

Tailed Frog Inventory, Merritt Forest District: Project Report 2001

Prepared by

Les W. Gyug, Reg. Prof. Biologist
Okanagan Wildlife Consulting
3130 Ensign Way,
Westbank, B.C. V4T 1T9
(250) 769-5907
Les_Gyug@telus.net

Prepared for

Southern Interior Region,
B.C. Ministry of Water, Land and Air
Protection,
Kamloops, B.C.

November 26, 2001.

EXECUTIVE SUMMARY

The Tailed Frog (*Ascaphus truei*) is a primitive stream-breeding amphibian limited to the wet mountain areas of western North America, that has been designated as “Identified Wildlife” under the Forest Practices Code of British Columbia because of concerns for the effects of forestry practices on the habitat and populations of this species. Okanagan Wildlife Consulting was contracted by the B.C. Ministry of Water, Land and Air Protection in 2000 and 2001 to conduct Tailed Frog surveys to determine the presence and distribution of Tailed Frogs within the Merritt Forest District, and to identify and describe stream habitats used by Tailed Frog tadpoles.

30-minute Time-Constrained Searches were undertaken at 111 widely scattered sites in 2000 and in 51 sites in 2001 at a present/not detected survey level to determine distribution. Tailed Frog adults and/or larvae were found at 58 of the 111 widely scattered sites in 2000 and at 14 of the 51 sites in 2001. The distribution of Tailed Frogs in the Merritt Forest District was mapped and occupies 19% of the area of the Forest District at its western edge. Tailed Frogs are also found in Easygoing Creek in the Ashnola River drainage of the Penticton Forest District. An additional 61 sites were sampled in five areas to determine the extent and types of streams inhabited by Tailed Frogs within single streams or drainages, as well as make recommendations for establishment of Wildlife Habitat Areas. Five such reaches were nominated for WHA status in 2000, but no new sites were recommended in 2001.

Tailed Frog larvae were found in streams of greater than 1.5% gradient, greater than 1.3 m bankfull width, and with cobbles (6 to 25-cm diameter) or larger substrate dominant or subdominant at the site. Within their range, they were found at all elevations between 1000 and 1700 m and occurred at equal frequencies in the ESSFmw, ESSFdc2, MSdm2, MS undifferentiated and IDFdk2. However, they only occurred in streams in the MS and IDF if these streams had their headwaters in an ESSF zone.

While Tailed Frogs can occur in clearcuts, populations entirely in clearcuts would not likely be viable because of elevated stream temperatures, and the likelihood of increased sedimentation and bed movement among other possible reasons. Within the Merritt Forest District, Wildlife Habitat Areas are recommended for Tailed Frogs on stream reaches that fit the following criteria:

1. Within the mapped core range of Tailed Frogs as presented in this report,
2. Where clearcut logging is proposed for major portions of 500-1000 ha drainages,
3. On S4 (fish-bearing but <1.5 m width), or S5 or S6 (non-fish bearing) streams that will not otherwise have any sort of forested reserve buffer,
4. On stream reaches where Tailed Frog larval occurrence is likely to be highest, i.e.
 - elevations between 1000 and 1700 m,
 - stream bank widths between 2.0 and 10.0 m,
 - gradients over 2.5%,
 - dominant streambed substrates >6.4 cm diameter.

TABLE OF CONTENTS

INTRODUCTION.....	5
Acknowledgements	5
STUDY AREA	6
SUMMARY OF LOCAL EXISTING INFORMATION.....	6
METHODS.....	7
Sample Design 2001	7
Inventory	7
Data Analysis and Reporting	9
RESULTS	10
Tailed Frog Distribution	10
Tailed Frog Larvae Habitat	17
Cunningham and Chisholm Creek Surveys.....	21
Adult Tailed Frog Habitat.....	25
Other Species.....	25
DISCUSSION.....	26
Sampling Efficiency	26
Temperature Limitations	27
Population Structure	28
Wildlife Habitat Area Recommendations	29
LITERATURE CITED	30

List of Figures

Figure 1. Time-Constrained Search sites during Year 2000 inventory, Merritt Forest District, showing Tailed Frog occurrences. Other known Tailed Frog locations in the district are shown, as well as the intensively sampled areas.	13
Figure 2. Moisture categories of BEC Zones in western Merritt Forest District showing Tailed Frog occurrence.	14
Figure 3. Intrusive bedrock geology in western Merritt Forest District showing Tailed Frog occurrences.	16
Figure 4. Elevation profile and Tailed Frog 30-minute Time-Constrained Search sites on Cunningham Creek, Merritt Forest District.	22
Figure 5. Elevation profile and Tailed Frog 30-minute Time-Constrained Search sites on Chisholm Creek, Merritt Forest District.	24

List of Tables

Table 1. Elevation and Biogeoclimatic Ecosystem Classification (BEC) Variants at Tailed Frog sampling sites, Merritt Forest District.	11
Table 2. Presence of Tailed Frogs in named creeks on the western side of the Merritt Forest District.	12
Table 3. Elevation and Biogeoclimatic Ecosystem Classification (BEC) Variants at all Tailed Frog sampling sites and other observations during Year 2000 and 2001 Inventories, Merritt Forest District.	17
Table 4. Bank and wet widths of streams at Tailed Frog sampling sites within Tailed Frog range in the Merritt Forest District.	18
Table 5. Stream bed substrates at Tailed Frog sampling sites within Tailed Frog, Merritt Forest District.	18
Table 6. Tailed Frog larval presence and amount of functional Large Woody Debris in streams at sampling sites within Tailed Frog range, Merritt Forest District.	20
Table 7. Water and air temperatures at sampling sites within Tailed Frog range, Merritt Forest District.	20
Table 8. Habitat characteristics and numbers of Tailed Frogs found at 30-minute Time-Constrained Search sites on Cunningham Creek, Merritt Forest District.	22
Table 9. UTM coordinates for Cunningham and Chisholm Creek Tailed Frog survey sites.	23
Table 10. Habitat characteristics and numbers of Tailed Frogs found at 30-minute Time-Constrained Search sites on Chisholm Creek, 2001, Merritt Forest District.	24

INTRODUCTION{tc \l 1 " INTRODUCTION "}

The Tailed Frog (*Ascaphus truei*) is a primitive stream-breeding amphibian limited to the wet mountain areas of western North America (Blaustein et al. 1995, Dupuis and Bunnell 1996). It has been designated as "Identified Wildlife" under the Forest Practices Code of British Columbia because of concerns for the effects of forestry practices on the habitat and populations of this species (B.C. Ministry of Forests and B.C. Environment, 1999). Okanagan Wildlife Consulting was contracted by B.C. Ministry of Water, Land and Air Protection in 2000 and in 2001, to conduct Tailed Frog surveys to meet the following objectives:

1. Determine the presence and distribution of Tailed Frogs within identified watersheds within the Merritt Forest District.
2. Identify and describe stream habitats used by Tailed Frog tadpoles.
3. Recommend candidate areas for Wildlife Habitat Area status,

Specific objectives for the year 2001 were to:

1. Complete the inventory begun in 2000 to fully define the distribution of Tailed Frogs within the Merritt Forest District,
2. Assess baseline Tailed Frog populations in Cunningham Creek, where a clearcut will harvest a 2.3 km section along the stream with a 20-m reserve buffer zone, as well as the adjacent Chisholm Creek as a control site.
3. Make recommendations for establishment of Wildlife Habitat Areas for Tailed Frogs.

Acknowledgements{tc \l 2 " Acknowledgements "}

Forest Renewal British Columbia provided funding for this project through the program of Tolko Industries. These funds were disbursed through B.C. Ministry of Water, Land and Air Protection, Southern Interior Region, Kamloops, B.C. John Surgenor, B.C. Ministry of Water, Land and Air Protection, Kamloops, was the contract monitor and provided valuable comments on the draft of this report. Technical assistance during the surveys was provided by Bruce Ryder and Laurie Rockwell. I thank Andy Bezener for providing additional location information on the Tailed Frog in the Merritt Forest District in 2000, and Tolko staff for another location in 2001.

STUDY AREA{tc \l 1 " STUDY AREA "}

The study area was the western portion of the Merritt Forest District west of Merritt and south and west of Princeton, B.C. This study area is within the Southern Interior Region of B.C. Ministry of Water, Land and Air Protection, and the Kamloops Forest Region of the B.C. Ministry of Forests. All previous records of Tailed Frogs in the Merritt Forest District were from this western area including the studies done in 2000 (Gyug 2000a) while the eastern portion of the Merritt Forest District is likely too dry to support Tailed Frogs (Dupuis et al. 2000).

The study area is in the Southern Interior Ecoprovince, and includes parts of the Northern Cascade Ranges, Interior Transition Ranges and Thompson-Okanagan Plateau Ecoregions. The study area includes parts of the Pavilion Ranges, Leeward Pacific Ranges, Hozomeen Range, Southern Thompson Upland and Okanagan Range Ecoregions. The study area includes the following Biogeoclimatic Ecosystem Classification (BEC) Zones or Variants (see Lloyd et al. 1990) that were inventoried: ESSFmw, ESSFdc2, ESSFxc, MSdm2, MS undifferentiated, MSxk, IDFd1, IDFd2, IDFxh1 and PPxh2.

Bedrock geology appears to also be an important determinant of Tailed Frog distribution with Tailed Frogs most likely to occur in areas of competent plutonic (intrusive) rocks (Dupuis et al. 2000). The Eagle Plutonic Complex is the dominant bedrock type along the spine of the Cascade Mountains on the western edge of the Merritt Forest District (Monger 1989a, Monger 1989b). The bedrock is predominantly granodiorite, which tends to break down into boulders and cobbles that should provide good Tailed Frog habitat in streams (Dupuis et al. 2000, Dupuis and Steventon 1999). The boundary of the Eagle Plutonic Complex roughly coincides with the eastern boundary of the ESSFmw. Further east in the Merritt Forest District, volcanic rock types predominate. The weathering products of some of these rocks (e.g. basalt) may form cobbles and boulders and good Tailed Frog habitat but the bedrock type also contains lava flows, breccias and tuffs among other rock types and the breakdown products are not as predictably good for Tailed Frogs as in the Eagle Plutonic Complex along the spine of the Cascade Mountains. There are some other large plutonic bedrock areas in the Merritt Forest District such as the Guichon Batholith northwest of Merritt, and the Pennask Batholith northeast of Princeton, but these areas are likely too dry to support Tailed Frogs.

