The Cariboo Underworld
Amphibians in Clearcuts and Forests

by Kirsty Ward and Bill Chapman

ABSTRACT
Terrestrial amphibians were surveyed in the Interior Douglas-fir, Sub-Boreal Spruce, and Interior Cedar-Hemlock biogeoclimatic zones in the area surrounding Williams Lake, and numbers were compared in adjacent clearcut and forested areas. Four species, the Long-Toed Salamander (Ambystoma macrodactylum), the Western Toad (Bufo boreas), the Wood Frog (Rana sylvatica), and the Pacific Treefrog (Hyla regilla) were found in the area. Some interesting colour variations were observed in the salamander populations. All species were as abundant in clearcuts as in adjacent areas. Possible explanations for this observation are presented. Clearcuts may have been wetter or temporarily had more coarse woody debris than adjacent forests, even though coarse woody debris levels might be expected to decline over subsequent rotations with continued timber harvesting.

INTRODUCTION
Although they are seldom seen or thought of, amphibians (Figure 1) are an important part of many forest ecosystems. Raphael (1984) estimated terrestrial salamander densities to be between 10 and 180 per hectare in Douglas-fir forests. Bury (1983) estimated terrestrial salamander densities of over 400 per hectare in old-growth redwood forests, while Burton and Likens (1975) estimated densities of 2.583 per hectare in the Hubbard Brook Experimental Forest in New Hampshire. The salamander habitat found in eastern deciduous forests is very different from that typically found in the Williams Lake region, but it is still interesting to note that the biomass of salamanders in the Burton and Likens study exceeded that of birds and was equal to that of mammals! Linda Dupuis, working on her master’s thesis in 1991 and 1992, reported about 300 Western Red-backed Salamanders (Plethodon vehiculum) per hectare in old-growth forests around Nahmint Lake near Port Alberni. She found declining numbers of salamanders in younger, second growth forests (Dupuis 1993). Few studies have been conducted on amphibians in the interior of British Columbia. Patterson and Steventon (1993), working in the Date
Creek drainage near Hazelton, British Columbia, found most amphibians by trapping and few in searches; they did not report numbers per unit area.

The distribution and abundance of terrestrial amphibians are influenced by numerous environmental factors such as levels of suitable cover, moisture availability, and temperature (Plough et al. 1987). Habitat varies greatly with forest type and abundance of burrowing amphibians has been positively correlated with the density of coarse woody debris such as logs and stumps (Jones 1988). In addition to providing cover, this material moderates moisture and temperature fluctuations (Jaeger 1980, Aubry et al. 1988). Other, more obscure, factors such as mineral soil pH (which influences burrowing amphibians inhabiting the mineral soil-forest floor interface), can also affect distribution and abundance (Wyman 1988).

The importance of old-growth forests to amphibian distribution has been examined for several species in forests of the Western United States (Franklin et al. 1981, Bury and Com 1988). These studies have found positive correlations between amphibian abundance and diversity and stand age for such species as the Oregon Slender Salamander (Batrachoseps wrightii), the Olympic Salamander (Rhyacotriton olympicus), and the Tailed Frog (Ascaphus truei). It has been clearly established that logging has the potential to alter many of the factors that influence amphibian populations.

Amphibians have been little studied in the Cariboo Forest Region. This study is an initial step in collecting data on amphibians in general and, more specifically, on the effects of timber harvesting on populations of these organisms. Such data are needed so that wildlife managers can begin to evaluate the need for special management for amphibians.

**STUDY AREA AND METHODS**

Amphibians were sampled using two methods of capture: time-constrained searches and pitfall traps. The time-constrained searches were conducted in forested and adjacent logged areas at six locations, with two locations (replicates) in each of three biogeoclimatic zones: the Interior Douglas-fir (IDF) Zone (elevation range 750-1 150 m), the Sub-Boreal Spruce (SBS) Zone (725-1 250 m) (Figure 2), and the Interior Cedar-Hemlock (ICH) Zone (725-1 250 m). These time-constrained searches were conducted in pairs at each location: one set of searches was made in a logged area and the second was conducted in an adjacent unlogged area. The logged areas were all recent clearcuts ranging in age from two years at the IDF site to seven years in the ICH. The clearcuts were all greater than 20 ha in size, while the unlogged areas were much larger than this, with little fragmentation. Pitfall traps were used in the IDF and SBS zones. As for the searches, the traps were also paired, traps being placed in forested areas as well as nearby logged areas. In both time-constrained searches and pitfall trapping, the study areas were set back at least 35 m from edges (roads, clearcuts, etc.) to reduce edge effect.

