Riparian Management of Perennial Coastal Streams with Potential Habitat for Tailed Frog (*Ascaphus truei*)

Discussion Paper

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Abstract

Assessments were conducted at stream reaches associated with recent harvesting in the mid coast of British Columbia to (1) determine how riparian vegetation has been managed around streams that do not typically require a riparian reserve but contain potential habitat for coastal tailed frogs (*Ascaphus truei*), and (2) correlate harvest prescriptions with habitat quality. The results are intended to guide decisions related to harvesting around small fish-bearing and all non-fish-bearing streams on the mid coast of British Columbia. Bedrock-dominated reaches exhibited less disturbance than erodible streams when subjected to riparian cutting, but their confined channels may have facilitated the transfer of road debris downstream, thereby creating blockages and dewatering. Tailed-frog tadpoles were observed where some riparian harvesting had occurred, but the channels were stable and stream flow was undisturbed. Recommendations for best practices when planning to harvest around perennial coastal streams include the consideration of geologic site characteristics prior to making harvesting decisions.

Introduction

Tailed frogs inhabit streams that are small, usually non-fish bearing, and fast-flowing, with a moderate to high gradient that drain relatively small (< 10 km^2) watersheds (Dupuis & Friele 2003). The coastal population of tailed frogs (*Ascaphus truei*) is blue-listed in British Columbia and is sensitive to human activities, especially those that disturb riparian areas and compromise water quality and flows. Although population inventory data are not extensive, Dupuis et al. (2000) found tailed frog tadpoles in 36% of 100 permanent creeks sampled along the mid coast of British Columbia. Michelfelder et al. (2008) confirmed tailed frog presence in 46% of coastal sample sites that had been modelled as suitable.

Like other amphibians, the tailed frog requires both aquatic and terrestrial habitats to complete its life cycle, and studies have found that regulations regarding riparian retention that were originally created to protect fish also provide similar benefits to amphibians (Dupuis & Steventon 1999; Jackson et al. 2001; Dupuis & Friele. 2006). However, in British Columbia, small fish-bearing streams and all non-fish bearing streams do not have specific mandatory reserves, which could jeopardize populations of tailed frogs. Best management practices and other guidance documents recommend leaving partial or full forest retention around these types of streams to buffer potential harvesting effects (B.C.

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Ministry of Forests 1995; Rex et al. 2009; Yukon Energy, Mines and Resources 2011), but the decision about how much to retain is often left to the licensee. This study examines recent (< 5 yrs) harvesting around perennial stream reaches on the mid coast of British Columbia to evaluate which practices may have affected potential habitat for tailed frog. Recommendations for logging around potential tailed frog streams are also provided. This report is not intended to give comprehensive management strategies for the protection of tailed frog habitat. Rather, it provides guidance for harvest prescriptions around perennial streams that do not otherwise have set reserves and where potential tailed frog habitat exists on the mid coast of British Columbia.

Methods

Planning

Geographic information system queries were used to identify first- or second-order stream reaches (1:20 000 scale) that drained small watersheds (< 10 km^2) and were within or adjacent to a recently logged or soon-to-be harvested block. Contour lines were reviewed to identify streams with gradients ≥ 20%, either within the sample reach or immediately downstream. Although tailed frogs and tadpoles may be present in reaches with gradients as low as 2–3% (Sutherland et al. 2001; Dupuis & Friele 2003), the 20% threshold was used to predict a low density of fish at the sample sites, which typically leads to greater population densities of tadpoles (Feminella & Hawkins 1994). The small, potentially non-fish-bearing characterization also led to the assumption that there may not be a legislated riparian reserve associated with the reach, which leaves the option to harvest riparian timber up to the discretion of the forest licensee.

Field

Field data collection included observations and measurements of habitat attributes identified in the literature and established protocols that are applicable to tailed frog requirements. These included stream and riparian indicators from the Forest and Range Evaluation Program's Riparian Management Routine Effectiveness Evaluation (Tripp et al. 2009), channel assessment measurements from the *Tailed Frog eDNA Sampling Procedures* (FLNRO 2014, unpublished), and basic water quality measurements (temperature, conductivity, pH, turbidity). The sampled reach was described in terms of morphology, and the potential for erosion was categorized by the percentage of bedrock observed at six point stations. Assessments were conducted over a length of 100 m, but this was extended if it seemed additional observations would give a more accurate assessment of representative conditions.

