Forest Renewal BC Research Program

Final Report

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SCBC does not have additional copies of deliverables or products from this project.
Please contact the project leader directly to obtain copies of any deliverables referenced within this report.

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Tailed Frogs and the effects of forest practices (Final Report 1996-2001)

FRBC # HQ96351-RE

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SUMMARY: This program of study was devoted to learning about how forest practices affect tailed frogs, and means for mitigating any detrimental effects. There are several component parts, each of which is briefly summarised below for the 5-year duration of the project. These components can be divided into: 1. repeated field surveys in streams draining through forests with different management histories; 2. experimental studies of the effects of different kinds of physical and biological changes on growth and survival of tailed frog tadpoles; 3. studies of movements of adults and juveniles in harvested and mature forests; and 4. demographic modelling and risk assessment for tailed frogs at the population and landscape scale. Data from the field studies and experiments were used to parameterise models of the impacts of various land-use changes on the persistence of tailed frog populations under different conservation tactics, including the use of the Identified Wildlife Management Strategy guidelines. A large number of articles and extension activities from the project are listed at the end.

1. Tailed Frog stream surveys and variation in densities due to forest harvesting, year, stream reach, and sampling efficiency.

Rationale

The larval stage of the tailed frog is the most easily censused given that tadpoles remain in the defined stream channel until metamorphosis, which may take up to 4 years. This technique has become the primary survey method for the species and has been used previously in BC (e.g. Richardson and Neill 1998, Dupuis and Steventon 2000, Richardson and Neill in prep) and elsewhere. Our study was designed to address two issues. The first was to obtain long-term census data in streams draining through forests of different harvesting histories, including old growth sites. The second objective was to determine how variable estimates of densities are at several scales. Two scales of variation include the plot to plot (a 5 m reach of stream) variation and year-to-year variation. Another type of variation that has not been considered is the sampling efficiency, i.e., how accurately does a single pass through a "plot" reflect the true numbers. These kinds of studies have been done extensively for fish and other organisms and are tested by multiple pass sampling systems, or other bias correction algorithms based on empirical results.

Since 1996, we have monitored tailed frog tadpole density in 10 headwater streams in the Chilliwack River watershed. In the summer of 2000, these same streams were surveyed for a fifth time. A test of survey efficiency was initiated in 1998 and continued in 1999. During the 2000 field season, additional testing was conducted to increase the sample size for this research.

The manuscript for this study is still in preparation (authors: Richardson and Shatford).

Methods

In August 2000, ten headwater streams in the Chilliwack river basin were surveyed for tailed frogs tadpoles. Stream segments were located in one of three forest age classes, recently clear-cut, second growth and old growth. At each site, a 100 meter reach was marked out into 5-meter segments,

typically we were able to use marks left from the previous years surveys. Starting at the downstream end, we searched alternate segments until a total of 10 segments were surveyed. Workers sorted through all loose material; rock, coarse woody debris, leaf packs, etc., in order to dislodge or initiate movement from the tadpoles. All rocks, cobbles and boulders (when possible) were lifted out of the stream to check for attached tadpoles. Tadpoles were captured using aquarium nets (12x16 cm, mesh size 1 mm). Nets were held directly downstream from the search area in order to filter tadpoles out of the water as they attempted to escape the site of disturbance.

Data collected during the surveys included; reach number, wetted width of stream, length of search time, water temperature and slope and aspect of stream bed. All tailed frogs and Pacific Giant salamanders (PGS) occupying a reach were caught and placed in buckets during the course of the search. Individuals seen, but not captured were recorded as 'escaped'. We recorded species, weight (in grams), total length (in mm) and snout-vent length of all amphibians captured before releasing them back into the site of capture. We also recorded the sex of adult frogs, hindlimb length of tadpoles and gill length of PGS larvae.

Data were collected to describe the forest stand along streams as well as the stream bed itself. Diameter at breast height (dbh) and species was noted for 10 trees along two transects crossing each stream. A list of the dominant understory plant community was also noted. A line intercept method was used to quantify stream bed characteristics. For five or more reaches per stream, we recorded the length of a transect line intercepted by each of several categories of substrate; boulder, cobble, gravel, sand, silt and coarse woody debris (Bury & Corn 1991).

Test of survey efficiency

This entailed searching the same 5-meter reach four to six times, consecutively. We recorded the time taken for two people to search each reach and estimated the area searched by measuring the wetted width of the reach at one-meter intervals. We removed all amphibians from the reach and kept them in buckets with water during subsequent searches. We measured each individual; weight, length, etc., as per surveys described above.