SUMMARY OF LOCAL EXISTING INFORMATION{tc \l 1 "SUMMARY OF LOCAL EXISTING INFORMATION "}

In 1999, before this project began, Tailed Frogs had been found at only six locations in the Merritt Forest District during surveys aimed primarily at other species (Gyug 1996, Gyug 1997, Gyug 1998). In 1996, they were found in one reach of an unnamed tributary to Spius Creek (Nicola River drainage) and at one location in July Creek (Coldwater River drainage). In 1997 they were found in one location in the upper Coldwater River and in an unnamed tributary to Sutter Creek (Tulameen River drainage). In 1998 they were found at two locations

in Cunningham Creek (a tributary of Podunk Creek in the Tulameen River drainage). In 1999 they were found in one location in an unnamed tributary to Podunk Creek just to the east of Mt. Davis. All these locations were on the east side of the Merritt Forest District within 6 km of the Cascade Mountain divide, and all were within the Eagle Plutonic Complex. During the extensive surveys of 2000, Tailed Frogs were found in many other places on the west side of the Merritt Forest District (Gyug 2000a).

METHODS

Sample Design 2001

Sampling in 2001 was designed to complete our knowledge of the Tailed Frog range in the Merritt Forest District by filling in gaps in areas that were not sampled in 2000 (see Gyug 2000a). Within these geographic gaps, sites were preselected on a GIS system on streams that were likely to be good Tailed Frog habitat. In particular, this meant streams that were likely to be permanent, of greater than 2% gradient, and likely to be 2 to 8 m in width. Usually two or more sites were selected in a given area or stream for sampling since sparse populations might have been missed if only one sample was completed in an area.

The second objective in 2001 was to begin to determine the extent of annual variability in numbers and habitat use by resampling sites on Cunningham Creek drainage where extensive sampling was undertaken in 2000. Cunningham Creek was sampled intensively in 2000 because a cutblock (Tolko, CP161-2) has been proposed which runs along the length of Cunningham Creek for 2.3 km. For 800 m the cutblock straddles the creek, although there is a 20-m streamside reserve zone along the entire 2.3 km length. In addition, a comparison/control site was selected in the next drainage east of Cunningham Creek for when CP 161-2 is eventually logged. Eight sites were selected on Chisholm Creek to provide this control site for Tailed Frog populations.

Inventory

Following the RIC standards for Tailed Frog inventory (RIC 2000) at the presence/not detected level, 30-minute Time Constrained Search (TCS) samples were the primary data collection method. The total search time at each TCS site was 30 minutes, i.e., usually 15 minutes each by two people but 30 minutes by one person if one person was sampling alone. The streambed was visually searched and cobbles or rocks not embedded in the streambed were turned over to search under the rocks, or for larvae clinging to the bottom side of the rocks. Rocks were replaced in their original spots once any larvae were removed from the rock.

At the downstream end of each TCS, the location was recorded in UTM coordinates (NAD83, Zone 10) using a handheld consumer-grade GPS unit (Garmin GPS 12XL) capable of 15-m accuracy 99% of the time in good satellite tracking conditions. Also recorded near the center of each TCS area were: BEC zone, elevation, stream order at 1:50,000 (National Topographic System) and 1:20,000 (TRIM) scales, tree species adjacent to the stream, structural

stage adjacent to each bank of the stream (herb, low shrub, tall shrub, pole/sapling, young forest, mature forest, old forest), air temperature, stream temperature, stream gradient and aspect, average bank width and wetted width from 6 points, stream depth at breaks and residual pool depth, flow stage, channel pattern, relative abundance of islands, presence of bars, the coupling with surrounding slopes, degree of channel confinement, the crown closure (>1 m above stream) over the stream, the relative abundance and distribution of Large Woody Debris, the relative amount and type of fish cover present, the dominant and subdominant substrate composition, the diameter of the largest 5% of substrate (D95) and the largest substrate elements that move at flood stage (D), the stream morphology (in particular the type of water flow between pools in the stream, i.e., riffle-pool, cascade-pool or step-pool morphology), and whether any fish were seen at, or near, the site. Standards for most of these measurements are outlined in the Reconnaissance Fish and Fish Habitat Inventory: Site Card Field Guide (RIC 1999).

At each TCS site, the number of Tailed Frog larvae and adults seen were recorded. The approximate size of all adults and tadpoles were estimated. Measurements of Snout-vent length (SVL) for adults and Total Length (TL) to the nearest mm for larvae were made for most adults and for the few larvae caught and measured at each site. Tailed Frog larvae were classified as Small (20-31 mm TL), Medium (32-41 mm TL) and Large (42-54 mm TL). This was the limit of what could be discerned quickly by eye without actually capturing and measuring all the larvae. Young-of-the-year larvae hatch in mid- to late-summer and are white in colour, rather than dark brown or green. None were seen during this study. Sex of adults was recorded. Any developmental features noticed on tadpoles such as hind limb buds or legs were noted including relative size of hindlegs where possible. No forelegs were seen on any tadpoles and all tadpoles examined had adhesive disc mouth parts.

These simplified size classes for Tailed Frog larvae do not correspond directly to cohort year classes based on the size/age class measurements of Brown (1990) in high-elevation Tailed Frog populations in the North Cascade Mountains near Mt. Baker, and Metter (1964) in northern Idaho and south-eastern Washington. Metter (1964) found considerable overlap in size ranges of one- and two-year old larvae that depended on close examination of the larvae to determine which year cohort they actually belonged to (one-year larvae lacked any appendages and were slimmer). The size classes used in this study probably correspond to age classes as follows:

- Young-of-the-year: White rather than green or brown in colour (none seen).
- Small (20-31 mm TL): Contains all the one-year old cohort of larvae, possibly a few 2-year cohort larvae.
- Medium (32-41 mm TL): May contain a few one-year old cohort, contains all the 2-year old cohort as well as some 3-year old larvae.
- Large (42-54 mm TL): Contains some 3-year old larvae as well as all the 4-year old or older cohort of larvae.

Data Analyses and Reporting {tc \l 2 " Data Analysis and Reporting "}

The distribution of Tailed Frogs within the Merritt Forest District was mapped from the surveys using the presence/not detected data. A range line was drawn that included all sites where adults or larvae were detected. Within that range, what I have termed here a "core" range could be delineated where Tailed Frogs were found in most streams with suitable habitat. Between this core range and the edge of the mapped range, there was what I have termed a "peripheral" range. In this peripheral range larvae were not found in most of the streams sampled, or even most of those that appeared to contain suitable habitat.

All data points were used for analyses of elevation and BEC Variant use. However, further habitat analyses were limited to the 128 sampling sites within the core Tailed Frog range. For analysis of presence/not detected by stream order, sampling sites on the same stream reach were lumped. Streams that were obviously unsuitable because of very flat gradients or widths too narrow to support Tailed Frog larvae were eliminated from the further habitat analyses. This limited the detailed habitat analyses to 120 sites.

The location of each survey site and all other data for these Tailed Frog surveys from both 2000 and 2001 is contained in one GIS shapefile set called *ASTR_2001_Merritt_Albers*. The database file (.dbf) in this shapefile set can be opened and manipulated in Excel or an Excel file of the same name is also provided. Photos are available in digital format for 126 of the sites and have been provided on CD to the B.C. Ministry of Water, Land and Air Protection in Kamloops. All UTM coordinates reported in those files or in this report are Zone 10, NAD83. An ARC GIS shapefile set is also provided for the Tailed Frog core and peripheral range in the Merritt Forest District (*MerrittFD_ASTR_range*) as mapped in this report.

The location of all observations of other red and blue listed species, or evidence of red and blue listed species, were recorded during field searches and provided to B.C. Ministry of Water, Land and Air Protection in spreadsheet and GIS files. The only red- or blue-listed species found during these surveys was Mountain Beaver sign. This has been reported separately (see Gyug 2001). The GIS coverage with these locations is a shapefile set named *APRU_records_to2001_albers*. The spreadsheet file with the year 2000 and 2001 Mountain Beaver UTM coordinates collected during these Tailed Frog surveys is named *APRU_post1999_other.dbf*. This file attaches to the GIS shapefile via a common field named APRU_ID so that data can be tied to locations in ARC GIS.

RESULTS

30-minute Time-Constrained Searches were conducted at 146 sites in the Merritt Forest District between August 24 and September 29, 2000, and at 66 sites between September 2 and 29, 2001, with one search conducted in June 2001 outside of this time period. A total of 52 adult Tailed Frogs and 947 larvae were found. Nine of the sampling sites sampled in 2000 were sampled again in 2001, so that only 204 separate sites were actually sampled. The total number of larvae found included a total of 184 Small (20-31 mm TL) larvae, 418 Medium (32-41 mm TL) larvae and 344 Large (42-54 mm) larvae. No newly hatched young-of-the-year were seen. Seven other "random" Tailed Frog observations were collected during the surveys, or contributed from other sources during the survey period, but habitat data was only available from two of these sites.

153 of the sites were widely scattered sites to provide information on range and 61 were sites grouped along five stream reaches or drainages for intensive habitat sampling of local areas. Except for the sampling on Chisholm Creek and the resampling of Cunningham Creek, the results of the other grouped sites were reported in Gyug (2000a).

Tailed Frog Distribution

Tailed Frogs adults and/or larvae were found at 103 of the 204 sampled sites (Figure 1, Table 1). Tailed Frogs were found in all the major watersheds that we examined including the Nicola, Coldwater, Tulameen and Similkameen River drainages (Table 2). The range of the Tailed Frog in the Merritt Forest District totals 2201 km², or 19.5% of the entire district (Figure 1). The area of core range is 1778 km², and of peripheral range is 423 km². However, when alpine and parkland areas are discounted from the core range area, then the core range is 1531 km² and the peripheral range area is 403 km².