A search for tadpoles was conducted concurrently with the collection of stream attribute data at each of six point stations along the survey transect by using hand searching methods described in *Inventory Methods for Tailed Frog and Pacific Giant Salamander* (B.C. Ministry of Environment, Lands and Parks 2000). The objective of tadpole sampling during the stream surveys was simply to establish presence; numbers of tadpoles were not tallied.

Analyses

RIPARIAN RETENTION

After the collection of field data, a riparian retention "score" was assigned to each site to simplify comparison of the evaluation results by harvest treatment. This score ranged from 0 to 14, with values based on the width of retention and whether one or both banks had been har-

vested (Table 1). A general assumption was made that a smaller reserve on both banks was more effective at providing benefits than was a larger reserve on only one bank. This assumption was supported by significant differences that were previously found between reaches with no reserve and those with just a 10-m reserve (Richardson et al. 2010; Rex et al. 2011). Harvest categories were also created at natural break points to add flexibility for statistical analysis.

Table 1. Retention scores and categories based on the width of riparian retention on each stream bank

Bank 1 retention (m)	Bank 2 retention (m)	Score	Category
0	0	0	1
1–10	0	1	2
10–20	0	2	
20–30	0	3	
> 30	0	4	
1–10	1–10	5	3
1–10	10–20	6	
1–10	20–30	7	
1–10	> 30	8	
10–20	10–20	9	4
10–20	20–30	10	
10–20	> 30	11	
20–30	20–30	12	5
20–30	> 30	13	
> 30	> 30	14	

HABITAT QUALITY

The stream and riparian zone in each reach was given a functioning condition ranking according to the Riparian Management Routine Effectiveness Evaluation (RMREE), which is based on the number of negative responses to 15 indicator questions in the protocol (Tripp et al. 2009). Each indicator question corresponds to a set of criteria that are assessed in the field. The condition rankings were converted to a score from 0 to 3 to further calculate tailed frog habitat quality (Table 2).

Table 2. Functioning condition rating from the Riparian Management Routine Effectiveness Evaluation and assigned score for analysis

Condition ranking	Score
Properly functioning	3
Functioning at risk	2
Functioning at high risk	1
Not properly functioning	0

Tolerance ranges and limits for the larval stages of tailed frogs with respect to three essential habitat requirements were included in the analyses. Ideal conditions were deter-

mined for (1) substrate size, (2) water temperature, and (3) flow type based on information and references in *COSEWIC Assessment and Status Report on the Coastal Tailed Frog* Ascaphus truei *in Canada* (COSEWIC 2011) that were specific to tadpole development. An additional nominal value (i.e., score) was assigned to values that met the specified condition in each of the three categories (Table 3).

Lastly, tailed frog habitat quality was calculated using the RMREE scores in Table 2 and the three habitat requirement scores in Table 3 to produce an index value of habitat quality that was between 0.00 (nil habitat) and 1.00 (optimum habitat). These values were then compared with riparian retention to identify which riparian prescriptions provided better habitat value.

Table 3. Ideal conditions for essential habitat requirements

Tailed frog habitat requirements	Ideal condition (score)
Substrate size (cm)	> 5 (1)
Water temperature (°C)	7-18 (1)
Flow type	turbulent/swift (2)
	laminar/slow (1)

Results and Discussion

Sample sites

In total, 27 sample reaches represented by four licensees across the mid coast were assessed in late May, mid-July, and late August 2015. Access was provided by helicopter, float plane, and boat to both island and mainland habitats (Figure 1).