RESULTS

Tadpole Surveys

The number of tadpoles captured during each year of the survey are provided in Figure 1. The highest number of tadpoles captured was consistently at Nesakwatch 2, a site that was clear cut in 1997, the winter after the first tadpole survey. The stream near Chilliwack lake, flowing through a second growth stand, also had a high frequency of captures in 1999 and 2000. Within-site variation for tadpole captures, as determined by the coefficient of variation, ranged from 44 to 100% (Table 1).

Search Efficiency

The proportion of tadpoles caught on the first pass was 0.46 (± 0.07 SE, Figure 1). The coefficient of variation around the estimate was 59.9%. By the second pass the proportion of tadpoles captured was 0.71 (± 0.07 SE), and the third pass had captured 0.91 (± 0.03 SE) of the tadpoles. The range for the efficiency of the first pass spanned from 0 to 1.0. The number collected on the first pass was a good predictor of the total number (log-log regression, $p<0.0001$, $r^2=0.80$, $n=15$).

Table 1. The number of tadpoles captured at 10 streams during five surveys between 1996 and 2000. Coefficient of variation calculated as Stdev/Mean x 100.

	Site	1996	1998	1999a	1999b	2000	Mean	SD	CV (x 100%)	Mean
		-----Number of tadpoles captured-								
Clear cut	ChipCC	17	53	n.d.	25	24	29.8	15.9	53.5	
	FoleyCC	30	3	7	8	18	13.2	10.9	82.5	58.1
	NesCC	9	19	11	22	21	16.4	6.0	36.5	
	Nes2	*97	90	9	64	64	56.8	34.1	60.1	
Second Growth	Chill	63	27	5	79	89	52.6	35.5	67.6	
	Prom	21	19	50	35	23	29.6	13.0	43.9	67.7
	Tam	9	0	11	23	47	18.0	18.2	100.9	
	Thurs	9	1	4	5	7	5.2	3.0	58.3	
Old Growth	ChipOG	34	50	n.d.	16	10	27.5	18.1	66.0	68.6
	FoleyOG	6	5	5	7	19	8.4	6.0	71.2	
Combined		198	267	102	284	322	212.8	82.7	38.9	

*=Old growth in 1996 n.d.=no data

Figure 1. Tailed frog tadpole captures in each of ten headwater streams, Chilliwack river watershed, 1996 through 2000.

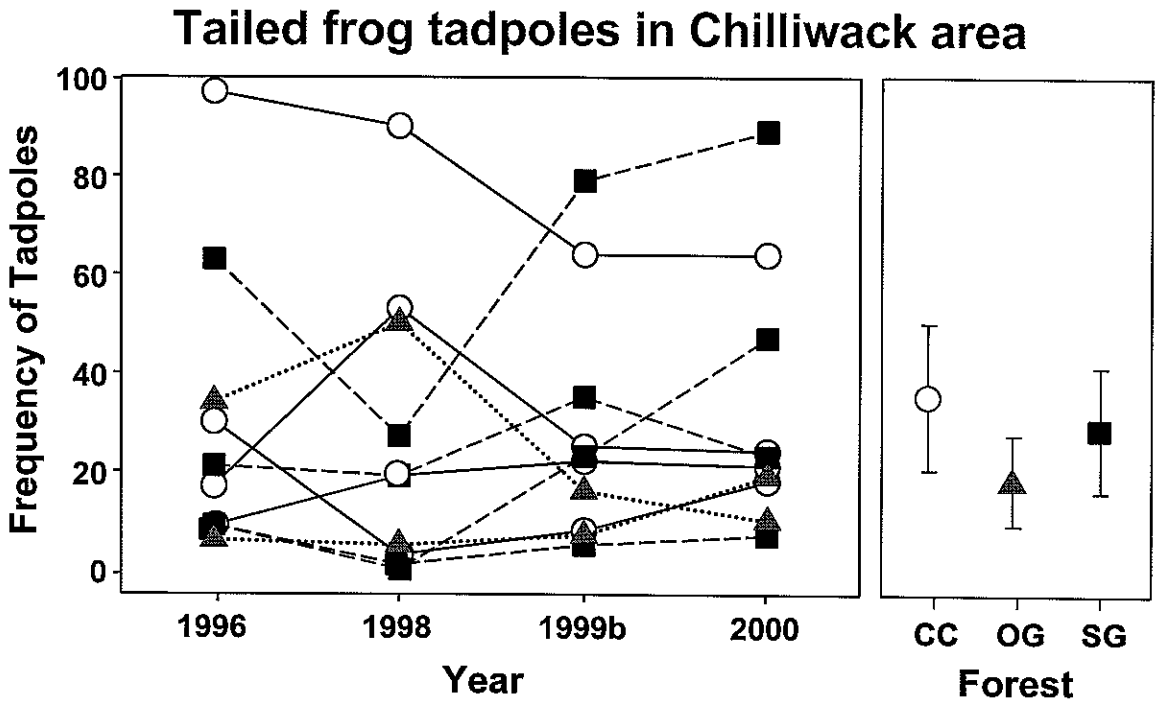
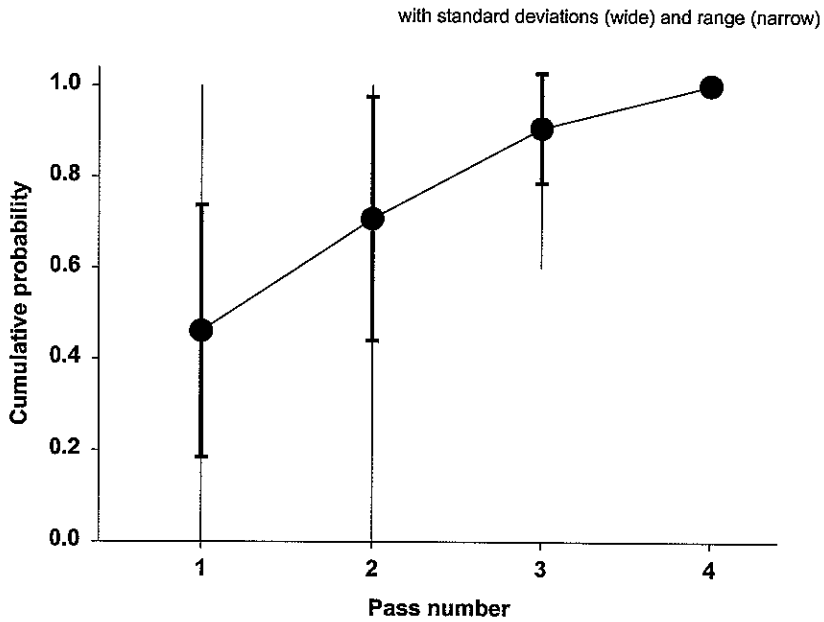


