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Evaluating Current approaches to Riparian Management in British Columbia

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Abstract

Riparian forests are tightly linked to freshwater streams making these ecosystems vulnerable to alterations that occur from timber harvesting. In order to protect stream resources, fixed-width buffers were implemented in BC in the Riparian Management Area Guidebook (1995) under the Forest Practices Code (FPC). It has been found that these buffers have not been extensively subjected to scientific validation and commonly under-protect site-specific conditions. The Forest and Range Practices Act (FRPA) was introduced in 2004 in order to deregulate management planning for licensees. However, FRPA uses result-based objectives which are difficult to measure, making it challenging for foresters to comply with the legislation, causing foresters to default to the Riparian Management Area Guidebook (1995). I used a survey to assess and quantify common riparian management protocols in BC. The survey found that foresters commonly follow the Guidebook, even though it is felt that the Guidebook is outdated and lacks adequate protection for small streams and site-specific conditions. Thus, foresters are found to deviate from the fixed-width buffers to manage for site-specific conditions, such as stands vulnerable to windthrow, sensitive fish habitat and other hydrologically sensitive areas.

Key Terms: FPC – Forest Practice Code, FRPA – Forest and Range Practices Act, Forest Stewardship Plan, Riparian Management Area Guidebook, fixed-width buffers, site specific guidelines, Sustainable Forest Management

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Introduction to Riparian Management Strategies in BC

Riparian areas are generally defined as the terrestrial ecosystems surrounding a freshwater ecosystem. These two ecosystems are tightly linked through essential physical, chemical, and biological interactions, and therefore have many valuable influences on one another (Wipfli & Richardson, 2016). Significant interactions include the interception of upland pollutants by riparian areas, shading and erosion control, nutrient exchange, and exchange of organic matter (Richardson & Danehy, 2007). Riparian areas also contribute large wood (LW) to streams, providing shade, bank stability, and complexity to a stream's morphology. Streams affect riparian areas by dispersing seeds, creating microclimates, and increasing soil moisture (Richardson & Danehy, 2007). These influences are beneficial to both ecosystems, and when altered can have consequences to natural processes and functions within each ecosystem.

Riparian areas are sensitive to structural alterations which in turn can have significant impacts on local and downstream ecosystems. Activities like timber harvesting, make modifications to the riparian areas, depending on the classification of the stream. Harvesting treatments can significantly vary from clearcutting riparian areas to leaving a 30 to 100 meter range of partial harvesting options (Lee et al., 2004). Riparian areas that are left behind are often altered in terms of plant community, vegetation compositions, and structural diversity (Moore & Wondzell, 2005; Wipfli & Richardson, 2016). Creating such unnatural stands has consequences on the streams ecology, by changing in-stream temperatures, increasing sediment loading, reducing biodiversity, and affecting nutrient exchange (Moore & Richardson, 2012). Also, recently harvested riparian areas receive heightened in-stream sunlight. As a result, temperatures increase and oxygen content is reduced which has consequential effects on fish habitat. Timber harvesting can also reduce LW by harvesting riparian forests (Fausch & Northcote, 1992). Over time, streams generally become straighter, wider, and shallower with the removal of LW, simplifying the stream morphology. Combinations of these factors cause a decline in fish habitat and production, affecting the food web structure and productivity of these ecosystems, which relies primarily on fish (Bisson & Bilby, 1998).

The impacts of harvesting on freshwater systems led to a global movement to maintain and restore stream resource values by protecting riparian forests (Bernhardt et al., 2005). Riparian buffers became a common conservation tool, designed to protect stream resources by retaining riparian forest at a fixed-width. Many jurisdictions have adopted these fixed-width buffers as their management strategies and have modified them depending on their management objectives and their land base (Richardson et al., 2012). A study found that a 30 m wide buffer is needed to effectively trap sediment at an 85% rate and to maintain natural in-stream temperatures and LW inputs (Sweeney & Newbold, 2014). Riparian buffers need to be >40 m wide to remove subsurface nitrate at an 89% efficiency. In conclusion, Sweeney & Newbold (2014) suggested that a 30 m no-harvest buffer needs to be retained in order to protect the integrity of the physical, biological, and chemical components of a stream.

The development of riparian buffers as a management strategy is beneficial for protecting stream resources. However, it is uncertain whether these fixed-width buffers are meeting environmental objectives (Wipfli & Richardson, 2016). Numerous publications have researched the effectiveness of these buffers and have concluded that not all site-specific conditions can be effectively managed with fixed-width buffers. Research suggests that buffers ranging from 15 – 30 m do not always protect streams from harvesting impacts, while buffers smaller than 10 m provide little to no protection on riparian functions under certain site-specific conditions (Johnson, 1992; Gomi et al., 2006; Kiffney et al., 2003). For small non-fish bearing streams, it is

often acceptable to harvest to the streams edge, even though small streams are disproportionally influenced by their surrounding forest. Small streams are managed in this manner because of their abundance, where leaving standing timber is argued to be costly in the loss of timber volume. However, harvesting to the stream's edge can have serious consequences on downstream ecosystems such as temperature changes and increased sediment loading (Richardson et al., 2012).