The IDF zone is dominated by Douglas-fir (Pseudosuga menziesii) and is...
transitional to grassland at lower elevations. At higher elevations it tends to be dominated by Lodgepole Pine (Pinus contorta), as it was at our study site. Common shrubs include Soopolallic (Shepherdia canadensis) and Kinnikinnick (Arctostaphylos uva-ursi). Pinegrass (Calamagrostis rubescens) is a dominant feature of the understory and Feathermoss (Pleurozium schreberi) is also common. The IDF has the warmer, drier environment for this region, with July/August tempera-

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<th>Biogeoclimatic Zone</th>
<th>Sample Date</th>
<th>Location</th>
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<tr>
<td>IDF</td>
<td>9 July 1993</td>
<td>70 Mile House</td>
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<tr>
<td></td>
<td>20 Aug 1993</td>
<td>Mountain House Road</td>
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<td>SBS</td>
<td>23 July 1993</td>
<td>Spokin Lake</td>
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<td></td>
<td>13 Aug 1993</td>
<td>Skulow Lake</td>
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<td>ICH</td>
<td>29 Aug 1993</td>
<td>Black Bear Road</td>
</tr>
<tr>
<td></td>
<td>3 Sept 1993</td>
<td>Polley Lake</td>
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ures ranging from 9° to 20°C. Rainfall is typically light, but was higher than normal during the summer of this study. This zone would have been burned frequently and lightly in its natural condition. In this region, and in the study area, the IDF is characterized by the presence of small standing bodies of water, many of which remain wet throughout the year.

The SBS zone is colder than the IDF in winter, and has later springs and earlier frosts, but comparable summer temperatures. Overall precipitation is higher, but the understory in the study areas still contained a large Pinegrass component. The poorly drained soils in the study area produced many small wet areas which would typically dry out during summer, but which remained wet for most of the summer during the study year. The dominant tree species is Lodgepole Pine which intergrades with Douglas-fir at the lower elevations.

Engelmann Spruce (Picea engelmannii) or White Spruce (P. glauca) is found in wet areas or in areas characterized by long time periods between catastrophic events. The canopy tends to be more even-aged, with fires periodically removing large areas of pine forest, thereby preventing or delaying transition to spruce forest.

The ICH is the wettest and most productive (in terms of timber) of the three zones. Summer temperatures are comparable to those of the other zones, but rainfall is higher. The ICH tends to have the most complex canopy, often with mixes of Douglas-fir, Western hemlock (Tsuga heterophylla), spruce and Western Redcedar (Thuja plicata) of various age classes. Devil's Club (Oplopanax horridus) is common in specific ecosystems of the ICH, as are deep, mossy forest floors. Coarse woody debris tends to be most abundant in this zone.

Time-constrained searches were undertaken by four individuals, each searching one area for two hours. The areas searched were similar distances from the closest body of water which might have been an amphibian breeding area. All searches took place between 10 a.m. and 3 p.m. with the cutout always searched first. This order of searching was designed to minimize the effects of temperature change during the search period: temperature change under the canopy tended to lag behind that in open areas. Each searcher worked back and forth along a 15 m front that was gradually moved in one direction. During searches all coarse woody debris and forest floor adjacent to the woody debris was pulled apart. However, the forest floor in general was not pulled up as the frequency of capture in these areas tended to be low and the practice was very destructive. After two hours, the area covered by each person was measured. The locations and timing of the time-constrained searches are shown in Table 1.
Pitfall trapping took place over nine weeks between the beginning of July and beginning of September, 1993. We have observed periods of peak amphibian movement in the spring and fall in this area. The goal of our summer trapping was to capture individuals from populations that occupy the study areas for long periods, as opposed to transient animals.

Traps consisted of 4-L ice cream pails buried so that the edge of the pail was even with the upper surface of the mineral soil. The bottom of each trap was perforated to allow drainage and was covered with a layer of debris to provide protection for any captured amphibians. The surface of the trap was covered either with dead wood found on site or with a layer of moss suspended over small sticks, depending on the characteristics of the site.