Figure 2. Plot cumulative proportion of the final tally (after four passes) plotted against the pass number. The total numbers are scaled to a proportion of 1.



2. Experimental studies of the effects of different kinds of physical and biological changes on growth and survival of tailed frog tadpoles

Several experiments have been undertaken to link specific physical and biological changes in streams caused by logging to responses in the growth and survival of tailed frog tadpoles. Forest harvesting causes a syndrome of changes in streams, but the particular mechanisms that impact on tadpole populations are important to know since the mechanism(s) of impact will determine the most prudent management practices. In these studies we have manipulated light, nutrient concentrations, densities of tadpoles, and types of algae.

These projects included a thesis by M.A. Kim (1999) and two other studies. Copies of the manuscripts (Kiffney, Richardson, and Bull - in prep; Kiffney and Richardson - in prep; Kim and Richardson - in prep) and papers (Kim and Richardson 2000, Kiffney and Richardson 2001) are attached.

3. Movements of adults and juveniles in harvested and mature forests, and the value of riparian reserves

There has been very little study of the adult and juvenile stages of tailed frogs in most of their range. Despite the absence of any scientific basis, reserves along natal streams of tailed frogs were prescribed by the Identified Wildlife Management Strategy for the protection of the species. It is not known if these reserves (wildlife habitat areas) are necessary or if they are insufficient. Two projects included consideration of these questions. The first, by Brent Matsuda, considered movements and capture rates in the Chilliwack area contrasting clear-cut areas with maturing forests (about 80+ years since harvest). The second, by Katherine Maxcy, was primarily devoted to consideration of the effectiveness of riparian reserve zones to protect amphibians and included the tailed frog as a minor member of the amphibian assemblages.

This part of the project has produced a couple of proceedings papers (Maxcy and Richardson 2000; Matsuda and Richardson 2000), and two theses. The manuscripts from both these studies are still in the early stages of transformation from theses and have not been listed as "in preparation" in this report. I anticipate preparing manuscripts from these two theses over the summer of 2001.

Methods

Trapping and Marking

Pitfall trap arrays were used to trap tailed frogs. Nine (Maxcy) or 16 (Matsuda) arrays consisting of 4 pitfall traps and drift fences were installed such that one trap each was oriented both downslope (trap 1) and upslope (trap 3) of the stream as well as in the downstream (trap 2) and upstream (trap 4) direction (Figure 3). The traps were intersected by a total of 20 m of drift fencing arranged in a cross with the length of each arm equal to approximately 5 m. This X arrangement of the pitfall arrays was designed to determine the direction of movement of the amphibians captured relative to the stream.

