,* it is far less picky. Pacific Giant Salamanders are plentiful in the Lower Klamath watershed, especially west of the Marble Mountains (Welsh and Lind 2002). The Scott River watershed might harbor some small populations in moist, forested areas such as those on the western side of the watershed.

Roughskin Newt (*Taricha granulosa)*:

These abundant salamanders are easily visible due to their dense populations and diurnal habits (Nussbaum et al. 1983). Their poisonous skin allows them safety from many predators (Stebbins 1972).

Figure 7. Photo of *T. granulosa* by J. Vincum

Figure 8. Photo of *T. granulosa* by G. Nafis

Life Cycle

Like all newts, *T. granulos*a spends part of the year foraging on land and part of the year breeding in streams. The exact timing of this cycle varies greatly between geographic areas (Nussbaum et al. 1983). According to Stebbins (1972) roughskin newts seek out moist terrestrial microhabitats in the dry late summer and emerge to forage with the fall rains. During this time their skin develops a rough texture to resist desiccation on land. In the late winter or early spring both sexes migrate to the water to mate and lay their gelatinous egg clumps on aquatic structures. They may be found in their breeding streams for several months. The breeding season generally begins earlier in warmer areas like California while in colder, snowier areas the breeding season may not begin until late spring or early summer (Nussbaum et al. 1983). Throughout their life cycle roughskin newts feed on a variety of aquatic and terrestrial invertebrates as well as some plant material (Stebbins 1972). They are also known to eat the eggs of their own species as well as those of other stream amphibians (Nussbaum et al. 1983).

Habitat

Roughskin newts are very tolerant to cold which allows them to range throughout the coast ranges and Cascade mountains from central California to southern Oregon. They dwell mostly in streams of the forested mountains and foothills to about 2800 m, but may also populate lakes in large numbers (Nussbaum et al. 1983)

Foothill Yellow-Legged Frog (*Rana boylei*):

Like the roughskin newt this frog is widely distributed and has broad habitat preferences. It is usually easy to spot basking on the edges of streams and rivers into which it will leap when approached. The simplest diagnostic feature of this otherwise typical frog is the bright yellow color on the underside of the legs.

Figure 9. Photo of *R. boylei* by California Academy of Sciences

Figure 10. Photo of *R. boylei* by Dennis Desmond

Life Cycle

According to Nussbaum et al. (1983) *R. boylei* spends the entire year in or near gentle to swiftly flowing water. Breeding time is attuned to water conditions; the gelatinous egg sacks must be deposited in the gravel or cobbles when the stream is not flooding. As in most frogs, the tadpoles are herbivorous while the adults feed primarily on aquatic and terrestrial invertebrates. In this way the species inhabits two very different ecological niches within its life cycle.

Habitat

R. boylei ranges widely throughout mountains and foothills at low and middle elevations from Baja California to central Oregon in the coast ranges, Sierra Nevada, and Cascade Mountains (Stebbins 1985). The species is confined to areas adjacent to permanent streams - although these streams may be quite small slow moving. Cobble, gravel, or sand substrates are preferred. (Nussbaum et al. 1983)

Species Distribution Patterns

Close examination of the habitat preferences of these species yields a basic distribution pattern showing how each of these species fits into the stream spectrum. The species are essentially arranged in a downstream distribution gradient.