The traps were arranged in square grids of 36 traps spaced 15 m apart. Six grids (three in clearcuts, three in forested areas) were placed in the SBS zone while only two grids (one clearcut, one forested) were placed in the IDF. In the SBS zone the clearcut and the forested sampling areas were about 1 km apart, but at approximately equal distances from the same slow-flowing creek (the major body of water in the area). They were similar in elevation, topography, soils, and aspect. The grids in the IDF were within 200 m of each other and were the same distance from a nearby pond. Traps were inspected weekly and trapped animals were taken off the grid and released (except for a few which were kept for identification or observation).

Coarse woody debris volumes for each sampling location were determined using the method of Lofroth (1992). Rainfall and temperature data were obtained from the closest Ministry of Forests weather stations and confirmed that 1993 was a wetter than normal year.

RESULTS
Four species of amphibians were found during this study: the Long-toed Salamander (*Ambystoma macrodactylum*), the Western Toad (*Bufo boreas*), the Wood Frog (*Rana sylvatica*), and the Pacific Treefrog (*Hyla regilla*) (Figure 3). Some interesting colour variations were observed in the salamander populations. We found both yellow and green Long-Toed Salamanders, perhaps representatives of two subspecies, the Northern and Western Long-toed Salamanders, respectively. These were found both in the SBS and IDF. In addition, we found one all-black Long-toed Salamander and two with pale gold blotches located on their sides. The unusual colour variations were all found at the Skulow Lake SBS site. More black salamanders were subsequently collected by us and another researcher who is doing genetic work with the black strain. Pacific Treefrogs were captured only in pitfall traps.

Time-constrained Searches
The results of the time-constrained searches are shown in Table 2. Each searcher typically examined 200 to 300 m² in two hours. Since our searches were not

<table>
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<th>Biogeoclimatic Zone</th>
<th>Western Toad</th>
<th>Long-toed Salamander</th>
<th>Wood Frog</th>
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<tr>
<td></td>
<td>Forested</td>
<td>Clearcut</td>
<td>Forested</td>
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<tr>
<td>IDF</td>
<td>0-9</td>
<td>0-27</td>
<td>0</td>
</tr>
<tr>
<td>SBS</td>
<td>0</td>
<td>0</td>
<td>22-65</td>
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<tr>
<td>ICH</td>
<td>0</td>
<td>0-22</td>
<td>0</td>
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Western Toads were most abundant in the IDF, the warmest driest zone, and were captured more often in clearcuts. Long-Toed Salamanders were most abundant in the SBS, with no obvious trend to greater abundance in clearcut or forest. Most Wood Frogs were captured in the IDF with some in the SBS; more were captured in clearcuts than in forested sites.

No significant correlation (correlation coefficient=-0.14) was found between the volume of coarse woody debris at each time-constrained search sampling location and the number of salamanders captured in that area. Since we did not find salamanders in the ICH, and are not even certain that they are there, these areas were not included in the calculations. The total number of observations used to calculate the correlation coefficient is, therefore, eight. This sample size is too small for meaningful correlation analysis.

Salamander captures were made in a variety of microsites. Sometimes they were found inside rotting wood or in the adjacent mossy forest floor. One particularly favoured spot seemed to be the small, moss-covered tunnel that is formed under the edge of a rotted log (Figure 4).

**Pitfall Traps**

Long-toed Salamanders and Western Toads were collected relatively frequently in pitfall...
traps while Wood Frogs and Pacific Treefrogs were collected only sporadically. Western Toads were collected considerably more frequently in clearcuts than in forested areas in both the SBS and IDF zones. Large numbers of recently metamorphosed toads were caught near the end of the season in the clearcut of the SBS, but even prior to this the catch rate in the clearcut was higher than in the forested area of this zone. (Unfortunately, the young toads were not counted separately from the adults.) In the IDF, considerably more salamanders were collected on average per grid per week in the clearcut than in the forested area (Figure 5). In the SBS, about equal average numbers of salamanders were collected in the clearcut and in the forested area (Figure 6). All of the Wood Frog captures were made in the clearcut at both the IDF and SBS, but these totals were only 6 and 13, respectively. One Pacific Treefrog was trapped in the forested area of the IDF, while in the SBS, nine tree frogs were trapped in the clearcut and one in the forested area.