Marking techniques for tailed frogs in the field included using a unique combination of elastomer dyes and toe clips. The following information was recorded for each tailed frog (and other amphibians) captured: date, location of capture, snout-vent length, total length, mass, sex (if possible), age (juvenile or adult), individual mark, and whether the animal was newly caught or a recapture. Following processing, each individual was released approximately 1 m from the array on the opposite side from where it was captured assuming the animal was moving in that direction.

RESULTS

Captures of tailed frogs were very variable in the buffer strip experiment and there was no significant differences between treatments or years. Numbers per site increased slightly, but not significantly from before harvest (11.83 + 14.41SD) to post-harvest (13.67 + 16.29SE) (Table 2). The coefficients of variation in estimates of relative numbers were in excess of 100% (119 to 122 %) of the mean.

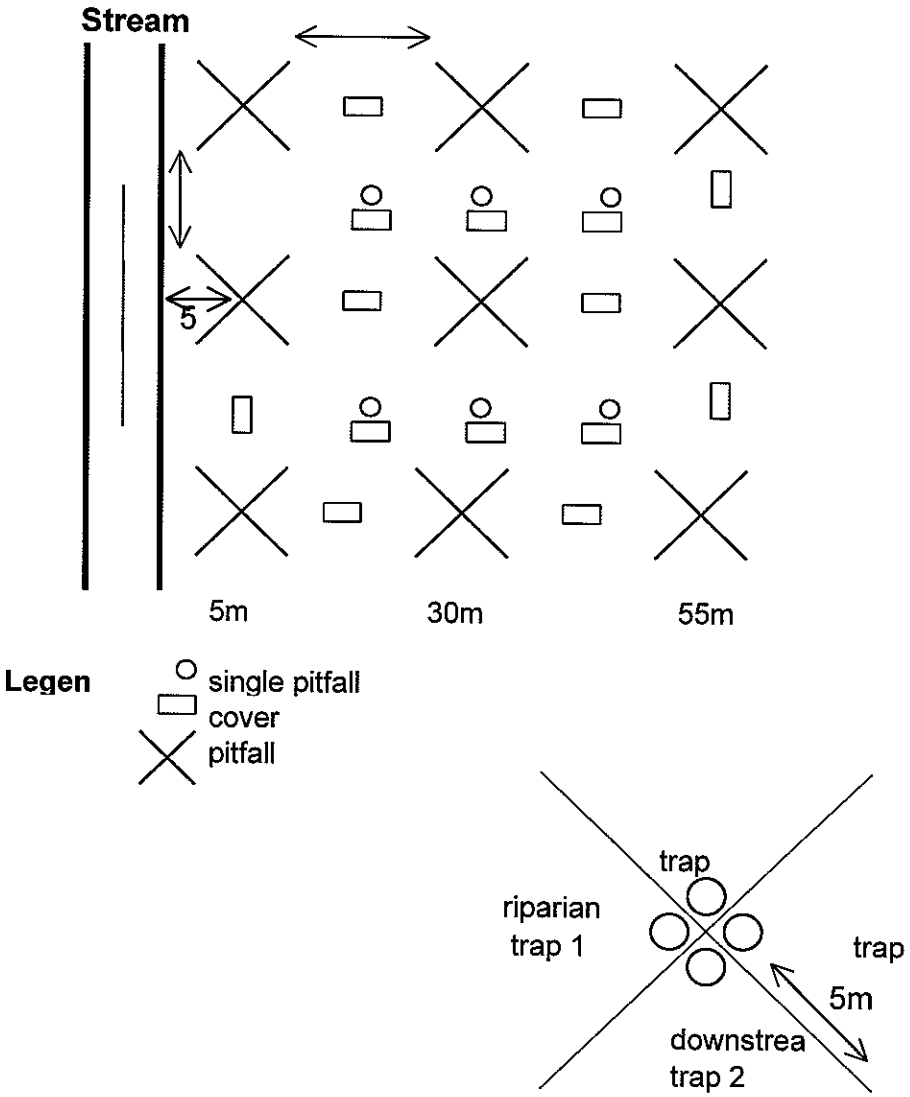
Tailed frog movement patterns - buffer strip experiment

The direction of movement of tailed frogs were analysed relative to the stream for both pre-treatment and post-treatment data (Figure 4). Tailed frogs tended to move more often in the upslope-downslope direction than parallel to the stream. However, after forest harvesting, the parallel movement of the frogs increased relative to the perpendicular.