At the north end of the range in the Merritt Forest District (Nicola and Coldwater River drainages), the distribution of Tailed Frogs is confined to areas within 7 km of the Cascade divide (Figure 1). This boundary approximates the boundary of the moist or wet BEC Zones (Figure 2) as well as the boundary of intrusive bedrock types (Figure 3).

At the south end of the range in the Merritt Forest District, i.e., the Tulameen and Similkameen river watersheds, the distribution is much further from the Cascade Divide. This boundary again approximates the boundaries of moist or wet BEC zones as well as intrusive rock types (Figures 2 and 3). This core range extends well beyond the moist or wet BEC Zones and intrusive rock types only in the Granite Creek watershed (Figure 2). However, the headwaters of that drainage are at high elevations in the moist ESSFmw or ESSFmwp, and stream substrates were found to be mainly intrusive (granitic) rocks even well downstream of the intrusive bedrock zone.

Table 1. Elevation and Biogeoclimatic Ecosystem Classification (BEC) Variants at Tailed Frog sampling sites, Merritt Forest District.

BEC Variant	BEC as % of Range*	No. Sites with Adults only	No. Sites with Larvae	Total No. of Sites	% Sites with Larvae	BEC Variant	BEC as % of Range*	No. Sites with Adults only	No. Sites with Larvae	Total No. of Sites	% Sites with Larvae
Sites within Tailed Frog core range (1531 km²)						Sites in peripheral portions of range (403 km²)					
ESSFmw	52.5	2	61	82	74	MSdm 2	37.6	3	0	14	0
ESSFdc2	20.4	0	20	23	87	ESSFdc 2	36.2	0	2	6	33
MSdm2	14.5	2	8	11	73	IDFdk2	13.9	1	1	4	25
IDFdk2	6.4	1	7	9	78	ESSFmw	9.1	0	0	2	0
MSundiff	4.7	0	3	6	50	MSundiff	2.7	0	0	2	0
Other	1.5	-	-	-	-	ESSFxc	1.1	0	1	2	50
Totals		5	99	131	76	Totals		4	4	30	13
Sites outside Tailed Frog range Total = 43 sampling sites											
PPxh2		0	0	1	0	MSxk		0	0	3	0
IDFxh2		0	0	2	0	MSdm 2		0	0	7	0
IDFdk1		0	0	7	0	ESSFdc2		0	0	4	0
IDFdk 2		0	0	16	0	ESSFmw		0	0	3	0

*Alpine and Parkland have been excluded from range area calculations.

The relative occurrence (percentage of sites with larvae) of Tailed Frog larvae is very similar in each of the major BEC Variants (ESSFmw, ESSFdc2, MSdm2, MS undifferentiated and IDFdk2) within their core range (Table 1). However, they only occurred in streams in the MS and IDF if these streams had their headwaters in an ESSF zone, which is true for most of the streams in the core range. Streams that arise at lower elevations in the MS and IDF are probably too small to have permanent flows and the steeper gradients required to support Tailed Frog populations in this area of the Merritt Forest District.

Tailed Frog larvae were found in Placer and Calcite Creeks and in the Peeve Creek drainages on the Merritt side of the Pasayten/Ashnola divide. They were also found in Easygoing Creek in the Ashnola drainage in the Penticton Forest District, where we spent one day of sampling. I considered this area to be one in the "peripheral" range of the Tailed Frog, because populations were not widespread and many searches turned up no larvae (Figure 1). Tailed Frogs have also been found at high elevations in Cathedral Provincial Park (Martin Gebauer, pers. comm.) in the Penticton Forest District, and Tailed Frogs also occur south of the U.S. Canada border in that area (Washington Dept of Fish and Wildlife 2000). While these areas are well beyond the wet or moist BEC Variants (Figure 2), this area is one of intrusive bedrock types (Figure 3) and high alpine elevations. The bedrock types appear to be providing good cobble and boulder habitat that is useable because of the consistent late summer flows from the high elevations.

Table 2. Presence of Tailed Frogs in named creeks on the western side of the Merritt Forest District.

Named Creeks by Drainage			Named Creeks by Drainage			Tailed Frog Detections			Tailed Frog Detections											
Nicola River Drainage						Tulameen River Drainage														
Guichon	Hector	Not Detected	Asp			Not Detected														
	Steffen	Not Detected	Tributary of Lower Tulameen below Granite			Not Detected														
Shakan			Cook			Not Detected														
Skuhun			Granite			Blakeburn			Present											
Manning						Newton			Present											
Nuaitch						Arrastra			Upper Arrastra			Present								
Spius			Prospect						Badger			Present								
			Maka						Frenchy			Present								
			(but expected at headwaters)																	
Upper Spius			Present			Otter			Eliot			Not Detected								
Coldwater River Drainage						Thynne						Adult male only								
Upper Coldwater			Present			Lockie						Adult males only								
Juliet			Present			McPhail						Not Detected								
Mine			Not Detected			Olivene						Not Detected (but might be expected)								
			(but expected at headwaters)																	
Other unnamed tributaries			Present			Lawless			Skwum			Present								
Similkameen River Drainage						Pioneer						Not Detected								
Copper			Present			Holm						Present								
Pasayten			Unnamed Tributaries			Present			Upper Lawless						Present					
			Calcite			Present			Lower Mainstem						Not Detected					
			Peeve			Present			Britton						Illal			Present		
Whipsaw			Present									Upper Britton			Present					
Placer			Present									Mainstem Britton			Present					
						Champion						Present								
						McGee						Present								
						Vuich			Mainstem Vuich			Present								
												Amberty			Present					
												Railroad			Present					
						Upper Tulameen			Squakin			Present								
												Packers			Present					
									Podunk			Chisholm			Present					
															Cunningham			Present		
															Whitecloud			Present		
															Upper Podunk			Present		
												Blackeyes			Present					
												Coates			Present					

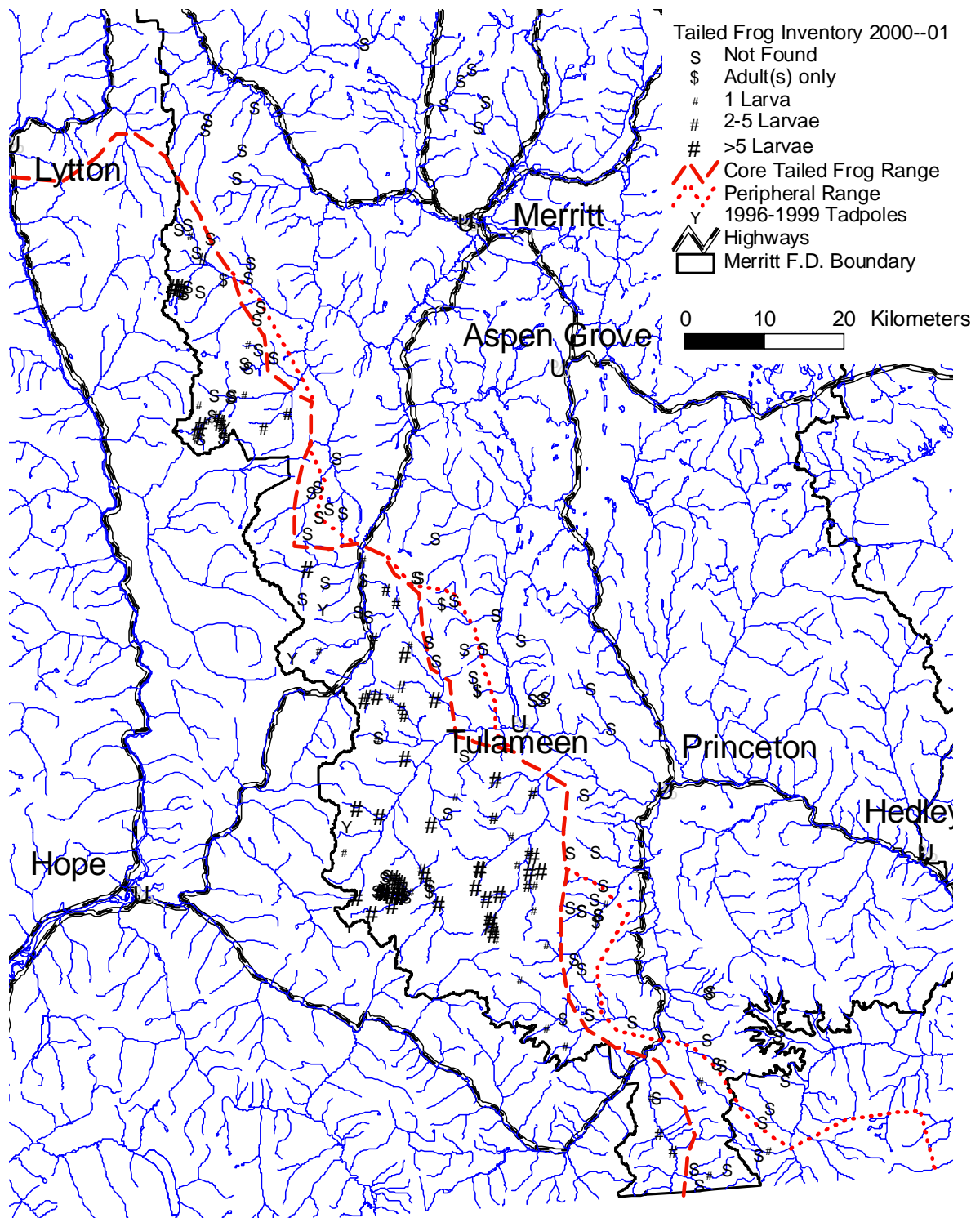


Figure 1. Time-Constrained Search sites during Year 2000 inventory, Merritt Forest District, showing Tailed Frog occurrences. Other known Tailed Frog locations in the district are shown, as well as the intensively sampled areas.