More toads were collected per week per grid in the SBS than the IDF, but this was the result of the huge number of young adults caught near the end of the study period. Prior to the influx of young adults, the numbers looked quite similar. More salamanders were captured per grid per week in the IDF, though the capture rate in the forested SBS increased greatly towards the end of the season (Figures 7 & 8).

**DISCUSSION**

The different capture techniques provided similar results except for treefrogs, which spend most of their time in trees except when they are in transit between locations (Green and Campbell 1992); this species was not captured during searches. Treefrogs are also quite mobile and fast moving (personal observation) and so it is not unexpected that they were not captured during searches.

We noted that the colour of the mustard yellow stripe on the typical Long-toed Salamander closely matched that of a mycorrhizal fungus that was abundant in rotting logs. The fungus was likely a species of Piloderma, perhaps *Piloderma bicola*. The stripe may serve as camouflage; it seemed to function that way during searches.

Our failure to capture salamanders in the ICH is surprising. Unfortunately we were unable to use pitfall traps in this zone. The ICH is a moister environment with abundant coarse woody debris which, while it might have been expected to provide good habitat, it may also have made it more difficult to find salamanders. There were

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**Figure 7.** Salamanders captured per week from pitfall traps in the SBS zone (Skilow Lake).

**Figure 8.** Salamanders captured per week from pitfall traps in the IDF zone (76 Mile).
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some qualitative differences in debris between the ICH and the other two zones examined. The ICH had a lot of cedar debris as opposed to predominantly Douglas-fir and pine debris in the other zones. Little of the fallen cedar in the ICH was covered with moss (in contrast to the SBS and IDF, where logs were typically moss covered) even though it grows abundantly in this zone. Moss does not seem to grow well on cedar bark, and cedar logs often seem to reach an advanced state of decomposition (i.e., the bark has fallen away and the wood is spongy) before they become moss covered. We will be doing further investigation to see if Long-toed Salamander populations tend to be lower in forests dominated by cedar (see Jaeger 1980). In the future we will pay closer attention to qualitative differences when trying to correlate population size with amount of coarse woody debris.

We were somewhat surprised by the relatively frequent capture of amphibians in clearcuts in the summer, given the results of other studies (Bury and Corn 1988, Dalrymple 1988, Ramotnik and Scott 1988). While it is true that timber harvesting negatively affects amphibian populations in some areas and under some conditions, there are some logical arguments to support suggestions that harvesting might not always have deleterious effects on amphibians. Some possible effects of timber harvesting include direct killing of animals by equipment, alteration of vegetation, microclimate, forest floor and coarse woody debris, and compaction of the soil and forest floor.

The number of deaths caused by equipment activities could be expected to vary widely. With cable logging systems the number of direct deaths might be quite small. In the Cariboo, ground-based timber harvesting systems are more common than other kinds, so machinery usually traverses a significant proportion of a harvested block. However, much of the harvesting takes place in the winter on relatively deep snow and it is possible that this type of activity has little direct impact on amphibians. Summer logging might be expected to have a greater impact. Even then, however, a considerable portion of the block would not be driven over during normal ground-based harvesting.

Clearcut timber harvesting can alter many aspects of microclimate, the two most obvious being ground temperature and moisture (Childs et al. 1987). Loss of the canopy generally results in reduced evapotranspiration and overall greater soil moisture levels (Swanson and Hillman 1977, Coulson 1991). This effect is predominant in the summer months when evapotranspiration is the highest. Soils in clearcuts may experience drying in the top few centimetres (Coulson 1991), but in clearcuts with an intact forest floor there is likely considerable opportunity for increased moisture levels in certain types of amphibian habitat.

The lack of a canopy also results in direct exposure of the forest floor to sunlight, which may increase surface temperatures beyond amphibian operating maximums. In addition, increased radiant cooling may lower temperatures below operating minimums. Higher surface temperatures and more wind in clearcuts could increase drying rates at the surface of the forest floor. With generally higher soil moisture levels resulting from the lack of a canopy, it is difficult to determine the net effect. Increased temperatures and surface drying might be detrimental to species which spend more time exposed on the surface, while increased moisture levels might simultaneously be advantageous to groups which spend time within the forest floor. However, it is not intuitively obvious whether these changes will result in a net advantage or disadvantage to any specific group of amphibians. It is likely that the effect will be site-specific. For example, much of the work that describes declines in amphibian populations as a result of timber harvesting took place in warmer climates. In such sites, upper temperatures may be the major limitation to activity, whereas in colder
areas, such as our study area, lower temperatures that may be more of a limitation. Furthermore, species such as toads, which tend to spend more time exposed on the surface, are also tolerant of warmer, drier conditions and so may be less affected by superficial changes in climate.