In general, it is argued that riparian buffers do not meet conservation objectives at a landscape level. Managing watersheds with fixed-width buffers can lead to high levels of blowdown and sediment loading which in turn will increase LW in streams, light penetration, and understory development (Bren 1998; Moore & Richardson, 2012). In addition, fixed-width buffers applied to a watershed tend to under-protect the slope junction at the head of a stream where along a stream, intersections are often over-protected (Bren, 1998). Therefore, management strategies that consider topography at a landscape level tend to have a greater protection against sediment loading in streams in relation to streams managed with fixed-width buffers (Bren, 1998). It is therefore recommended that management strategies incorporate landscape level management to achieve the conservation objectives.

A meta-analysis tested the effectiveness of fixed-width buffers for riparian fauna (Marczak et al., 2010). The review analysed 397 publications that studied post-harvesting effects on a short term basis (under ten years). Results found that the abundance of taxonomic groups differed within a riparian area, where edge-preferring species had an overall increase in abundance. Arthropods and certain bird species were found in greater abundance in these reserve zones than in an unharvested riparian ecosystem, while amphibian populations decreased in size. Because of the change in species abundance, the analysis concluded that buffers fail to maintain the natural composition of terrestrial fauna, where smaller buffers are suggested to insufficiently maintain terrestrial fauna levels (Marczak et al., 2010).

Background

Forest harvesting practices had once neglected the environmental values for streamside ecosystems and freshwater systems. In the 1800s, the common practice in forest harvesting was to transport harvested trees via freshwater systems. Any obstructions such as shoreline trees and LW were removed to allow for log transport (Sedell et al., 1991). As a result, these practices made many consequential alterations towards the stream's functions and processes including bank destabilization (Bilby & Ward, 1991).

In the twentieth century, it had become evident that these practices had harmful environmental effects. In turn, there was a demand for stronger regulations to protect environmental values (Richardson et. al., 2012). The Forest Ecosystem Management Assessment Team (FEMAT, 1993) proposed that potential tree heights should be used as the indicator to determine riparian buffer widths on Coastal federal forests of the western United States. FEMAT concluded that tree heights are a meaningful indicator based on the crucial linkage between streams and their adjacent vegetative ecosystem. However soon afterwards, fixed-width buffers became standardized under the Forest Practices Code (FPC) in the Riparian Management Area Guidebook (1995) due in part to their political acceptance and simple administration (Richardson et al., 2012).

Under the Riparian Management Area Guidebook (1995) buffer zones are called Riparian Management Areas and are divided into a Management Zone and a no harvest zone called the Reserve Zone. The Management Zone is the outermost buffer that is designed to protect the Reserve Zone from edge-effects such as windthrow and bank instability. Therefore, this zone is managed as a low impact harvest area which can be

prescribed a variety of harvesting treatments, including clearcutting and partial cutting. Small streams are often managed with a Management Zone and no Reserve Zone, allowing foresters to harvest merchantable trees up to the stream's edge. The Riparian Management Area is based on the classification of the stream, where larger streams are managed with wider buffers. Streams are classified based on the presence of fish and the average channel width and are designated as one of the six riparian classes from S1 to S6. Fish-bearing streams are classified as S1 to S4 streams, where the largest fish-bearing stream is an S1 stream. On the other hand, non-fish bearing streams are classified as S5 and S6 streams, where S5 has the larger average channel width. These Riparian Management Areas are modified by each jurisdiction, to account for the differences in the topography, water body type, water resources, and size (Lee et al., 2004).

Riparian management in BC became the interest of many stakeholders and First Nations Communities in the 1900s (Bernhardt et al., 2005). The FPC had become the legislation with one of the highest environmental standards in the forest industry. Foresters stressed that the new policies were costly and burdensome because of their significant expansion on government regulations on forest practices (Hoberg, 2011). However, concerns arose that the FPC was only satisfying the minimal environmental requirements, due to their minimal scientific evaluation (Castelle et al., 1994). Previous to the administration of these fixed-width buffers under the FPC, it had already been feared that these management tools would become the new standard (Board, 2014).