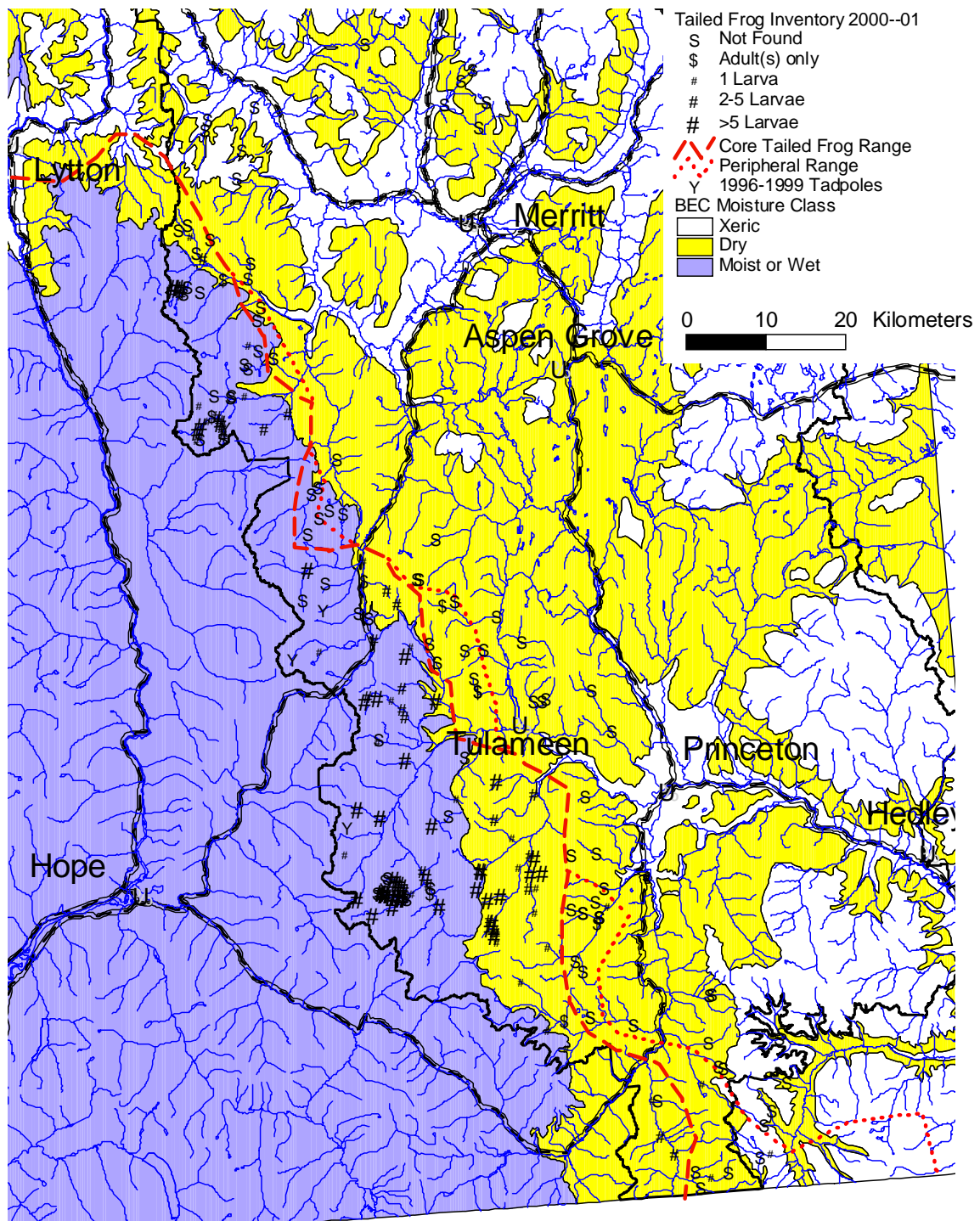


Figure 2. Moisture categories of BEC Zones in western Merritt Forest District showing Tailed Frog occurrence.

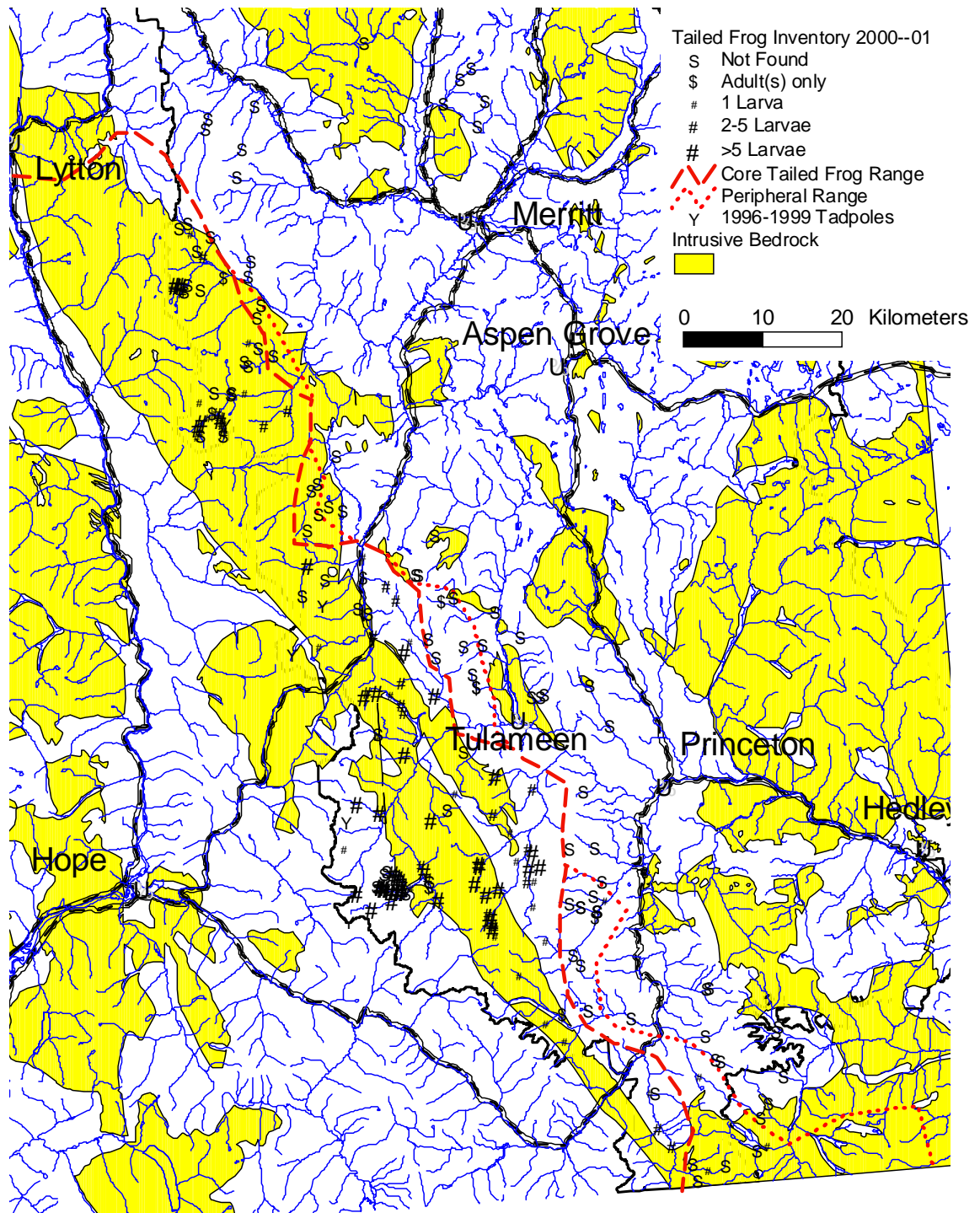


Figure 3. Intrusive bedrock geology in western Merritt Forest District showing Tailed Frog occurrences.

Table 3. Elevation and Biogeoclimatic Ecosystem Classification (BEC) Variants at all Tailed Frog sampling sites and other observations during Year 2000 and 2001 Inventories, Merritt Forest District.

Elevation (m)	No. Sites with no Larvae or Adults	No. Sites with Adults Only	No. Sites with Larvae	Total No. of Sites Sampled	% Sites with Larvae
600-799	1			1	0
800-899	3			3	0
900-999	1			1	0
1000-1099	5	1	5	11	45
1100-1199	17	3	7	27	26
1200-1299	13	2	16	31	52
1300-1399	16	3	29	48	60
1400-1499	15		23	38	61
1500-1599	14		21	35	60
1600-1699	6		7	13	54
1700-1799	1		2	3	67
1800-1899	1		1	2	50
Total	93	9	111	213	52

Tailed Frog Larvae Habitat

At the 1:50,000 scale, Tailed Frog larvae occurred in equal frequencies in zero-order (i.e. unmapped) streams (64% of 14 reaches), first-order streams (79% of 52 reaches), and second-order streams (66% of 29 reaches) (Chi-square (2 d.f.) = 2.24; $p > 0.10$, N.S.). They also occurred commonly in third-order streams (80% of 5 reaches sampled), but we did not sample many fourth-order streams because they were generally too wide, too deep to sample using hand-search methods, or of very low gradient.

At the 1:20,000 scale, Tailed Frog larvae occurred at lower frequencies in first-order streams (47% of 15 reaches) than in second-order (84% of 37 reaches) or third-order streams (77% of 43 reaches) (Chi-square (2 d.f.) = 7.96; $p < 0.05$). They appeared less commonly in fourth-order streams (50% of 8 reaches), but only apparently "suitable" fourth-order streams were sampled so the sample was not random or pre-selected. First-order headwater streams tended to be too small and ephemeral to contain permanent populations of Tailed Frog larvae. Few first-order 1:20,000 streams were chosen for sampling because many seemed to be dry during the sampling period of late summer and fall.

Streams were sampled between 600 and 1900 m elevation with larvae occurring equally commonly between the elevations of 1000 and 1700 m (Table 3). They were not found in low elevation streams below 1000 m, and very few streams were sampled above 1700 m.

Table 4. Bank and wet widths of streams at Tailed Frog sampling sites within Tailed Frog range in the Merritt Forest District.