The spatial distribution of tailed frogs was also analysed relative to the stream (Figure 4). In the control sites, were just captured more often 30 m and 55 m from the stream than at the 5 m distance. In the 30 m buffer site, the frogs were captured more often 55 m from the stream but following forest harvesting, were captured within 30 m from the stream on greater than 90% of the trapping occasions.

In the clearcut sites, tailed frogs were captured most often 5 m from the stream during both pre-treatment and post-treatment data collection.

Figure 3: Layout of sampling grid for capture of adult and juvenile *Ascaphus truei*.



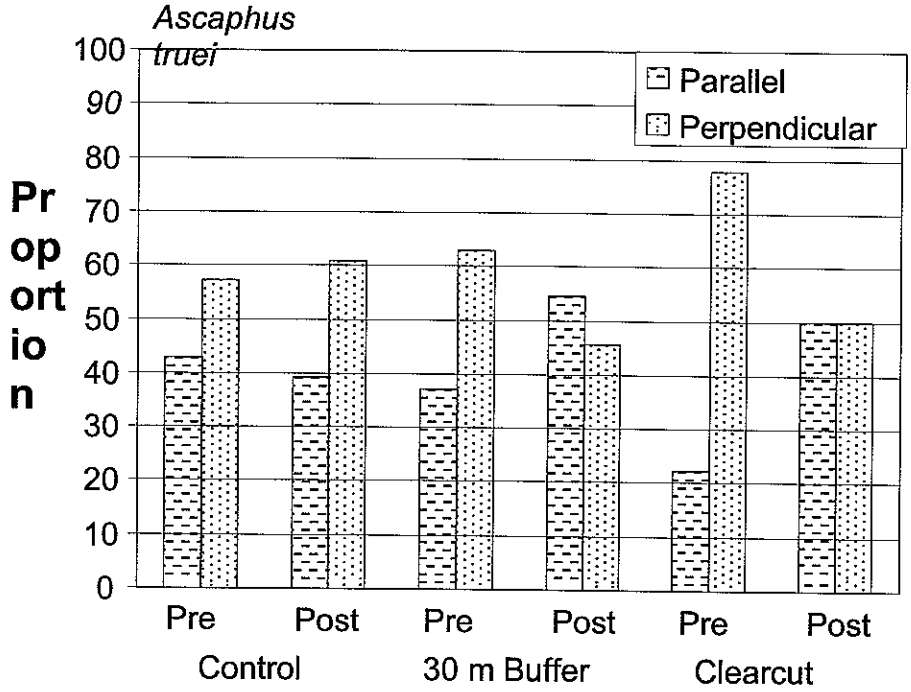


Figure 4. Direction of movement of *Ascaphus truei* relative to the stream pretreatment and postreatment data colleciton.

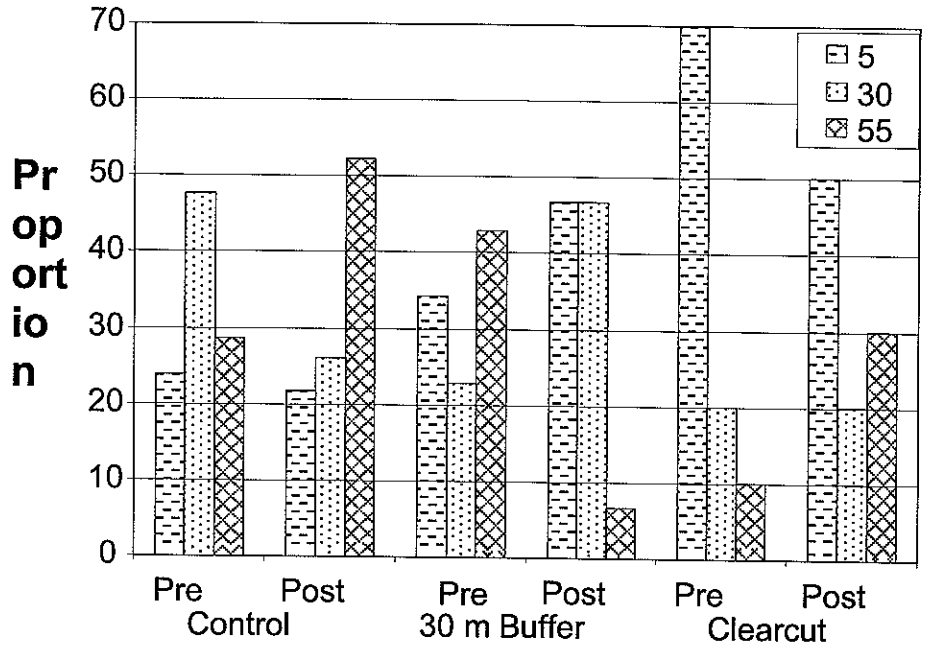


Figure 4. Spatial distribution of *Ascaphus truei* relative to stream pretreatment and posttreatment data collection.