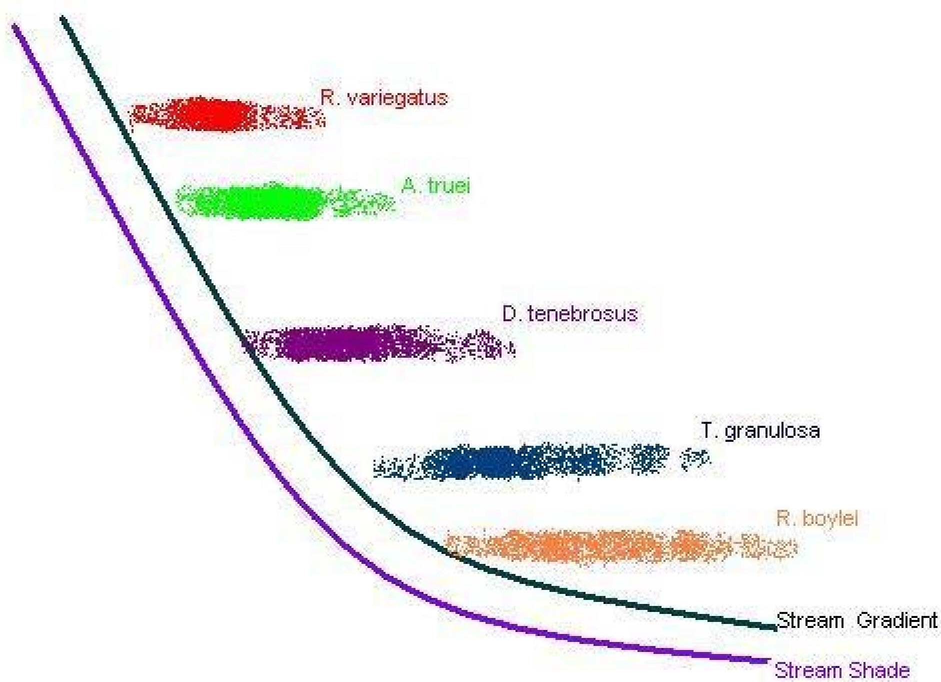

Figure 11. Distribution spectrum of amphibian species along a generalized habitat gradient.

Torrent salamanders and tailed frogs inhabit the smallest and steepest perennial headwaters. Pacific giant salamanders mingle with these species a little but remain concentrated in the mid-level creeks and tributaries. The predatory and interactions between *Dicamptodon* and *Rhyacotriton* may keep them separated to some degree while the same interaction may keep *Dicamptodon* and *Ascaphus* together. Pacific Giant Salamanders have broader habitat tolerances than the other two 'headwater dwellers' and therefore are likely to range farther downstream. Rough skinned newts and foothill yellow legged frogs inhabit the shallow shorelines and sheltered backwaters of the larger creeks and tributaries where flows are slower and substrates are more varied. These species also mix with *Dicamptodon* in various locations. Terrestrial salamanders such as those in the family Plethodontidae (the 'slender' and 'woodland' salamanders) are often present on the edges of stream habitat. Although these species are not obligate stream dwellers they may share habitat with amphibians that are.

The actual distributions and relative abundances of these species vary greatly throughout the Klamath-Siskiyou region. On the cool, moist western sections of the Salmon and Trinity watershed one is likely to find that all five of these species are abundant within their particular stream niches. However, at the eastern end of the Klamath-Siskiyou region, where the Scott watershed lies, precipitation is not nearly as abundant and temperature can get quite warm during the dry season (Mount, personal communication 2003). Those amphibians that rely on cool, high gradient, perennial headwater streams are likely to be absent from the majority of these watersheds. On the Scott River watershed few (if any) tailed frogs and no torrent salamanders are likely to be found. If these species are present, they will be on the western side of the watershed, which is the wetter and steeper side. Therefore, species such as the roughskin newt and the foothill yellow legged frog are likely to make up a larger proportion of the stream dwelling amphibian fauna. In this way, the species spectrum is dominated by species at the downstream end.

WATERSHED CONSERVATION IMPLICATIONS

Given that some these species are so dependant upon the consistent environmental conditions of very specific microhabitats, it is not surprising that they can be very susceptible to habitat alteration. *T. granulosa* and *R. boylei* both range throughout large areas of western North America and therefore show adaptability to a wide range of environmental conditions (Bury and Pearl 1999). The other three species, especially *R. vareigatus* and *A. truei*, have evolved to rely on the unique habitats of coniferous old growth forests since the Mesozoic period. As human activities such as logging and road construction permeate and alter these forests, the preferred microhabitats of these species become increasingly scarce. Sedimentation, temperature increase, elimination of riparian vegetation, and removal of large woody debris have all been investigated as possible threats to stream amphibian species. These alterations can occur as a result of logging, road building, mining, grazing, vegetation removal, or other anthropogenic disturbances. Although direct effects of such activities on amphibian species may not be apparent, the changes they cause indirectly to critical stream microhabitats can have drastic effects on species abundances (Welsh and Lind 2002).