Timber harvesting has the potential to affect coarse woody debris in several ways. Because dead standing trees are often knocked over the end result of harvesting can be a short term increase in the coarse woody debris that can serve as protection for toads and frogs (Enge and Marion 1986, Plough et al. 1987). After harvesting, fresh woody debris is often somewhat elevated, tangled, and not yet melted into the surface of the forest floor. This would provide good shelter for mobile amphibians and an obstacle to certain types of predators. The impact on salamanders over the short term could be less obviously, positive as it takes time for fresh debris to develop the moss-covered niches that salamanders seem to prefer. These and other effects may have influenced our ability to correlate coarse woody debris with salamander populations; we did not make judgements on how suitable the habitat was for salamanders when surveying coarse woody debris.

Over the longer term of several rotations, repeated timber harvesting would occur as the trees approach maturity — before they begin to die and create coarse woody debris. As a result, one would expect a decline in the input of coarse woody debris to the forest floor and thus a decline in the levels of such debris. Although management practices in this province now require maintenance of coarse woody debris levels, it is an inescapable fact that with timber harvesting the input of woody debris will be reduced.

The capture of large numbers of recently metamorphosed toads was an interesting phenomenon. We have no way of knowing if our clearcut pitfall grids were, by chance, located on preharvest migration pathways or whether young toads in fact preferred to utilize clearcuts. In the SBS all six of the sampling grids were located in proximity to the body of water that was probably the source of the young toads (Heinen 1992). Even in the IDF, which was located many miles from the SBS site, more toads were found in the clearcut. Young toads do not seem to exhibit an aversion to moving through clearcuts, and looking at toad populations before the young toads appeared, it seems clear that adults also utilize the clearcuts. Toad use did not seem to be at the expense of other groups (Bury 1983), as all amphibian species found in this study were found in clearcuts.

It should be noted that the logged areas in this study had relatively little logging disturbance compared to that sometimes associated with logging (the only post-harvest treatment that was applied was broadcast burning on the ICH site). Our results agree with Plough et al. (1987), who concluded that small scale modifications to amphibian habitat resulting from timber harvesting had no negative effect on the abundance of amphibians. More severe interventions, like higher intensity broadcast burns (which are being regulated against in this region), or intensive mechanical preparation of soil for tree planting, could be expected to have more severe effects. Operations like these have been implicated in a decrease in reproductive success following timber harvesting (Enge and Marion, 1986). Examination of such interventions was beyond the scope of this study as they do not represent common situations in the Williams Lake area. However, there are currently plans to manage large areas of the IDF and SBS zones — which we have identified as good amphibian habitat — more intensively. In keeping with current provincial government policy we will be required to ensure that all aspects of biodiversity, including amphibians, are maintained in those areas.
CONCLUSION

There are significant amphibian populations in the bioclimatic zones that make up a large proportion of the Cariboo Forest Region. Long-Toed Salamanders (Figure 9), which are seldom seen by the casual observer, are common. All of the amphibians found in this study seem to be able to utilize clearcuts in the summer, and while we did not attempt to test statistical significance, the data do not indicate a trend towards lower capture rates in clearcuts. Surprisingly, we did not find salamanders in the Interior Cedar-Hemlock Zone; we expected to find them in abundance because of this zone’s deep forest floors and abundant woody debris. We will reexamine the ICH to verify this observation. We also plan further study to confirm whether our observations regarding activity in clearcuts are consistent across a greater range of conditions.

LITERATURE CITED


Kirsty Ward graduated in 1995 from the University of Alberta with an Honours Bachelor of Science in Zoology. She completed this work as her honours thesis.

Bill Chapman is a soil biologist with the Research Section of the Forest Service in Williams Lake. His main interest is soil fungi, especially mycorrhizal fungi, but he is interested in any organisms that spend the majority of their life in the mineral soil or the forest floor, including soil arthropods, worms, nematodes and roots.