Bank Width (m)	Mean Wet Width (m)	No. Sites with no Larvae	No. Sites with Larvae	Total No. of Sites	% Sites with Larvae
1.0-1.9	0.9	5	2	7	29
2.0-2.9	1.5	7	15	22	68
3.0-3.9	2.0	4	23	27	85
4.0-4.9	2.5	5	21	26	81
5.0-5.9	2.3	3	18	21	86
6.0-6.9	3.7	3	8	11	73
7.0-7.9	3.6	2	4	6	67
8.0-8.9	3.8	0	5	5	100
9.0-9.9	4.2	0	2	2	100
13.7	4.8	1	0	1	0
Totals		30	98	128	77

There were limits on widths of streams in which Tailed Frog larvae were found (Table 4). The smallest stream in which larvae were found was 1.4 m bank width. However, while larvae were found in 2 streams with <2.0 m bank width, in each case only one larvae was found. All streams were checked during low water conditions in late August and September, so wet width averaged only 55% of bank width. Tailed Frog larvae were not found in any streams in which the mean wet width was below 1.0 m, except in two cases where larvae were found in pools in streams that were flowing intermittently. They were very uncommon in streams below 2.0 m bank width, but common in all streams between 2.0 and 9.9 m bank width (Table 4).

Tailed Frog larvae were found in streams with gradients between 2.0 and 36.0 %, which was the maximum gradient of any stream surveyed. They were found in only 1 of 4 sites within their range with gradients of 2% or less, and at that site only one larvae was found. They were found in 80% of the 112 streams with gradients from 2.5 to 19.5% but were slightly less common in higher gradient streams, only being found in 58% of the 12 streams from 20 to 32.5% gradient. However, this difference was not statistically significant (Chi-square (1 d.f.) = 3.08, P>0.05).

The remainder of the habitat analyses took into account what appeared to be the basic gradient and stream width requirements for Tailed Frog larvae. The most level sites (<2.0%) and the smallest streams (bank widths <2.0 m) were excluded from the analysis of other habitat characteristics because they were assumed to be unsuitable habitat based on the width and gradient characteristics alone. The remainder of the habitat analyses were based on 120 sites that had gradients and widths that would make them potentially suitable for Tailed Frogs.

Table 5. Stream bed substrates at Tailed Frog sampling sites within Tailed Frog, Merritt Forest

District.

Dominant Substrate	No. Sites with no Larvae	No. Sites with Larvae	Total No. of Sites	% Sites with Larvae	Mean No. of Larvae per site that had larvae
Bedrock (>400 cm)	1	5	6	83	14
Boulder (25.6 - 400 cm)	2	22	24	92	7.5
<i>Cobble with Subdominant Boulder</i>	3	20	23	87	7.8
<i>Cobble with Subdominant Gravel</i>	<u>11</u>	<u>37</u>	<u>48</u>	<u>77</u>	<u>10.6</u>
Total Cobble (6.4 - 25.6 cm)	14	57	71	80	9.6
<i>Gravel with Subdominant Cobble</i>	7	10	17	59	5.2
<i>Gravel with Subdominant Fine</i>	<u>0</u>	<u>2</u>	<u>2</u>	<u>100</u>	<u>1.5</u>
Total Gravel (0.2 - 6.4 cm)	7	12	19	63	4.6
Total	24	96	120	80	8.6

Tailed Frog larvae were found more significantly more commonly in streams on north and east aspects than on south or west aspects. They were found at 88% of 84 sites between 316° and 135° (north and east) but only found at 61% of 36 sites between 136° and 315° (south and west) (Chi-square (1 d.f.) = 11.47, P<0.005).

Tailed Frog larvae occurred most frequently in streams dominated by bedrock and boulder substrates (83-92% of sites), and were less common as dominant substrates decreased in size to cobbles (80% of sites) and then gravel (63% of sites, Table 5). In most of the sites where gravel was the dominant substrate, cobbles were the subdominant substrate. Fine substrates did not dominate the streambed in any of the sites within the Tailed Frog range with gradients >1.5% and bank widths >1.9 m. The number of larvae found at sites where gravel was the dominant streambed material was half the number at sites where cobbles, boulders or bedrock were the dominant streambed material (Table 5).

Occurrence of Tailed Frog larvae in streams did not appear to vary according to amounts of large woody debris in the streams (Table 6, Chi-square (2 d.f.) = 2.26, P>0.10). Occurrence of Tailed Frog larvae in streams also did not appear to vary with differing amounts of canopy closure directly over the stream (Table 6, Chi-square (2 d.f.) = 1.20, P>0.10). Canopy closure in this case did not measure the closure of the streamside forest, but only the trees or tall shrubs that extended their canopies directly over the stream.

Table 6. Tailed Frog larval presence and amount of functional Large Woody Debris in streams at sampling sites within Tailed Frog range, Merritt Forest District.

Tailed Frog Larvae	Amount of Functional* Large Woody Debris in stream			Total No. of Sites
	Abundant (> or = 1 piece per bank width)	Few (<1 piece per bank width)	Very Few to None (< 1 piece per 5 bank widths)	
Not Detected	9	9	4	22
Present	24	51	12	87
Total No. of Sites	33	60	16	109
	% Canopy (>1 m in height) Crown Closure directly over stream			
	0-20%	21-40%	41-100%	
Not Detected	11	9	3	23
Present	52	26	8	86
Total No. of Sites	63	35	11	109

*Functional Large Woody Debris includes only those pieces attached or embedded in the stream or bank that directly influence the morphology of the stream channel by influencing sediment storage and/or local flow conditions.

Table 7. Water and air temperatures at sampling sites within Tailed Frog range, Merritt Forest District.

Water Temp. (C)	Mean Air Temp. (C)	Range Air Temp. (C)	No. Sites with no Larvae	No. Sites with Larvae	Total No. of Sites	% Sites with Larvae
2-3	2.8	1-6	0	5	5	100
4	5.8	4-7	2	2	4	50
5	7.7	4-11	5	6	11	55
6	8.7	6-14	7	21	28	75
7	9.3	4-14	5	27	32	84
8	11.4	9-14	3	16	19	84
9	12.5	8-16	2	13	15	87
10-11	15.2	13-16	0	6	6	100
Totals			24	96	120	80

Stream temperatures recorded at sample sites within Tailed Frog range were between 2 and 11 C with the majority (75%) between 5 and 8 C (Table 6). Tailed Frog larvae were found in water of any temperature within the range. Air temperatures were between 1 and 16 C during these samples. There was a correlation of stream temperature with air temperature although stream temperatures appeared more stable and less variable than air temperatures on a within-day basis. It did appear that Tailed Frog larvae were more active and easier to find at water temperatures warmer than 8C and there was a significant correlation between water temperatures and number of larvae found ($r = 0.39$, $F_{(1,96)} = 17.64$, $P < 0.001$) only considering those sites where larvae were present.

Cunningham and Chisholm Creek Surveys {tc \l 2 " Cunningham and Chisholm Creek Surveys "}

In Cunningham Creek, Tailed Frog larvae were very common from about the 500 m point up the stream to the 3200 m point with small one-year old cohort larvae most common in the central portion of the stream from about 800 m to 3000 m (Figure 4, Table 8). Numbers of larvae counted were much lower in 2001 than in 2000 but were only abundant in the same places in 2001 as they were in 2000. Water temperatures during the surveys were between 8-10 C in 2000 and 7-8 C in 2001. Surveys were carried out on August 24 and 25, 2000, and on September 5, 2001. Larval numbers at each site were lower at every site on Cunningham Creek in 2001 compared to 2000 by an average of 21.9 larvae per site. This difference was statistically significant (paired t-test, N = 7 pairs, $t=2.81$, $P=0.026$). It is not known if the difference in numbers counted between years represents an annual population fluctuation because we do not yet know how much fluctuation there might be in counts on any given site even within one year.

The first portion of Cunningham Creek at its mouth is a debris deposition area where the stream levels out as it enters the Podunk Creek valley. Cunningham Creek is intermittent for its first 200-300 m as it flows through deep coarse material in the Podunk valley. One larvae was found at the mouth of the stream in a puddle in 2000, but none were found in this area in 2001. In 2000, fish were only seen in the stream from the mouth to a point about 300 m upstream, but none were seen in 2001. Podunk Creek has a streambed of predominantly gravel and fine substrates, is low gradient, is excellent trout habitat based on the number of trout seen, and is generally not suitable habitat for Tailed Frog larvae.

Dominant substrates on Cunningham Creek were cobbles throughout the stream except at Site 85 (Figure 4) where bedrock formed the streambed, and at the headwaters where coarse gravels were the dominant substrate. The stream becomes too small and uninhabitable by Tailed Frogs where it hits the steep (>20%) headwaters from about the 3800-m point.

In the very hot and dry summer of 1998, most of Cunningham Creek flowed underground with only the portion constrained by bedrock near Site 85 (Figure 4) consistently with surface water. This was only one of two sites on the stream (Site 88) where we happened to notice Tailed Frog larvae while searching the banks for Mountain Beaver sign. Most of the other portions of the stream would not have been suitable for Tailed Frog larvae in 1998 since there was no surface water in the stream. However, even in that summer of 1998 when most of the stream went dry, survival of larvae must have been good since we did not find any absence of 2+-year-old cohort larvae in the stream in 2000. It would appear that larvae survived in small pockets of suitable habitat in the summer of 1998 and dispersed throughout the stream in 1999 or afterwards when water levels returned to normal.

Adult females were only found at Sampling Site 84 about 800 m from the mouth of the stream in both years. All other adults found were males at Sites 83, 89 and 148. The area suitable for Tailed Frog reproduction, i.e., where adult females were found, may be quite small and dispersal of larvae may account for most of the populations found over the stream length. It is also possible that adult females occurred elsewhere on the stream but were not found.