Contrasting clear-cut sites and mature sites in the Chilliwack River valley.

When the capture rates were analysed incorporating the 1999 data, it confirmed the findings of the analysis which was conducted on the 1998 data alone that there were no significant differences between mature stands and clear-cut sites with regards to capture distance from streamside nor direction of movement. However, there were two exceptions. When the t-test (arcsine converted, $\alpha = 0.05$) analysis was conducted for the 1998 data, significantly more adults were captured in mature stands 25-m from streamside than in the clear-cut sites. Similarly, significantly more adults were captured moving towards the stream in mature stands in 1998 than in the clear-cut sites (see April 1999 Progress Report). When the 1999 data were added and re-analysed, these results were not significant. There were no other significant differences in the analysis once the 1999 data was added.

4. Demographic modelling (Glenn Sutherland, PhD)

RISK ASSESSMENT FOR CONSERVATION UNDER ECOLOGICAL UNCERTAINTY: A CASE STUDY WITH A STREAM-DWELLING AMPHIBIAN IN MANAGED FORESTS

Efforts to quantify risks of alternative management options to species considered vulnerable to forestry practices are usually limited by uncertainties in their habitat associations, as well as life history and population trend data. The tailed frog (*Ascaphus truei*), classed as vulnerable (blue-listed) in British Columbia, is a habitat specialist that depends on small, montane streams and their associated riparian zones. It may thus be sensitive to effects of degradation or loss of habitat through some forestry practices. This potential vulnerability, gaps in knowledge, and the potentially high cost of habitat protection for headwater streams, make the tailed frog a good candidate for examining how to evaluate alternative management policies under uncertainty. I used both field data and simulation models, and: 1) developed hierarchical classification models of habitat relationships across the species' range in British Columbia; 2) assessed effects of plausible demographic rates on likely population responses to habitat change, and 3) identified possible outcomes of forest harvesting and disturbances on long-term population persistence within and among streams.

I used classification and regression trees (CART) to develop habitat associations for the tailed frog in British Columbia. Biophysical variables at meso- and micro-scales, such as geology and geomorphology, had a greater influence on occurrence and abundance of larval frogs than did adjacent forest practices, although this influence varied geographically. Direct and indirect spatial autocorrelation between habitat factors and response variables combined with substantial residual uncertainty in habitat relationships implies that no single set of habitat models can be proposed with current data.

I used a life stage-based population matrix model to explore consequences of life history strategies and environmental variation on measures of long-term persistence of tailed frog populations in streams that varied in productivity and carrying capacity. I conducted sensitivity analyses of the likelihood of loss of populations to uncertainty in their demography under different regimes of stochastic environmental variation. I found that regardless of life history scenario, tailed frog populations were sensitive to (in decreasing order) changes in population growth rates, tadpole and adult survival, and fecundity. As well, populations appear slightly more sensitive to changes in survivorship of in-stream stages (eggs, hatchlings and tadpoles) than riparian stages (juveniles/adults). My results imply that clinal, elevational, and local reductions in habitat productivity (e.g., shorter

growing seasons, reduced light penetration in mid-seral forests), are dominant factors mediating how local fluctuations in demographic rates (e.g., annual survival, fecundity) determine risks of loss of small populations, even if environmental variation is relatively low.

Long-term effects of forest management on tailed frogs or other stream-dwelling amphibians are not known with certainty. To explore plausible hypotheses of how habitat alteration could impact populations in response to forest harvesting and disturbance, I developed a stochastic and spatially explicit metapopulation-landscape dynamics model. With this model, I found that at a watershed scale, risks to populations from disturbances and effects of forest harvesting depended strongly on assumptions about the age at first reproduction. Incremental effects of forest harvesting on risks of loss of local populations were generally small. Effects of disturbances on demographic parameters lead to long-term vulnerabilities at least as great or greater than undisturbed populations. Long term reductions in growth and/or survivorship due to altered successional trajectories are the single largest source of increased vulnerability, and are apparently not countered by enhanced growth of tadpoles due to immediate opening of the canopy, or enhanced fecundity in breeding adults. However, uncertainties about the impacts of harvesting, forest succession, and stochastic environmental variation upon demographic rates render evaluation of alternative riparian protection systems difficult with present knowledge.