Sedimentation of streams as a result of logging and road building activities is a process that has received significant attention due to its impact on salmon fisheries all over the Pacific Northwest (Moyle, personal communication 2003). Like salmon, amphibians such as the tailed frog and the southern torrent salamander are negatively affected by this process. In their study of streams in western Oregon, Corn and Bury (1989) reported that the only significant difference between streams in logged forest stands and those in intact forest stands was that those in logged stands had finer substrates as a result of increased sedimentation. In addition they found that "[amphibian] species richness was highest in streams in uncut forests" while " logging has a long lasting negative effect on all species." These findings were supported by Welsh and Ollivier (1998) who completed a similar study in a coastal redwood forest stream that had been polluted by sediment from a road construction project. The most obvious mechanism causing this negative relationship, although surely not the only mechanism, is the filling of substrate crevices that are used for cover by small amphibians (Corn and Bury 1989, Parker 1989). Cover availability has been shown to have a major effect on the density of larval *Dicamptodon* (Parker 1991).

While ample research has shown the immediate detrimental effects of sedimentation around clear cuts, the long term effects of such logging on stream communities are much more variable. Higher gradient streams resist the effects of sedimentation by pushing fine sediments downstream (Murphy and Hall 1981). This process may allow amphibian communities to endure the effects of sedimentation in steeper headwaters but not in slower downstream areas (Corn and Bury 1989). Furthermore, the effects of sedimentation can be altered by streamside vegetation removal. Stream sections that are exposed to sunlight due to shade removal will exhibit a temporary increase in primary productivity followed by an increase in salamander density. Salamander density then declines sharply as trees and shrubs regenerate along the banks (Hawkins et al. 1983, Murphy and Hall 1981). The removal of shade plants can also lead to increased sunlight exposure and higher average temperatures in streams (Moyle and Mount, personal communication 2003) thereby producing less than optimal conditions for amphibians that prefer cold water. Torrent salamanders and tailed frogs are known to prefer colder waters and therefore may be negatively affected by shade removal (Welsh and Lind 2002, Welsh and Lind 1996).

The complex interactions of a variety of ecosystem processes make the effects of stream sedimentation difficult to gauge. For this reason forest managers need to look at such effects on the broad scale of an entire watershed. Although amphibians may endure sedimentation in steep headwaters; the sediment carried downstream will undoubtedly impact amphibians and other organisms in the lower reaches of the watershed (Murphy and Hall 1981). No scientist can refute that old growth forest is the ideal setting for the ancient amphibians of the Klamath-Siskiyou region. The stable environmental conditions within such ancient forests important in maintaining stable populations of equally ancient species like *A. treui*, *R. variegatus*, and *D. tenebrosus*.

Because amphibians are so sensitive to perturbations in their preferred microhabitat, many scientists believe that they make excellent 'bioindicators'. A good bioindicator is a species or group of species that is maintains relatively stable populations under undisturbed natural conditions, but is highly sensitive to anthropogenic environmental changes (Welsh and Ollivier 1998). Thus, if a population of the species begins to decline there is reason to believe that the ecosystem in which it lives is suffering degradation of some kind. Stream dwelling amphibians could be especially valuable in determining the health of the troubled Lower Klamath watershed. Controversy over ecosystem health in this watershed has focused on declining stocks of salmonid fishes (Moyle, personal communication 2003). Although salmon and trout can make good bioindicators at times, their natural population fluctuations and relatively short life spans can confuse interpretation of long-term trends. Welsh and Ollivier (1998) pointed out that stream amphibians might be easier to monitor over time due to greater longevity and more stable population dynamics. In addition they require habitat with course streambed structure as do juvenile salmonids, resident fishes, and many stream invertebrates. Therefore the effects of sedimentation on stream amphibians can be seen as analogous to the effects of sedimentation on fish, aquatic insects, and the entire stream community. Land managers can learn a great deal about the effects of logging, road building, and other such activities on a watershed through close observation and monitoring of the salamanders and frogs that inhabit small headwater streams.

SUMMARY

The distribution of stream amphibians throughout the Lower Klamath watershed underscores how important habitat conditions are to these ancient species. The fragile species spectrum pattern that can be observed along the length of a single stream demonstrates this important relationship. Even small changes in microhabitat can lead to changes in the species distribution and makeup of a particular stream. The fragile nature of the stream amphibian communities is what makes them such useful bioindicators. Because they are so sensitive to habitat changes, stream amphibians can be monitored to detect subtle changes in a watershed that would otherwise go unrecognized. It is likely that the detrimental effects of logging and other human activities on fragile species like the tailed frog will be observable in the Scott river watershed. One can only hope that once anthropogenic environmental perturbations are recognized they can be stopped before it’s too late for the amphibians and for other species that rely on such unique fragile stream habitats.

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