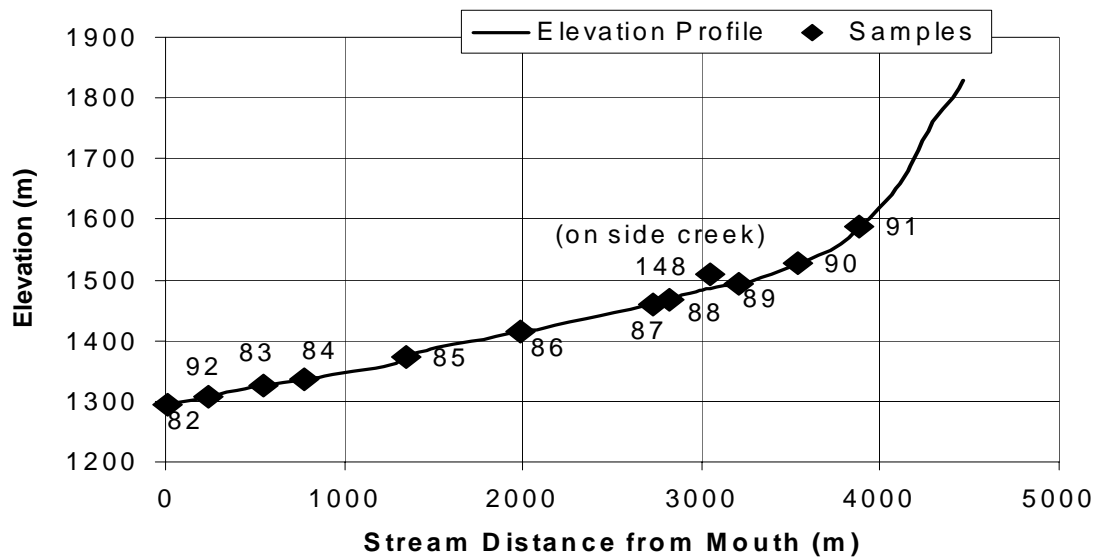


Figure 4. Elevation profile and Tailed Frog 30-minute Time-Constrained Search sites on Cunningham Creek, Merritt Forest District.

Table 8. Habitat characteristics and numbers of Tailed Frogs found at 30-minute Time-Constrained Search sites on Cunningham Creek, Merritt Forest District.

Habitat Variable	Sampling Point (See Table 9 for UTM coordinates)											
	82	92 ¹	83	84	85	86	87	88	148 ¹	89	90	91
Bank Width (m)	5.7	3.5	4.6	6	4.8	2.8	3.2	3.2	0.5	3.6	2.5	2.3
Wet Width (m) 2000	0 ²	1.3	1.4	2.3	2.3	1.5	1.8	1.8	0.3	1.3	1.1	1.4
Wet Width (m) 2001	1.5	NS ³	1.1	1.7	2.2	2.2	1.7	2.1	NS	0.9	NS	NS
Gradient (%)	4	3.5	6.0	6	12	4.5	7.0	6.5	16	9	13.5	20
Dom. Substrate ³	C	C	C	C	R	C	C	C	G	C	C	G
Subdom. Substrate	G	G	G	G	C	B	G	G	C(5%)	G	R	C
Numbers of Tailed Frogs 2000												
Adults	0	0	0	3	0	0	0	0	1	0	0	0
Larvae >1 year-old	1	4	22	25	54	41	17	30	0	28	3	0
1-year-old Larvae	0	0	0	3	7	11	11	3	0	4	2	0
Numbers of Tailed Frogs 2001												
Adults	0	NS	1	2	0	0	0	0	NS	3	NS	NS
Larvae >1 year-old	0	NS	6	20	4	8	12	17	NS	5	NS	NS
1-year-old Larvae	0	NS	2	7	3	3	11	2	NS	3	NS	NS

¹ Samples 92 and 148 were random observations and not 30-minute Searches. Point 148 was on a side stream.

² Substrates: R = Bedrock, B = Boulder, C= Cobble, G = Gravel (see Table 5 for size ranges)

In Chisholm Creek, Tailed Frog larvae were common from about 1000 m up the stream to about 3000 m up the stream point with small one-year old cohort larvae distributed throughout this section. (Figure 5, Table 10). Water temperatures during the surveys were between 7-9 C when the surveys were done on September 6, 2001. Only 3 of the 4 adults seen were caught and identified, and all were male. Only one Site (No. 15) was sampled in both 2000 and 2001, so not many comparisons can be made between the two years. At Site 15, 5 larvae were seen in 2000 but only one in 2001. Water temperature was 9 C on August 30 when the site was sampled in 2000.

Boulders were the pre-dominant substrate in the portion of Chisholm Creek where Tailed Frog larvae were common. Gradients are 5-9% and spring flows appear to have scoured most gravels and finer material out of this reach. Above the 3000-m point on the stream the stream gradient is lower (4-5%) and this area appears to be a deposition zone in the upper valley for gravels washed in from the hillsides. The stream flows intermittently through these gravels, is dry for 90% of this reach, and the area is not inhabited by Tailed Frog larvae.

While fish generally do not have good access to Cunningham Creek at low flow levels because it is intermittent for its lowest few hundred meters, Chisholm Creek appears to be a larger creek with higher flow volumes, and is continuous as it flows into Podunk Creek. The area drained by Chisholm Creek is approximately 750 ha, while the area drained by Cunningham Creek is approximately 475 ha. Fish were seen co-existing with Tailed Frog larvae at Site 15 800 m up the stream in both 2000 and 2001. No fish were seen above Site 15 in 2001.

Relative density of Tailed Frog larvae based on the 30-minute TCS method were not significantly different in Chisholm and Cunningham Creeks in 2001 based on a comparison of numbers at sites in the central section of each creek (Cunningham Sites 83-89; Chisholm Sites 200-203) where more than 1 larvae were found in 2001. The sites had variances that were not significantly different ($F = 1.18$, $P = 0.48$, N.S., pooled variance 63.49) and mean numbers of larvae found that were not significantly different (Cunningham = 14.7, $N = 7$; Chisholm 19.0, $N = 4$; $t=0.86$, $P= 0.41$, N.S.).

Table 9. UTM coordinates for Cunningham and Chisholm Creek Tailed Frog survey sites.

Cunningham Creek				Chisholm Creek			
Sampling Point	UTM Easting	UTM Northing	Distance from Stream Mouth	Sampling Point	UTM Easting	UTM Northing	Distance from Stream Mouth
82	647201	5468000	0	15	647108	5470217	770
83	646780	5469145	550	200	646800	5470572	1257
84	646559	5469228	774	201	646454	5470925	1772
85	645995	5469342	1348	202	646117	5471180	2195
86	645402	5469411	1984	203	645834	5471578	2695
87	644657	5469774	2724	204	645428	5471644	3117
88	644598	5469738	2824	205	644915	5471739	3704
89	644236	5469874	3204	206	644556	5471502	4150
90	643890	5469871	3544				
91	643595	5469970	3884				

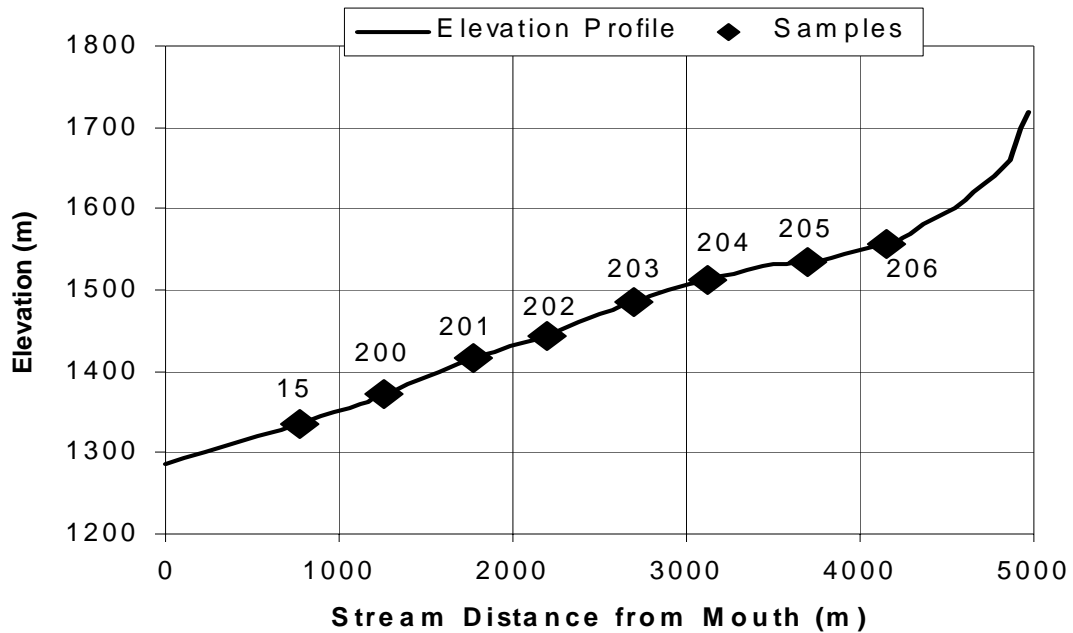


Figure 5. Elevation profile and Tailed Frog 30-minute Time-Constrained Search sites on Chisholm Creek, Merritt Forest District.

Table 10. Habitat characteristics and numbers of Tailed Frogs found at 30-minute Time-Constrained Search sites on Chisholm Creek, 2001, Merritt Forest District.

Habitat Variable	Sampling Point (See Table 9 for UTM coordinates)								
	15 (2000)	15 (2001)	200	201	202	203	204	205	206
Bank Width (m)	5.9	8.3	8.8	5.3	3.9	4.3	3.1	-	-
Wet Width (m)	2.4	2.0	2.2	1.4	2.5	1.3	2.1	0	0-
Gradient (%)	8.5	8.5	8	9	5	6	4	4	5
Dom. Substrate ³	B	B	B	B	B	B	G	G	G
Subdom. Substrate	C	C	C	C	C	G	C	F	F
Numbers of Tailed Frogs									
Adults	0	0	0	2	1	0	1	0	0
Larvae >1 year-old	2	0	12	5	14	4	0	0	0
1-year-old Larvae	3	1	5	5	7	24	1	0	0

³ Substrates: B = Boulder, C= Cobble, G = Gravel; F = Fines (see Table 4 for size ranges).