My study demonstrates that over most plausible ranges of habitat productivity, long-term carrying capacities of stream and adjacent riparian areas combine with larval growth rates and survivorship to dominate population responses to disturbance. Populations in unproductive streams are vulnerable to almost any level of disturbance, whereas populations in more productive streams appear resilient to moderate levels of disturbance to riparian or stream substrates. Management strategies should: a) include the scale-dependent and site-specific habitat relationships of tailed frogs; b) maintain headwater stream channel morphology and natural substrate regime by adopting rates of cut and road locations that limit the total disturbed area at any given time; and c) recognize that substantial uncertainties remain in linking effects of forest practices at the site and landscape to long-term risks to this species.

References

Bury, B.R. and P.S. Corn. 1991. Sampling methods for amphibians in the Pacific Northwest. USFS. Pacific Northwest Research Station. Gen. Tech. Report PNW-GTR-275.

Corn, P.S. and B.R. Bury 1989. Logging in Western Oregon: Responses of headwater habitat and stream amphibians. Forest Ecology and Management 29: 39-57.

Diller, L.V. and R.L. Wallace. 1999. Distribution and habitat of *Ascaphus truei* in streams on managed, young growth forests in north coastal California. Journal of Herpetology 33: 71-79.

Dupuis, L.A. and F. L. Bunnell, 1997. Status and distribution of the tailed frog in British Columbia.

OUTREACH AND EXTENSION ACTIVITIES

There have been several presentations made on the work on this project. Presentations were made to naturalist groups, the Wildlife Branch, the Habitat Protection Branch in Victoria, school groups, university classes (UBC and UVic), Urban Stewardship Groups, and a variety of small groups of visitors to UBC's research forest and Chilliwack. Many talks on the various activities were given at conferences in BC and beyond, including a Tailed Frog workshop hosted at UBC. Three invited

seminars at other universities were delivered based on this work (Washington State University - Pullman campus; Washington State University - Vancouver, WA campus; University of Washington, School of Fisheries). Five graduate students were supported by this grant (Kim, Wahbe, Maxcy, Sutherland, Matsuda). A list of publications (published and in preparation) are listed at the end of this report.

List of Publications and Presentations

Refereed articles

Richardson, J.S. and W.E. Neill. 1998. Headwater amphibians and Forestry in British Columbia: Pacific Giant Salamanders and Tailed Frogs. Northwest Science 72, Special Issue 2:122-123.

Kiffney, P.M. and J.S. Richardson. 2000. Interactions among nutrients, periphyton, and invertebrate and vertebrate (*Ascaphus truei*) grazers in experimental channels. Copeia 2000:422-429.

Proceedings articles

Richardson, J.S. and T.R. Wahbe. 1997. Tailed Frog Workshop. University of British Columbia, April 14-15 1997.

Kim, M.A. and J.S. Richardson. 2000. Effects of light and nutrients on grazer-periphyton interactions. pp. 497-502 In: Darling, L.M. (editor) Proc. Biology and Management of Species and Habitats at Risk, Kamloops, BC, 15-19 Feb. 1999.

Matsuda, B.M. and J.S. Richardson. 2000. Clear-cut timber harvest and movement patterns in tailed frogs, *Ascaphus truei*. pp. 485-488 In: Darling, L.M. (editor) Proc. Biology and Management of Species and Habitats at Risk, Kamloops, BC, 15-19 Feb. 1999.

Sutherland, G.D., J.S. Richardson, and F.L. Bunnell. 2000. Uncertainties linking tailed frog habitat and population dynamics with riparian management. pp. 477-484 In: Darling, L.M. (editor) Proc. Biology and Management of Species and Habitats at Risk, Kamloops, BC, 15-19 Feb. 1999.

Articles in preparation

Kim, M.A. and J.S. Richardson. Relative importance of top-down and bottom-up influences on stream periphyton. Manuscript in revision.

Kiffney, P.M., J.S. Richardson, and J.P. Bull. Riparian buffers and light-mediated control of stream communities in experimental channels.

Sutherland, G.D., J.S. Richardson, and F.L. Bunnell. Estimation of some demographic parameters in a stage-based organism.

Sutherland, G.D., L.A. Dupuis, P. Friele, and F.L. Bunnell. Patterns of distribution and abundance in coastal populations of *Ascaphus truei* in relation to broad and fine-scale biophysical factors.

Sutherland, G.D. J.S. Richardson, and F.L. Bunnell. Persistence of tailed frog (*Ascaphus truei*) populations in relation to uncertainty in life history characteristics.

Sutherland, G.D., A. Fall, and J.S. Richardson. Incorporating effects of uncertainties when evaluating landscape management policies for a threatened species.

Richardson, J.S. and J. Shatford. Scales of variation in populations of tailed frogs: sampling, annual, and land-use variation.