The Forest and Range Practices Act (FRPA) legislation was introduced in 2004 to guide sustainable management in BC, promote innovation, and to deregulate management planning for licensees (BC, 2002). Deregulation was achieved by reducing the required government oversight in extensive management plans (White, 2005). This deregulation allowed the government to transfer the responsibilities of environmental stewardship to licensees (BC, 2002). Under FRPA, result-based objectives were used to define the appropriate outcomes to a management plan, giving licensees room for flexibility in their management strategies. This flexibility was also designed to promote innovation in licensees management plans (Board, 2006). Management plans under FRPA are known as the Forest Stewardship Plans (FSP) which require foresters to identify their management areas and strategies were harvesting may occur over the next five year period. These FSPs are hoped to meet and exceed the government's environmental objectives through innovation, however these plans do not require government approval (Board, 2014).

An evaluation of the riparian management under FRPA was completed by the Forest Practices Board (2014) to address apprehensions with the effectiveness of the result-based framework. As a result of the major deregulation in forest management, there are now concerns with the legislation's reliance on professional stewardship and the lack of government intervention. It is argued that foresters are given excessive flexibility and discretion in their management plans with the new legislation (White, 2005). The result-based objectives are also criticised as vague, making the outcomes of management strategies difficult to measure and assess. The study also found that management plans following the new framework include proposals that are generally ambiguous and with limited innovation (Board, 2014). Innovation is not always cost effective and requires sound rational, where licensees wish to attain compliance with legislations (Board, 2014). Furthermore, licensees generally do not wish to spend money evaluating new means for managing riparian values.

In 2001, an evaluation was completed in the Interior of BC on fixed-width buffers and their effectiveness in achieving the government's environmental objectives (Chatwin et al., 2001). This district level pilot study analyzed short-term, post-harvesting effects (2-3 years) on small fish-bearing streams, classified as S4

streams (Riparian Management Area Guidebook, 1995). Windthrow was an issues in all treatment types, however, it was the highest in partial-cut treatments at an average of 46% of streams having a moderate to high level of windthrow. Where no Reserve Zones were required**,** it was found that the Management Zone still provided sufficient channel stability and windthrow resistance for the stream. However, it was concerning that 31% of the assessed streams lacked retention of large trees within the Management Zone. The study found that 8% of streams had a moderate level of disturbance due to windthrow, a 7% of disturbance due to shade loss and 3% had a loss of streambank trees. The report concluded that the best management practice for S4 streams would be to retain all trees within the 10 m Management Zone, where wildlife trees should always be retained in the Riparian Management Area (Chatwin et al., 2001).

Basis for Current Study

The purpose of the following research paper is to analyze riparian management trends in BC with a focus on fixed-width buffers. The structure of this paper will cover the development, use and results of current riparian management standards. A survey was developed and distributed in order to quantify and examine current management protocols in the Interior and the Coast and to evaluate licensee's consistencies or deviations with these riparian guidelines. The survey established insight on how industrial forestry companies manage riparian areas and whether or not they utilize fixed-width buffers that are set out under the Forest Practice Code (FPC).

Methodology

Allowing licensees to default to the Riparian Management Area Guidebook (1995) creates uncertainty in the management strategies used to protect conservation values. Although FRPA was designed to promote innovation in forest resource management, few licensees were found to deviate from the guidelines (Board, 2014). To get a better understanding of the management protocols in BC, questions in the survey ask how specific components of riparian forests and freshwater ecosystems were being managed. Other components of these riparian areas were also addressed in the survey including the deciduous component of the riparian ecosystem, the neighboring terrain, and also concerns with windthrow.

Before distributing the survey, an ethics application under the Research Information Service (RISe) needed to be approved. The TCPS 2: CORE certificate needed to be completed, in order to receive a government issued ethics number H16-00020 for the ethics application. The TCPS 2: CORE is an online tutorial on the ethics of conducting research involving humans. The American program SurveyMonkey was used to design and easily distribute the survey online. Participants were given the option to skip questions and to select multiple answers for the multiple-choice questions. The web link was then sent out through the e-newsletter of the Members of the Association of BC Forest Professionals (ABCFP). The survey was launched on February 9, 2016 and was closed a month later. The Ministry of Forests, Lands and Natural Resource Operations (FLNRO) also helped distribute the survey by sending it to their contacts in the Skeena and Stikine district in BC.

Results

There are approximately 5,300 members of the ABCFP, where 94 members responded to the survey. It was found that 74% of the participants that responded where located in the Interior while 23% were from the Coast (Figure 1). To test whether the probability of Coast and Interior responses were independent of one another, a Chi Squared Contingency test was used with a significance level of $\alpha = 0.05$ making the critical value 3.85.

$$\chi^2 = \sum \frac{(Observed - Expected)^2}{Expected}$$

The test found that the foresters' responses from the Coast and Interior did not differ significantly. Therefore, the report will no longer identify whether the information is from participants from the Interior or the Coast.

