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Headwater Amphibians and Forestry in British Columbia: Pacific Giant Salamanders and Tailed Frogs

The Pacific giant salamander (*Dicamptodon tenebrosus*) and the tailed frog (*Ascaphus truei*) are species characteristically found in small, headwater streams of western North America. These two species are included on British Columbia's red (threatened) and blue (vulnerable) lists respectively; and, for both amphibians, forest practices are putative threats. Amongst the factors that make these two amphibians potentially vulnerable to forest harvest impacts are the long larval period (about 3-4 years) during which they are restricted to their natal streams, their apparently limited periods of activity during the year, and low reproductive rates. Adults are strongly associated with riparian areas through the dry part of the year and thus may require riparian protection to ensure survival of adults and newly metamorphosed juveniles. Most populations of these two species are found in small streams lacking fish, and therefore currently do not receive a riparian reserve zone under British Columbia's Forest Practices Code.

We have studied populations of amphibians in a variety of forest seral stages at a range of elevations (from 120 to 1360 m asl) in the Chilliwack River and Skagit River basins about 100 km east of Vancouver. We compared sites by classifying them as recently clearcut (<10 years), second growth (>25 years since cutting), or old-growth (never cut; 250+ years old). If forest harvest leads to reductions in population sizes then we predict that there should be a greater chance of local extinction for populations in harvested areas and therefore lower frequency of occurrence. Occurrence of larvae of these two species showed no significant differences associated with age of the surrounding forest (c^2-test, both $p>0.1$). Pacific giant salamander occurred at 44% of clearcut sites (11 of 25 sites) and at 27% of second-growth and old-growth sites (13 of 49, and 9 of 34, respectively). Tailed frog tadpoles were found at 46% (second growth, n=69), 54% (clearcut, n=39) to 58% (old growth, n=36) of sites surveyed.

At many of the sites we counted and weighed the larval animals present in defined reaches of stream (using standard methods - Bury and Corn 1991). For both species the densities were higher (but not significantly so, $p>0.1$) in clearcut than in old-growth sites, but both had lower average individual weight in clearcut sites. The above observations could be explained by at least two hypotheses: (1) survival to older age classes is impaired in cleared reaches, resulting in age- and size-frequency distributions skewed towards smaller individuals; and (2) developmental rates are enhanced in clearcuts (perhaps from higher temperatures and greater algal productivity) such that animals metamorphose earlier and at a smaller size. For the tailed frog in second-growth sites, both density ($p<0.05$) and biomass per unit area ($p>0.05$) were less than a third of the same measures for populations in old-growth or clearcut sites. Three interpretations of those results are: (1) the intense shading in second-growth forests reduces the production of algae (which is the food resource for their tadpoles), or (2) that fine sediment intrusion effects on habitat (reducing refugia for tadpoles) are slow to develop and become detectable, or (3) a combination of both processes.

We proposed a series of five hypotheses that might explain the occurrence of supposedly old-growth-dependent species in streams flowing through earlier seral-stage forests: (1) these environments are sinks for larval individuals leaving upstream or downstream refuge habitats (late seral-stage forests); (2) these individuals represent the remnants of a population that is slowly going locally extinct; (3) the habitat is infrequently

recolonized by adults laying eggs in a site that has low larval survival and recruitment; (4) disturbed sites may have fewer places for the larvae to hide and make it easier to catch them than in undisturbed sites; and (5) there is no impact of forest harvest, i.e. our null hypothesis. We have set out to test each of these possibilities in ongoing studies.

We have found that net movement rates of giant salamander larvae are exceedingly low (on the order of 1 m/season) and their occurrence in clearcut sites cannot be accounted for by short-term movements from forested refugia upstream or downstream. Radiotelemetry studies with adult salamanders indicate they are capable of moving considerable distances (several hundred metres in a few days) when weather becomes cool and damp in the early autumn, irrespective of forest harvest history. Studies of the demography of Pacific giant salamanders using mark-recapture techniques have been ongoing for three years for 12 populations in streams draining successional forests classed as clearcut, second growth, or old growth. Some of the results from that study suggest that a large fraction of each population is likely to be missed on a given sampling date, i.e. around 80% of larvae are missed in a given sampling bout. This low capture efficiency is presumably because the habitat is more complex in the third dimension, i.e. in the rocky substrate, than previously realized.

Literature Cited

Bury, R.B. and P.S. Corn. 1991. Sampling methods for amphibians in streams of the Pacific Northwest. USDA. For. Serv., Gen. Tech. Rep. PNW-GTR-275, Pac. Northwest Exp. Sta., Portland, OR.

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