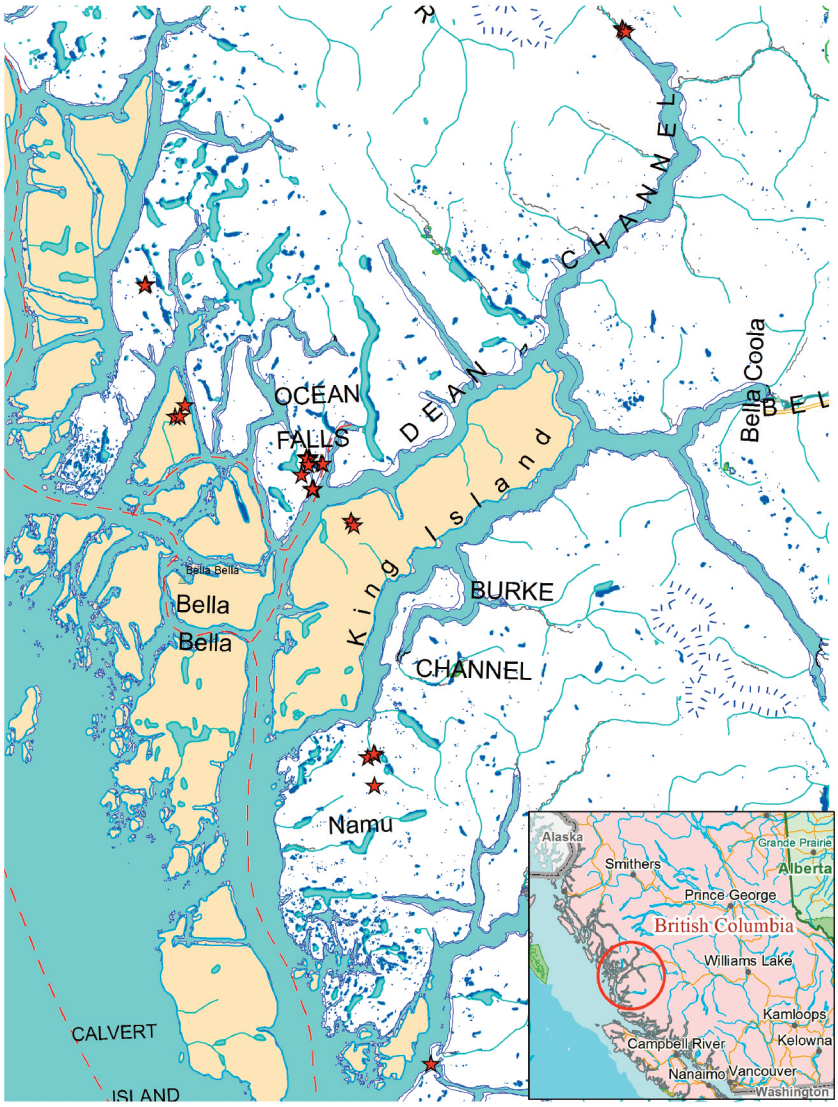

Figure 1. Location of habitat assessment sites (stars)

Water quality parameters

Water quality parameters were not outside the ranges of natural variation at any of the sites (Table 4), and variability was not always explained by harvest activity. For example, the stream with the highest water temperature also had a 30-m riparian reserve with high shade values on both sides of the stream. The higher water temperature was likely a result of warm outflow from a small lake immediately upstream.

Table 4. Summary of water quality measurements in sample reaches

Water quality parameter	Min	Max	Median
Water temperature (°C)	8.8	16.8	12.9
pH	5.5	8.6	7.3
Conductivity (µS/cm)	8.8	66.0	19.5
Turbidity (NTU)	0.001	7.8	0.71

Riparian retention and habitat quality

Six sample reaches received the highest score for riparian retention (Table 5), meaning there was > 30 m of riparian forest on each bank of these streams. Eleven sample reaches were clearcut to the stream edge of both banks; therefore, they received a riparian score of zero. In these cases, all the understory and non-merchantable timber was also cut, and there was no apparent effort to fall and yard away from the channel.

Habitat index scores spanned the range from 0 to 1 among all sites. The correlation between riparian retention score and tailed frog habitat quality was positive (Pearson; $r = 0.88$), which indicated that habitat quality was generally higher with increased riparian retention. This is consistent with previous studies that have found that the width of riparian retention relates directly to the functioning condition and ecological processes in a stream (Beschta & Platts 1986; Brinson 1993; Fetherston et al. 1995; Wallace et al. 1995; Gessner & Chauvet 2002).

Table 5. Site characteristics for the sample reaches

Site	Ave. slope (%)	BfW[a] (m)	EP[b]	Riparian retention score (0-14)	Habitat index
King1*	52	6.6	0	9	1.00
King2*	35	4.5	0	4	0.71
Yeo1	35	5.7	0	9	0.86
Yeo4	15	3.5	1	9	0.86
Yeo3	10	7.0	2	3	0.57
Snass1*	10	5.9	0	4	0.57
Snass Control*	31	2.5	0	14	1.00
Johnston	10	1.1	2	0	0.43
Doc4	48	2.7	2	0	0.57
Doc2	18	15.0	0	14	1.00
Doc3*	35	6.5	0	5	0.57
Doc1	28	7.0	0	10	1.00

Table 5. Site characteristics for the sample reaches (cont.)