Riparian Management Area Guidebook (1995)

Current legislation allows foresters to default to the Riparian Management Area Guidebook (1995), a standard that is considered to be a minimal requirement for protecting environmental objectives. It was found that 70% of respondents agreed to following these guidelines, of which 93% (of 56 participants) agreed to doing more than the Guidebook required (Table 1). In the written response section of the survey, these guidelines were commonly described as 'outdated' and 'ambiguous,' where foresters felt that the Guidebook lacked 'up-to-date scientific knowledge.' One participant commented that the Guidebook is "too broad to cover different stream morphology and riparian area characteristics," where 40% of 44 respondents felt that small S4, S5 and S6 streams were under-protected by the guidelines (Table 1). Many foresters also felt that the Guidebook for wetlands and windthrow needed management guidelines that were better defined.

Several forest professionals working for consulting companies felt that as consultants they are required to cater to the management standards set by the client. Therefore, they cannot develop management strategies for site-specific conditions, unless it is requested by the licensee. On the other hand, a handful of foresters felt that these survey questions pertaining to the Guidebook were irrelevant because they believed that these guidelines were no longer in use.

Question	*Responses*	*Sample Size*	*Percentage (%)*
3	Respondents that follow the Riparian Management Area Guidebook	86	70
	Respondents that don't follow the Guidebook		30
2	Find the Guidebook Restrictive	74	60
	Find the Guidebook Broad		40
6	Does more than the Guidebook requirements	56	93
	Does less than the Guidebook requires		7

Table 1: Survey questions that focus on the Riparian Management Area Guidebook (1995).

Managing for Windthrow and Large Wood

Riparian buffers are often susceptible to becoming blowdown and therefore need to be addressed in a management plan. Only 18% of the 57 foresters that answered the question stated that windthrow was not being managed for. Some of those participants concluded that windthrow was an 'afterthought,' while others reasoned that 'windthrow is beneficial to streams'. The other 82% of participants came up with a range of management strategies used to reduce the chances of riparian buffers from being blow down. Common management strategies included widening buffers (47%), retaining understory, patch-cut treatments, stubbing trees, removing windthrow-prone trees, and retaining wind-firm trees. Many forms of tree crown modification were also specified such as hand and helicopter pruning, topping, and feathering.

Trees that are expected to becoming windthrow post-harvest are often harvested. Of the 85 total participants, 51% 'sometimes' harvest these trees, while 32% 'often' harvest these trees and 17% leave these trees as retention. Participants also commented that stands were harvested to the stream's edge in Mountain Pine Beetle (MPB) stands because of their vulnerability to becoming blowdown. Others concluded that only the dead standing trees are removed in the riparian forest. When trees fall during harvest operations, foresters often leave the fallen logs behind. However, 32% of respondents lift and remove the logs while another 10% pull the logs across the stream (Figure 1). Pulling logs across a stream is illegal because of the damage it can have to valuable habitat for aquatic species through increased sediment loading and reduced bank stability. Because participants were given the option to choose multiple answers for each questions, the percentages for the graphs may seem disproportionate.

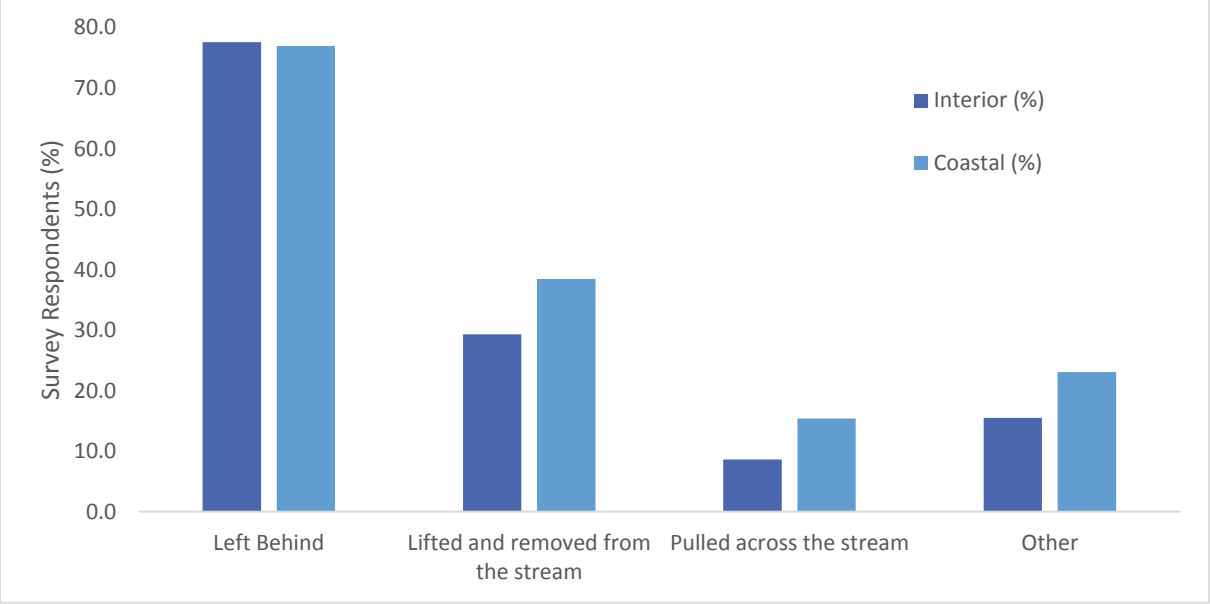

Figure 1: Illustrates how trees are dealt with when they fall across the stream during harvest or by wind throw. Number of respondents: Interior: 58 Coast: 26.