Adult Tailed Frog Habitat {tc \l 2 "Adult Tailed Frog Habitat "}

Only 50 adult Tailed Frogs were observed in the sample sites, and an additional 3 in random observations. These included 33 males, 11 females, and 9 that were not caught and therefore their sex was not identified.

Mature adult female Tailed Frogs (i.e., SVL >35mm) were only identified at seven of the 36 sites where adults were found. Each of these sites also contained Tailed Frog larvae. One of the adult females was found within a stream in a clearcut 100 m from a mature forest. However, only adult males and immature adult females (22 and 24 mm SVL) were found at the ten sites where there were adults but no larvae. Of these 10 sites with adults but no larvae, three would have been considered too narrow for larvae (bank widths < 1.5 m). Since it was only adult males or immature females that were found on streams without larvae, then these adults were probably either dispersing juveniles, or adult males searching for mates during the September breeding season. It would appear that adult females are far less prone to wander away from potential breeding streams than males or immature females.

Other species{tc \l 2 "Other Species"}

Fish were found at 19 of the 120 sites considered to be potentially suitable for Tailed Frog larvae and within the core range of the Tailed Frog. At 16 of these 19 sites they were found in conjunction with Tailed Frog larvae, and at three of the sites there were also adult Tailed Frogs. All fish that were seen and identified during the sampling appeared to be trout or salmonids. The only fish positively identified was a Rainbow Trout found dead in a section of Illal Creek.

The only other red- or blue-listed species encountered during these surveys was Mountain Beaver, as recognized by their distinctive tunneling and haypiles at 19 of the sampling sites. Some of the 19 sites were outside the known range of Mountain Beaver as reported in Gyug (2000b). This data has been incorporated into the report on Mountain Beaver submitted separately (Gyug 2001), but under this same contract, to B.C. Ministry of Water, Land and Air Protection. (See method section for data file names as submitted to B.C. Ministry of Water, Land and Air Protection.)

DISCUSSION

This study confirmed that Tailed Frogs inhabit cold, clear, rocky, permanent mountain streams in the Merritt Forest District-as it does elsewhere in B.C. (Dupuis et al. 2000, Sutherland et al. 2000). In particular, at a large geographic scale, the distribution was explained primarily by precipitation, or, to be more accurate, the wet or moist BEC zones that I used here as a stand-in for precipitation, as found in the Coast and Kootenay populations (Sutherland et al. 2000). On smaller scales in this study, Tailed Frog larval occurrence was most often associated with elevations between 1000 and 1700 m, stream gradients >2%, streams >2.0 m bank width, and with cobble-sized (6.4 cm diameter) or larger substrate materials near plutonic bedrock types. Sutherland et al. (2000) found meso and micro scale Tailed Frog habitat associated with elevation, bedrock type, and dominance of boulder substrates in coastal populations, and with % area logged, slope and predominance of cobble and boulder substrates in the Kootenay populations.

Sampling Efficiency

The 30-minute Time-Constrained Search method was not 100% effective in determining the presence of Tailed Frogs. Where larval numbers were low, they may easily have been missed. An example was at Fifteen-mile Creek in the Whipsaw Creek drainage near Princeton. We did not find any larvae in the three samples done on that stream, even though Andy Bezener (pers. comm.) had found larvae in the same stream reach during September 2000. However, in 2001, we did two more samples on Whipsaw Creek in that area, and did find Tailed Frogs on both.

Even within their core range, Tailed Frogs were only found in 80% of apparently suitable habitat (based on gradient and stream bank widths). At the periphery of the range, this figure was much lower, with larvae found at only 18% (4 of 22) of sites and a further 14% (3 of 22) sites with adults found but no larvae. While the core range map is not likely to change significantly even with more sampling, the lines drawn for the peripheral range could easily change with more sampling. Consequently, the edge of the peripheral distribution map must be interpreted with caution, since low larval numbers may exist at the edge of the area, and sometimes beyond.

Dispersal corridors

The survey methods used here to detect tadpoles are not very efficient at detecting adult Tailed Frogs, which are better found on warm and humid nights when they are more active. However, given that only adult males and immature adult females were found on very small streams or other streams that do not contain larvae, these streams are probably used as dispersal corridors. Therefore small streams should not be disregarded as unimportant to Tailed Frogs simply because they are too small to contain populations of larvae. These probably serve important functions as landscape connections to allow for dispersal of adults.

Temperature Limitations{tc \l 2 " Temperature Limitations "}

Inland populations of Tailed Frogs breed in September and October, but the females do not lay the fertilized eggs until the next July, after which they develop in about 6 weeks (Brown 1975). The females also seem to be very specific in the areas they use to lay the eggs, sometimes aggregating in July to lay eggs in what is assumed to be ideal egg-laying habitat (Brown 1975). It is not known how specific the adult females are in choosing egg-laying sites according to temperature since that has never been specifically studied. However, Tailed Frog adults, eggs and larvae have different temperature tolerances as follows:

- 50% of adults die when exposed to temperatures of 25 C for 8 hours (Claussen 1973a, Claussen 1973b),
- Embryos in eggs only develop between temperatures of 5 and 18 C, although development time at 5 C is doubled to over 10 weeks compared to the actual development time of 6 weeks normally observed (Brown 1975).
- One-year old larvae prefer temperatures of 5-9 C (De Vlaming and Bury 1970),
- Older larvae prefer temperatures of 12-16 C (De Vlaming and Bury 1970),
- All ages of larvae avoid temperatures >22 C (De Vlaming and Bury 1970).

We did not record any temperatures above these upper tolerances, but we were sampling only in late summer and fall when air temperatures never exceeded 19 C at any of the sampling sites. Since air temperatures can get considerably higher than 19 in mid summer, stream temperature data for the area was examined from the Sensitive Stream Temperature Project in the Merritt Forest District (Henderson Environmental Consulting Ltd. 2001). That project examined some of the same streams in which we found Tailed Frogs.

For instance, in the unnamed tributaries of Aspen Creek in the area of Aspen Planers CP61/CP610 area, there were two Tailed Frog Survey Sites (25 and 26), and 8 Stream Temperature Stations (ASP15-22). The maximum stream temperature recorded in 2001 was 14.7 C in the drainage at elevations between 1220 and 1680 m. The 7-day maximum (mean daily maximum for any 7-day moving average) was 13.7 C. The headwaters of this drainage are above 1800 m on Stoyoma Mountain. This maximum temperature is well within the maximum temperature tolerance of Tailed Frogs at any stage of their life cycle.

In the Aspen Planers CP22/CP70 area of the Spius Creek drainage, recording stations were between 1235 and 1420 m, the streams flowed from maximum elevations of 1640 m, and the streams flowed through some large clearcuts. Annual maximum temperature on one stream was 11.2 C (10.6 C 7-day maximum) above a clearcut, and 18.3 C (17.2 C 7-day maximum) at the downstream end of the clearcut (Stream Temperature Stations ASF16-17). On another stream (Tailed Frog Survey Site 31, Stream Temperature Stations ASF12-14), annual maximum temperature was 16.9 C (12.9 C 7-day maximum) above a clearcut, 19.2 (18.1 C 7-day maximum) 1200 m within the clearcut, and 15.3 C (14.6 7-day maximum) 500 m downstream of the clearcut. Tailed Frog larvae were present 500 m downstream of the clearcut. In both these

cases, the stream temperatures within or at the downstream end of the clearcut were above the tolerances for egg development for Tailed Frogs. However, it does not appear that the elevation of stream temperatures within clearcuts lasts far downstream since the temperature was reduced to levels within the tolerance of Tailed Frog eggs after the stream had flowed for 500 m through a forest. A further 3.5 km downstream of these sites (Tailed Frog Survey Site 30, Stream Temperature Stations ASF11, elevation 1040 m), annual maximum temperatures (14.9 C) and annual 7-day maximum (14.6 C) were still within the tolerance of Tailed Frogs, and Tailed Frog larvae were present.

The Sensitive Stream Study (Henderson Consulting Ltd 2001) also found that stream temperatures were greatly elevated at the outlet of wetlands since streams skimmed off the top warmest water layers. This layer could be up to 26 C in the Spius drainage (Stream Temperature Station ASF15, elevation 1225 m) where other streams flowing within forests at the same elevation had typical annual maxima of 14-17 C. This warm water influx caused annual maximum stream temperatures >18 C as least as far downstream as 1.5 km. Therefore large wetlands may also dictate stream temperatures, and therefore suitability of Tailed Frog habitat in the downstream area.

Population Structure

We did not make measurements of the complete size structure of any population of Tailed Frog larvae, so are unable to provide exact age classes of any population based only on the size classes we were easily able to distinguish by eye in the field (see Methods section). There are also different growth rates for different streams and populations (Metter 1964, Brown 1990, Bull and Carter 1996). Larvae also grow throughout the summer with the one-year old cohort increasing by 7-10 mm in the first full summer of growth as one-year olds (Bull and Carter 1996). Careful examination and measurement of larvae in each stream or population is required to accurately determine age classes of Tailed Frog larvae.

We cannot assume that just because Tailed Frog larvae were found in a stream that reproduction is occurring at that spot. As in Cunningham Creek in this study, older age class larvae (2+ years) had a wider distribution in the stream than did the one-year old larvae or did the adult females. This makes interpretation of larvae found in clearcuts problematic since we never did find any larvae that were just hatched at any site nor did we find any egg masses or nest sites. Are the larvae found in clearcuts dispersing to these sites from forested sites where reproduction is occurring, or is reproduction occurring in the non-forested sites as well?

We do not know how mobile the Tailed Frog larvae may be within the streams they inhabit. Wahbe (1996) found Tailed Frog larvae moving up to 65 m within streams in old growth but only 3 m in clearcuts. Given the redistribution of Tailed Frogs throughout Cunningham Creek two years after it largely dried up in the summer of 1998, I suspect that Tailed Frog tadpoles can probably move much further than 65 m within a stream.