Site	Ave. slope (%)	BfW[a] (m)	EP[b]	Riparian retention score (0-14)	Habitat index
Cousins1	18	4.0	0	14	1.00
Cousins2	50	3.7	0	14	0.86
Cousins3U	4	6.2	2	14	1.00
Cousins3L	18	7.1	2	0	0.57
Cousins4	22	3.0	2	0	0.29
Cousins5	25	2.2	2	0	0.29
C-obs only	25	-	-	0	0.29
Cousins6	21	1.1	2	0	0.29
Cousins7	12	3.2	0	14	1.00
Cousins8	15	1.1	2	0	0.29
Cousins9	10	1.6	1	8	0.71
Cousins10	10	1.2	2	0	0.29
Kimsquit1	26	11.0	1	7	0.86
Kimsquit2	25	5.0	2	0	0.00
K-obs only	25	-	2	0	0.00

[a] BfW = channel bankfull width. [b] EP = erosion potential based on percent of bedrock: 0 = non-erodible, 1 = moderately erodible, 2 = highly erodible; * = tailed frog tadpole observation

Five of 11 sites that scored high (≥ 0.86) for habitat quality were also subjected to partial riparian harvesting on both banks. However, little disturbance was noted in these channels, which may be explained by their bedrock-dominated morphology and the practice of falling and yarding away from the channel. The erodibility potential of the channel bed and banks was added as a categorical covariate in a general linear model of habitat and retention, and was found to be significant ($p = 0.029$), which indicated that some of the variability in habitat scoring versus retention among sites can be explained by the erodibility of the sample site.

Habitat index scores were averaged by riparian category (see Table 1 for categories) to compare different treatment types (Figure 2). Significant differences in habitat quality were found between streams that had been clearcut to both banks (Category 1) and the remaining retention categories (ANOVA; $p < 0.05$).

Evidence of cross-channel falling and yarding were noted at the Category 1 sites, which likely caused observed disruptions in flow patterns, dewatering, and input of fine sediment, especially where the soil was erodible. Several of the channels that had been clearcut to the stream edges and cross-yarded were blanketed in sand, which not only reduces the RMREE score but also eliminates ideal substrate for tadpoles. Temperature increases associated with a more open canopy would also be expected in clearcut reaches but were not observed in this study, possibly because the channel was shaded by new shrub growth or was covered with logging debris.

Although bed and bank disturbances were noted where streams had been harvested to the bank, they were not as extensive where bedrock was prevalent. These "non-alluvial" channels seemed to fare especially well when coupled with even a thin riparian buffer and timber had been fallen and yarded away from the channel. Tailed-frog tadpoles were observed in two of the non-alluvial reaches where riparian timber was very thin or clearcut to the edge of one bank, but flow, temperature, and substrate remained within ideal ranges. These findings are consistent with other studies that have found that riparian harvesting does not always negatively affect larval densities of amphibians and may even result in increased abundance by improving primary production and thus food supply by opening the canopy (Richardson & Neill 1998; Sutherland et al 2000). Despite the low impact that partial harvesting may have on non-alluvial streams, clearcutting all riparian vegetation will likely affect populations by increasing water temperatures and limiting the cool, moist terrestrial habitats that are necessary for adult frogs.

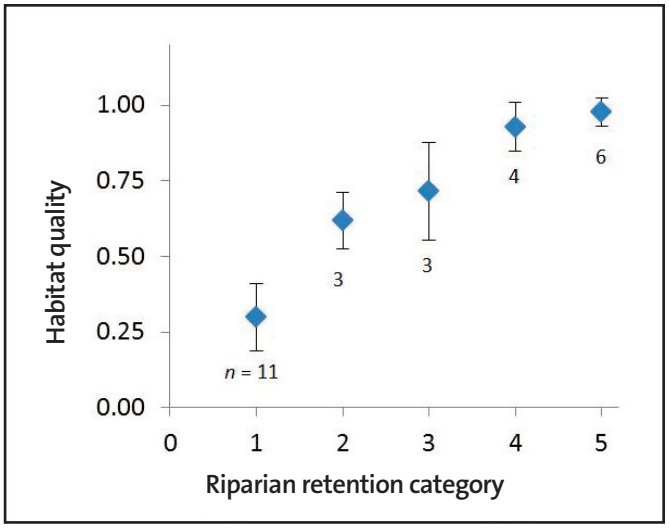

Figure 2. Habitat quality means and 95% confidence intervals in each of the riparian retention categories