Where harvesting is allowed in the Riparian Management Area, merchantable trees are often harvested while the deciduous component is retained. Out of 88 respondents, 78% of those foresters differentiate between the merchantable and non-merchantable trees when developing the buffers for a stream. With the deciduous component of a buffer, 90% of foresters leave the trees behind, while 7% remove the trees and burn them as slash (Figure 2).

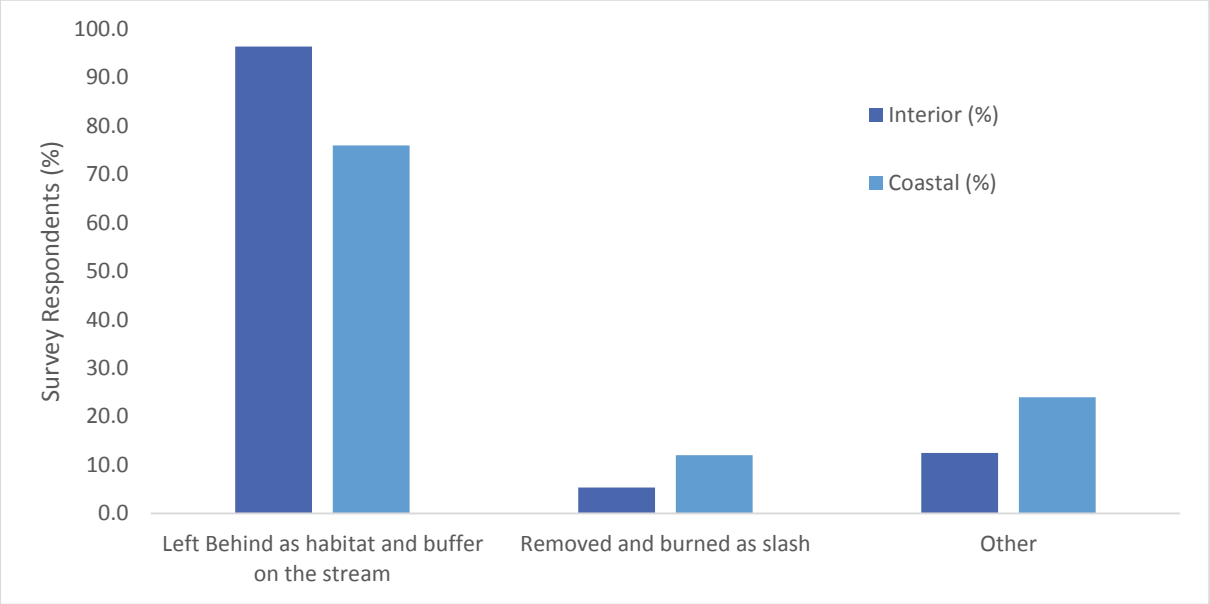

Figure 2: Illustrates what is being done with the deciduous component in areas where it is possible to harvest up to the edge of the stream. Number of respondents: Interior: 56 Coast: 25.

Site-Specific Guidelines

Protecting stream values with fixed-width buffers does not account for sites and specific conservation targets that are more vulnerable to harvesting impacts. The majority of respondents stated that fixed-width buffers were being used to determine riparian widths unless site-specific management was warranted. Out of 67 participants 73% used fixed-width buffers as a core management strategy with minimal deviation. Conditions that were used to determine riparian widths were usually a result of fish sensitive habitats, riparian stands susceptible to windthrow, or steep terrain (Table 2).

The survey also directly addressed other sensitive components of a freshwater ecosystem. Hydrologically sensitive areas had 49% of respondents deviate from the Guidebook (1995), while 25% did not manage for these areas, and 26% were uncertain (Table 2). Those that managed for hydrologically sensitive areas concluded that site-specific management strategies were determined by a hydrologist. It was also found that even fewer respondents managed for tributary junctions. Out of 67 respondents, 68% did not manage for these junctions, while those that did commonly left hesitant responses such as 'seldom,' 'if warranted' and 'not usually.' However, 84% of respondents did agree to site-specific management in areas with stream-dependent endangered species (Table 2). On the other hand, a handful of respondents felt that the Forest

Stewardship Plan accounted for areas that needed site-specific management and therefore were not required to deviate from the guidelines.