Theses

Wahbe, T.R. 1997. Tailed frogs (*Ascaphus truei*, Stejneger) in natural and managed coastal temperate rainforests of southwestern British Columbia, Canada. M.Sc. thesis, UBC.

Kim, M.A. 1999. The influence of light and nutrients on interactions between a tadpole grazer and periphyton in two coastal streams. M.Sc. thesis, UBC.

Sutherland, G.D. 2000. Risk assessment for conservation under ecological uncertainty: a case study with a stream-dwelling amphibian. Ph.D. Dissertation, UBC.

Maxcy, K.A. 2000. The response of terrestrial salamanders to forest harvesting in southwestern British Columbia. M.Sc. thesis, UBC.

Matsuda, B.M. 2001. The effects of clear-cut timber harvest on the movement patterns of tailed frogs (*Ascaphus truei*) in southwestern British Columbia. M.Sc. thesis, UBC.

Examples of Presentations at conferences and other meetings (plus many others not listed)

Brent M. Matsuda and John S. Richardson. Amphibian diversity and abundance in clear-cut and mature forests of southwestern British Columbia. Society of Northwestern Vertebrate Biology 2001 meeting

Brent M. Matsuda and John S. Richardson. The effects of clear-cut timber harvest on the movement patterns of tailed frogs (*Ascaphus truei*) in southwestern British Columbia. Society for Conservation Biology meeting held in Washington, DC.

Brent M. Matsuda. The effects of clear-cut timber harvest on the movement patterns of tailed frogs (*Ascaphus truei*) in southwestern British Columbia. General public for BC Parks in Cultus Lake near Chilliwack, in August 2000.

Sutherland Nov 6, 1999. presented a research seminar entitled "Risk, uncertainty, and habitat protection" to the Forest Biodiversity 4th year class, Faculty of Forestry, UBC.

Sutherland Nov 26, 1999. presented a research seminar entitled "Spatial models in habitat management and endangered species protection" to the graduate Ecological Modeling class, School of Resource and Environmental Management, SFU.

Sutherland April 7, 2000, presented a research seminar entitled: "Bounding the Plausible: assessing consequences of disturbances and management on a riparian species" to the 3rd Annual Centre for Applied Conservation Biology Research Symposium, Faculty of Forestry, UBC.

Richardson June 7, 1999, presentation to the Wildlife Branch, Ministry of Environment, Lands & Parks on tailed frog ecology and forestry effects. Victoria, BC

Matsuda, Brent M. and John S. Richardson. The effects of clear-cut timber harvest on the movement patterns of tailed frogs (*Ascaphus truei*) in southwestern British Columbia. Society for Northwestern Vertebrate Biology Meeting in Ocean Shores, Washington on March 15-17, 2000

Richardson, J.S. Seminar presented to Faculty of Forestry, UBC, on 20 October 1998: "Headwater Amphibians as indicators of riparian and stream processes affected by forest practices."

Richardson, J.S. Interview on Tailed Frogs published in Vancouver Aquarium's Magazine "Waters": Autumn 1998, page 7.

Kim, M.A. and J.S. Richardson. The influence of light and nutrients on growth of a grazing tadpole (*Ascaphus truei*). (poster presentation). Ecological Society of America, The Land-Water Interface. St. Louis, MO, 7-12 June 1998.

Kim, M.A. British Columbia Festival of Science and Technology Week (October 16-25) slide show presentation to 200 students at Grandview Elementary School (an inner city school in East Vancouver).

Kim, M.A. Burke Mountain Field Naturalists: Natural History and Conservation of Amphibians of the Lower Mainland (oral presentation)

Kim, M.A. and J.S. Richardson. Species and Habitats at Risk, Kamloops, BC, Feb 1999. Effects of light and nutrients on grazer-periphyton interactions (oral presentation)

Matsuda, B. and J.S. Richardson. 3rd Annual Meeting of the Canadian Amphibian and Reptile Conservation Network/11th Annual Meeting of the Declining Amphibian Populations in Canada Task Force (DAPCAN) in Saskatoon, 3-4 October 1998 (oral presentation)

Matsuda, B. Fish, Wildlife and Recreation class at the BCIT, 23 October 1998. (oral presentation)

Matsuda, B. *Pacific Ecology Conference* held 5-7 February 1999 in Parksville, BC (oral presentation)

Richardson, J.S. and W.E. Neill. Forestry and sensitive headwater amphibians in BC: Pacific Giant Salamanders and Tailed Frogs. Conference on Structure, processes and diversity in successional forests of coastal British Columbia, Victoria, BC, 19 February 1998.