Figure 3. Suspected road debris in dewatered channel ~70m downstream of forestry road crossing

Although the bedrock-dominated reaches were not as susceptible to bed and bank disturbance compared to more alluvial channels, they may have facilitated the transport of road debris to downstream bottleneck or flatter areas, and thus contributed to blockages and/or dewatering. Dewatering was observed at three sites where a road crossed upstream of sample reaches that were composed primarily of bedrock (Figure 3). Although the riparian vegetation may be intact in dewatered reaches, the lack of flowing water precludes the presence of eggs and tadpoles, and reduces the habitat quality for adult frogs.

Summary

Overall, riparian retention was positively related to habitat quality. This is consistent with other studies, which have found that the functioning condition of a stream and riparian habitat improves with increased buffer distance. More revealing was the observation of tadpoles in reaches that had been subjected to partial riparian harvesting. In these cases, all essential habitat attributes were within ideal ranges in undisturbed portions of the channel. This is consistent with Wahbe & Bunnell (2003), who concluded that stream microhabitat and site parameters such as substrate size and water temperature were dominant influences on larval populations post harvest. Sutherland et al. (2001) used classification and regression clusters to develop habitat associations for tailed frogs in British Columbia, and they revealed that biophysical variables such as geology and geomorphology had a greater influence on the occurrence and abundance of larval frogs than did adjacent forest practices.

The findings from these assessments suggest that the variability of site parameters can result in a range of effects from forest harvesting, and these should be considered prior to making harvesting decisions around perennial coastal streams where tailed frog presence is unknown. The following recommendations are for logging practices around perennial coastal streams that do not have a specified reserve, and are in agreement with the *Objectives for Upland Stream Areas* in the recently established Great Bear Rainforest Order (FLNRO 2016).

Recommendations

Riparian retention for erodible stream channels

Also known as alluvial, erodible stream channels consist of loose, unconsolidated soil or sediments that are easily detached from the channel bed and bank and transported by water. These channels can be recognized as containing more sand, gravel, and cobble than boulders and bedrock. This study found disruptions in flow, blockages, and dewatering where erodible soils were present; therefore, the recommendation is to retain a minimum 10-m full riparian reserve on both sides of the channel to provide stability and protect the habitat from harvest-related inputs, erosion, excessive sedimentation, and subsequent dewatering. There were not enough erodible stream channels in this study to complete a comprehensive analysis on buffer widths; the minimum 10 m is based on other research that involved alluvial streams (Richardson et al. 2010; Rex et al. 2011).

Riparian retention for non-erodible stream channels

Non-erodible channels are easily recognized as those that are composed mainly of bedrock. At a minimum, all non-merchantable timber, understory, and shrubs should be retained within 10 m of the stream bank to limit disturbance, provide shade to the stream, supply future wood debris, and regulate bank microclimate. If there is a low abundance of non-merchantable timber, sub-dominant and/or co-dominant trees should also be retained to

maintain riparian functionality. Any timber harvested within this zone should be fallen away from the channel, and cross-channel yarding should not occur.

Riparian retention for known tailed frog streams – all channel types

Although in this study, tailed frog tadpoles were observed where riparian logging had occurred, cutting is not recommended where this species at risk is known to be present. Studies on selective harvesting and adult frog populations are too few to support partial retention; therefore, the recommendation is to default to the Accounts and Measures for Managing Identified Wildlife (B.C. Ministry of Environment 2004), which recommends a 30-m reserve plus a 20-m management zone around reaches that have been confirmed to contain tailed frogs.

ROAD DEBRIS CONTROL — ALL CHANNEL TYPES

In all cases, road crossings should be designed, constructed, and maintained to eliminate the potential for road debris to enter any stream channel.

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