Question	*Site*	*Management Strategy*	*Sample Size*	*Percentage*
12	Sensitive areas	Site specific management	67	67
		Fixed-width buffers		33
13	Tributary junction	Site Specific management	67	32
		Fixed-width buffers		68
11	Stream-dependent endangered Species	Site Specific Management	82	84
		Fixed-width buffers		16
14	Hydrologically sensitive areas	Site specific management	59	49
		Fixed-width buffers		25
		Other		26

Table 2: The percentage of respondents that protected sensitive areas of a freshwater ecosystem with fixed-width buffers using the Riparian Management Area Guidebook (1995) or with site-specific management.

Fish-bearing and Non-Fish Bearing Streams

Under the Riparian Management Area Guidebook (1995), small non-fish bearing streams classified as S4 streams, are often managed without a Reserve Zone. As seen in Figure 3, 58% of respondents harvest to the stream's edge for non-fish-bearing streams, whereas 33% left partial retention, 21% left variable-width reserves, and 19% left fixed width reserves. Only 10% of participants left full-retention buffers on non-fish-bearing streams. For fish bearing streams 51% of participants left full-retention reserves, followed by fixed-width buffers (40%), variable width reserves (28%), partial retention (16%), and clear-cutting (2%) (Figure 3). Most respondents chose multiple Silviculture treatments for the two multiple-choice questions as a result of the question failing to specify between the size and classification of the stream as well as the buffer zone within which each treatment is being applied to.

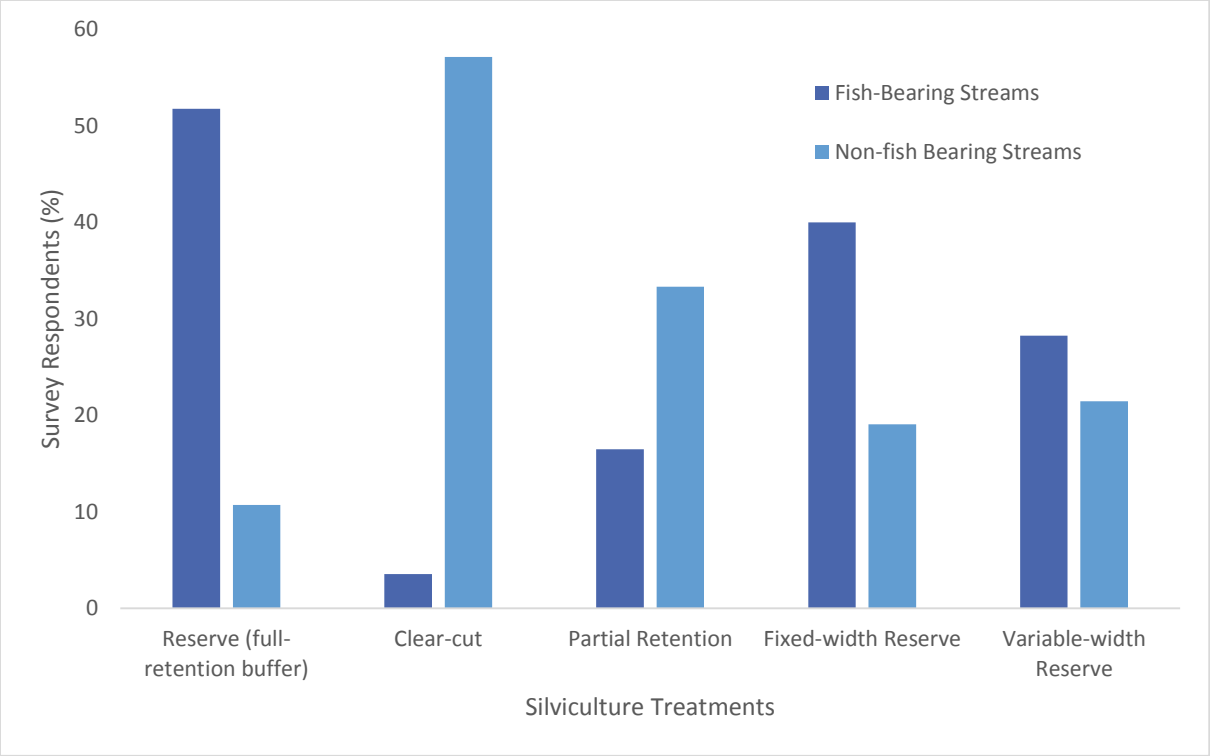

Figure 3: Percentage of survey respondents that use certain Silviculture treatments to manage for fish-bearing streams and non-fish bearing streams. Number of respondents: Fish-bearing streams: 86 and Non fish-bearing streams: 87.