Wildlife Habitat Area Recommendations {tc \l 2 " Wildlife Habitat Area Recommendations "}

Besides the temperature effects, clearcutting tends to promote stream characteristics that are unfavourable to Tailed Frog larvae and adults such as unstable streambeds, and increased detritus, fine substrates and woody debris. Consequently there is usually an overall lower abundance of Tailed Frogs in streams surrounded by clearcuts (Dupuis and Steventon 1999, Corn and Bury 1989, Welsh and Ollivier 1998, Bull and Carter 1996). Matsuda and Richardson (2000) also found that most adult Tailed Frogs occurring in clearcuts were non-reproductive juveniles moving through the areas, indicating that clearcuts were sub-optimal habitat for reproductive adults.

While this study did show that Tailed Frogs can occur within clearcuts (Gyug 2000a), it is not clear how much clearcutting can take place and a viable population still be maintained. Major gaps in our knowledge of Tailed Frog biology include knowledge of the types of habitats where egg laying is taking place, how far larvae and adults move within or along streams through forested or clearcut areas, and survivorship and reproductive potential in the two habitats.

The existence of forested buffers on streams seemed to be the best predictor of increased larval and adult occurrence in clearcuts in two studies (Dupuis and Steventon 1999, Bull and Carter 1996). Population simulations also suggest that the cumulative effects of forestry practices do have the potential to place populations at moderate to high risk of extirpation in the long term (Sutherland et al. 2000). The Managing Identified Wildlife Guidelines have therefore adopted the approach of establishing forest buffers on streams for Wildlife Habitat Areas (WHA) for Tailed Frogs.

It would be recommended to continue Tailed Frog surveys on stream reaches with the intent of establishing WHAs only in the following areas:

1. Within the mapped core range of Tailed Frogs as presented in this report,
2. Where clearcut logging is proposed for major portions of 500-1000 ha drainages within this range,
3. On S4 (fish-bearing but <1.5 m width), or S5 or S6 (non-fish bearing) streams that will not have any sort of forested reserve buffer maintained by the application of existing Forest Practices Code fish-stream guidelines
4. On stream reaches where Tailed Frog larval occurrence is likely to be highest, i.e.
 - elevations between 1000 and 1700 m,
 - stream bank widths between 2.0 and 8.0 m,
 - gradients over 2.5%,
 - dominant streambed substrates >6.4 cm diameter.

It would typically take two field days by a team of two for surveys to determine exact placement of WHAs within a drainage of 500-1000 ha. If no separate Tailed Frog surveys were to be undertaken, the best placement of any WHA could be estimated by applying the above procedure once the stream surveys had been completed at the block layout stage.

LITERATURE CITED{tc \l 1 " LITERATURE CITED "}

- B.C. Ministry of Forests and B.C. Environment. 1999. Managing identified wildlife: procedures and measures. Volume 1. Co-published by B.C. Ministry of Forests and B.C. Environment, Victoria, British Columbia.
- Blaustein, A.R., J.J. Beatty, D.H. Olson and R.M. Storm. 1995. The biology of amphibians and reptiles in old-growth forests in the Pacific Northwest. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-337.
- Brown, H.A. 1975. Temperature and development of the tailed frog, *Ascaphus truei*. *Comp. Biochem. Physiol.* 50A: 397 - 405.
- Brown, H.A. 1990. Morphological variation and age-class determination in overwintering tadpoles of the tailed frog, *Ascaphus truei*. *J. Zool., Lond.* 220:171-184.
- Bull, E.L. and B.E. Carter. 1996. Tailed frogs: distribution, ecology and association with timber harvest in northeastern Oregon. USDA Forest Service Research Paper PNW-RP-497.
- Claussen, D.L. 1973a. The thermal relations of the tailed frog, *Ascaphus truei* and the Pacific treefrog, *Hyla regilla*. *Comparative Biochemistry and Physiology.* Great Britain, Pergamon Press. 44A:137-153.
- Claussen, D.L. 1973b. The water relations of the tailed frog, *Ascaphus truei* and the Pacific treefrog, *Hyla regilla*. *Comparative Biochemistry and Physiology.* Great Britain, Pergamon Press. 44A:155-171.
- Corn, P. S., and R. B Bury. 1989. Logging in western Oregon: responses of headwater habitats and stream amphibians. *Forest Ecology and Management* 29:39-57.
- DeVlaming, V.L. and R.B. Bury. 1970. Thermal selection in tadpoles of the tailed frog, *Ascaphus truei*. *Journal of Herpetology* 4:179-189.
- Dupuis, L.A. and F.L. Bunnell. 1996. Status and distribution of the Tailed Frog in British Columbia. Unpublished Report prepared for Ministry of Forests, Nanaimo, B.C.
- Dupuis, L.A. and D. Steventon. 1999. Riparian management and the tailed frog in northern coastal forests. *Forest Ecology and Management* 124(1999):35-43.
- Dupuis, L.A., F.L. Bunnell and P.A. Friele. 2000. Determinants of the Tailed Frog's range in British Columbia, Canada. *Northwest Science* 74(2):109-115.
- Gyug, L.W. 1996. Forest Development Plan Red- and Blue-listed Species Inventory for Small Mammals: Mountain Beaver (*Aplodontia rufa*), Cascade Mantled Ground Squirrel (*Spermophilus saturatus*), and Sagebrush Northern Bog Lemming (*Synaptomys borealis artemisiae*). Report prepared for B.C. Env't, Penticton, B.C.
- Gyug, L.W. 1997. Forest Development Plan Red- and Blue-listed Species Inventory for Mountain Beaver (*Aplodontia rufa*), Cascade Mantled Ground Squirrel (*Spermophilus saturatus*), Sagebrush Northern Bog Lemming (*Synaptomys borealis artemisiae*), and Tailed Frog (*Ascaphus truei*). Report prepared for B.C. Min. of Environment, Southern Interior Region, Penticton, British Columbia
- Gyug, L.W. 1998. 1998 Forest Development Plan Inventory in the Merritt Forest District, British Columbia: Mountain Beaver (*Aplodontia rufa*), and Tailed Frog (*Ascaphus truei*). Report prepared for British Columbia Ministry of Environment, Southern Interior Region, Penticton, British Columbia. 21 pp.
- Gyug, L.W. 2000a. Tailed Frog Inventory, Year 2000, Merritt Forest District. Unpublished report prepared for B.C. Ministry of Environment, Lands and Parks, Kamloops, B.C.
- Gyug, L.W. 2000b. Status, distribution and biology of the Mountain Beaver, *Aplodontia, rufa*, in Canada. *Canadian Field Naturalist* 114(3):476-490.
- Gyug, L.W. 2001. The Impact of Alternative Timber Harvesting Techniques on Mountain Beaver (*Aplodontia*

- rufa*), in the Merritt Forest District, British Columbia: Progress Report 2001. Unpublished report prepared for B.C. Ministry of Water, Land and Air Protection, Southern Interior Region, Kamloops, B.C.
- Henderson Environmental Consulting Ltd. 2001. Stream Temperature in the Spius Creek Watershed Second Year Results: 2000 summer /fall. Unpublished report prepared for Aspen Planers Ltd. Merritt Division, Tolko Industries Ltd. Nicola Valley Division, Weyerhaeuser Canada Ltd. Merritt Division, Merritt, B.C. Available at URL <http://www.for.gov.bc.ca/kamloops/district/merritt/tss/index.htm>
- Lloyd, D, K. Angove, G. Hope and C. Thompson. 1990. A guide to site identification and interpretation for the Kamloops Forest Region. B.C. Min. of Forests, Victoria, B.C.
- Matsuda, B.M. and J.S. Richardson. 2000. Clearcut timber harvest and movement patterns in Tailed Frogs p. 485-488. IN Laura Darling (ed.). At risk: proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, B.C. 15-19 Feb. 1999. University College of the Cariboo, Kamloops, B.C. and British Columbia Ministry of Environment, Lands and Parks, Victoria, B.C.
- Metter, D.E. 1964. A morphological and ecological comparison of two populations of the tailed frog, *Ascaphus truei* Stejneger. Copeia. 1964:181-195.
- Monger, J.W.H. 1989a. Geology, Hope, B.C. Map 41, Sheet 92H 1:250,000. Geological Survey of Canada, Ottawa. Available in digital form as ARC coverage at <http://www.em.gov.bc.ca/Mining/GeolSurv/MapPlace/Default.htm>
- Monger, J.W.H. 1989b. Geology, Ashcroft, B.C. Map 42, Sheet 92I 1:250,000. Geological Survey of Canada, Ottawa. Available in digital form as ARC coverage at <http://www.em.gov.bc.ca/Mining/GeolSurv/MapPlace/Default.htm>
- Resources Inventory Committee. 2000. Inventory methods for Tailed Frog and Pacific Giant Salamander. Standards for Components of British Columbia's Biodiversity No. 39. Version 2.0. Resources Inventory Committee, Wildlife Branch, Ministry of Environment, Lands and Parks, Victoria, British Columbia.
- Resources Inventory Committee. 1999. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Site Card Field Guide. Resources Inventory Committee, Wildlife Branch, Ministry of Environment, Lands and Parks, Victoria, British Columbia.
- Sutherland, G.D., J.S. Richardson and F.L. Bunnell. 2000. Uncertainties lining Tailed Frog habitat and population dynamics with riparian management. p. 477-483. IN Laura Darling (ed.). At risk: proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, B.C. 15-19 Feb. 1999. University College of the Cariboo, Kamloops, B.C. and British Columbia Ministry of Environment, Lands and Parks, Victoria, B.C.
- Wahbe, T.R. 1996. Tailed frogs (*Ascaphus truei*, Stejneger) in natural and managed coastal temperate rainforests of southwestern British Columbia, Canada. Centre for Applied Conservation Biology. Department of Forest Sciences. University of British Columbia. M.Sc. Thesis. 49p.
- Washington Dept. of Fish and Wildlife. 2000. Washington GAP Analysis Data Products. Available on Washington Dept. of Fish and Wildlife Website: <http://www.wa.gov/wdfw/wlm/gap/dataprod.htm>
- Welsh, H.H. Jr. and L.M. Ollivier. 1998. Stream amphibians as indicators of ecosystem stress: a case study from California's Redwoods. Ecological Applications 8(4):1118-1132.