Discussion

Most participants felt that the Riparian Management Area Guidebook (1995) should be updated, considering the abundant studies on riparian management and forest practices. Therefore, it was common for participants to use the Guidebook as a broad-based application, applying additional management strategies to areas more vulnerable to adverse harvesting effects. Additional protection was often given to areas susceptible to windthrow and areas with stream-dependent endangered species and sensitive fish-bearing streams (Table 2). Other sensitive conditions including tributary junctions and small, non-fish-bearing streams (S4, S5, and S6) were most commonly left without any additional protection. Respondents that were managing sensitive areas without additional protection also felt that the Guidebook should include site-specific guidelines. In order to have all professional foresters managing for site-specific conditions it would be best to modify and update the Guidebook to account for these vulnerable sites.

It was found that increasing riparian buffer widths was the most common management strategy used to protect sensitive sites including tributary junctions and sensitive fish-bearing streams. This result may be due to the simplicity and the effectiveness of this management strategy. Increasing buffer widths was also commonly associated with riparian areas vulnerable to windthrow and steep terrain. Unfavorable terrain is often inoperable and is therefore left behind as a part of the buffer. Harvesting on these topographic features can lead to slope failure and sediment loading especially on steep slopes and ridge tops.

Respondents were found to manage for windthrow with a large range of methods including tree crown modifications and Silviculture treatments. Although most respondents accused the Riparian Management Area Guidebook of lacking defined windthrow management guidelines, they seemed to still use a variety of methods to increase the resilience of stands to windthrow. Non-fish bearing streams were often managed with a form of variable retention, where most participants harvested to the streams edge (Figure 3). These variable retentions buffer zones can often increase the risk and severity of windthrow, where partial-cut reserves were found to have the highest level of windthrow on S4 streams (Chatwin et al., 2001). In addition, harvesting to the edge of small, non-fish bearing streams results in consequential impacts on downstream ecosystems such as increased in-stream temperatures, sediment loading, and nutrient loading.

Harvesting operations significantly impact the abundance of current and future LW in freshwater ecosystems through the direct removal of LW and standing trees. Furthermore, the retention of riparian forests within the Riparian Management Area can lead to high levels of blowdown. In general, respondents removed the merchantable wood from the riparian forest and left the deciduous component behind. In addition, 32% of respondents harvested trees that were expected to be blown down, where 40% of respondents removed trees that had fallen during harvest. This removal of large standing trees has consequential effects on local and downstream ecosystems such as the reduced inputs of LW. Thus, best management practices suggests that licensees leave all wildlife trees behind.

Future Applications

The Riparian Management Area Guidebook should incorporate the findings of the extensive studies on the relationship between forest practices and freshwater ecosystems (Richardson & Thompson, 2009). This development would create a more complex set of guidelines that would include watershed level planning (Lee et al., 2004). Protecting important riparian resources may be achieved more effectively by managing site-specific conditions with specific conservation targets that are clear and quantitative. In order to achieve more reasonable management objectives, targets should be identified based on a reference site within a managed landscape, instead of a reference site within an unmanaged and pristine landscape. Management targets should then be evaluated through the assessment of long term outcomes (Richardson & Thomson, 2009).

Survey Limitations

The survey was not considered scientific because the survey was concerned with the general opinion of licensees and also had a relatively small sample size. A few of the survey questions were unclear and ambiguous resulting in limitations to the survey data. For example, question 6 asked if foresters ‘deviate from the Guidebook, do more than Guidebook or do less.’ The question is unclear because all three responses describe deviating from the Guidebook (Appendix A). As a result, the values for respondents that ‘deviate from the Guidebook’ were removed. In addition, a handful of participants were concerned with the multiple choice questions, which asked respondents to identify if they followed the Riparian Management Area Guidebook (Appendix A: Question 3). Participants argued that these questions may affect the results because they suggest that licensees strictly follow this Guidebook.

It was also found that the Guidebook was commonly described by respondents as both broad and restrictive. The survey failed to consider that both of these terms could be used to describe similar concerns with the riparian Guidebook. For example, the Guidebook is restrictive in the sense that it fails to give room for innovation and site-specific considerations. However, the Guidebook is also broad because it applies standardized fixed-width buffers to large areas without the consideration of site-specific conditions. As a result, the survey question design makes the responses difficult to interpret. In order to reduce the caveats in the survey design, the survey should have gone through a practice run before being distributed to Professional Foresters.

Conclusion

The survey was developed for assessing and quantifying current management protocols in the Interior and the Coast and to determine if foresters were following the Riparian Management Area Guidebook (1995) under the FPC. It was found that the responses from the Interior and the Coast were independent through the use of the Chi-Squared Contingency test. It was also found that most foresters used fixed-width buffers under the Guidebook to manage for environmental values, where sensitive areas were managed with site-specific management. Foresters often commented that the Guidebook under-protected small streams and failed to define guidelines for wetlands and lakes. The Guidebook was also described as outdated and ambiguous, where researchers found that these buffers were ineffective at protecting all environmental objectives. In order for the Guidebook to provide adequate protection for freshwater ecosystems, the legislation needs to consider landscape-level management as well as complex site-specific guidelines.

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Appendix A: Survey

Riparian Management Trends in British Columbia

1. Are you working out of the Interior or the Coast?
    a. Interior
    b. Coast

2. If you are following the Riparian Management Area Guidebook (1995) guidelines, do you find them overly restrictive or too broad?
    a. Restrictive
    b. Broad

3. Do you follow the Riparian Management Area Guidebook (1995) from the Forest Practices Code?
    a. Yes
    b. No

4. State any concerns you have with the Riparian Management Area Guidebook (1995) from the Forest Practices Code.

5. What is being done with the deciduous component in areas where it's possible to harvest up to the edge of the stream?
    a. Left behind as habitat and buffer on the stream
    b. Removed and burned as slash
    c. Other

6. If you follow the guidelines do you:
    a. Deviate from the requirements
    b. Do more than they require
    c. Do less than they require

7. Are any strategies being used to avoid riparian buffers from being blown down? If so, what are they?

8. How are trees dealt with when they fall across the stream during harvest or by wind throw?
    a. Left behind
    b. Lifted and removed from the stream
    c. Pulled across the stream
    d. Other

9. Are trees harvested in the riparian management zone when it is expected that retention trees will become windthrow post- harvest?
    a. Often
    b. Sometimes
    c. Never

10. When developing buffers for streams, is there a differentiation made between merchantable and non-merchantable trees in retention?
    a. Yes
    b. No

11. Are riparian management zones left in areas where there are stream-dependent endangered species?
    a. Yes
    b. No

12. Are there scenarios where site-specific guidelines are used to determine riparian width or are fixed-width buffers always used? If so, what's a common scenario?

13. For tributary junctions (where two streams of any size merge), are there any additional or special protection methods being used?

14. When following Riparian Management Area Guidebook (1995) guidelines, are there deviations or alterations made to the buffers where the channel are hydrologically sensitive?

15. Do factors like the surrounding terrain, tributaries to major waterbodies or soil type effect the type of management on a stream?
    a. Yes
    b. No

16. Which riparian Silviculture treatment is most commonly used for fish bearing streams?
    a. Reserve (full-retention buffer)
    b. Clear-cut
    c. Partial Retention
    d. Fixed-width Reserve
    e. Variable width Reserve

17. Which riparian Silviculture treatment is most commonly used for non-fish bearing streams?
    a. Reserve (full-retention buffer)
    b. Clear-cut
    c. Partial Retention
    d. Fixed-width Reserve
    e. Variable width Reserve

Appendix B: Consent Form

Consent to Participate in Online Survey

Identification of Investigator and Purpose of Study

You are invited to participate in a research study, entitled "Riparian Management Trends in BC." The study is being conducted by Stephanie von Loessl under the supervision of Dr. John S. Richardson and Head of Department of Forest & Conservation Sciences of The University of British Columbia, 3041 – 2424 Main Mall Vancouver, BC, Canada V6T 1Z4, (604) 822-6586, john.richardson@ubc.ca**.**

The purpose of this research study is to examine current management protocols in the Interior and the Coast. Your participation in the study will contribute to a better understanding of riparian management trends in BC. You are free to contact the investigator at the above address and phone number to discuss the study. If you agree to participate in the survey will take approximately fifteen minutes of your time.

Risks/Benefits/Confidentiality of Data

There are low risks for participating in this survey as there are no identifiers in the questions that will link you directly to the data. There will be no costs for participating, nor benefits. Your name and email address will not be collected during the data collection phase and a limited number of researcher team members will have access to the data during data collection.

Participation or Withdrawal

Your participation in this study is voluntary. You may decline to answer any question and you have the right to withdraw from participation at any time. If you do not want to participate either stop participating or close the browser window.

Contacts

If you have any concerns or complaints about your rights as a research participant while participating in this study, contact the Research Participant Complaint Line in the UBC office of Research Ethics t 604-822-8598 or if long distance e-mail RSIL@ors.ubca.ca or call toll free 1-877-822-8598.

This online survey company called SurveyMonkey is located in the USA and is subject to US laws. In particular, the US patriot Act which allows authorities access to the records of internet service providers. If you agree to participate in the survey, your responses to the survey will be stored and accessed in the USA. The security and privacy policy for SurveyMonkey can be found at the following link: https://www.surveymonkey.net/mp/policy/privacy-policy/

If you agree to participate, click on the following link: https://www.surveymonkey.com/r/R9R7V8D

Thank you.

Please print a copy of this document for your records

Appendix C: Survey Data

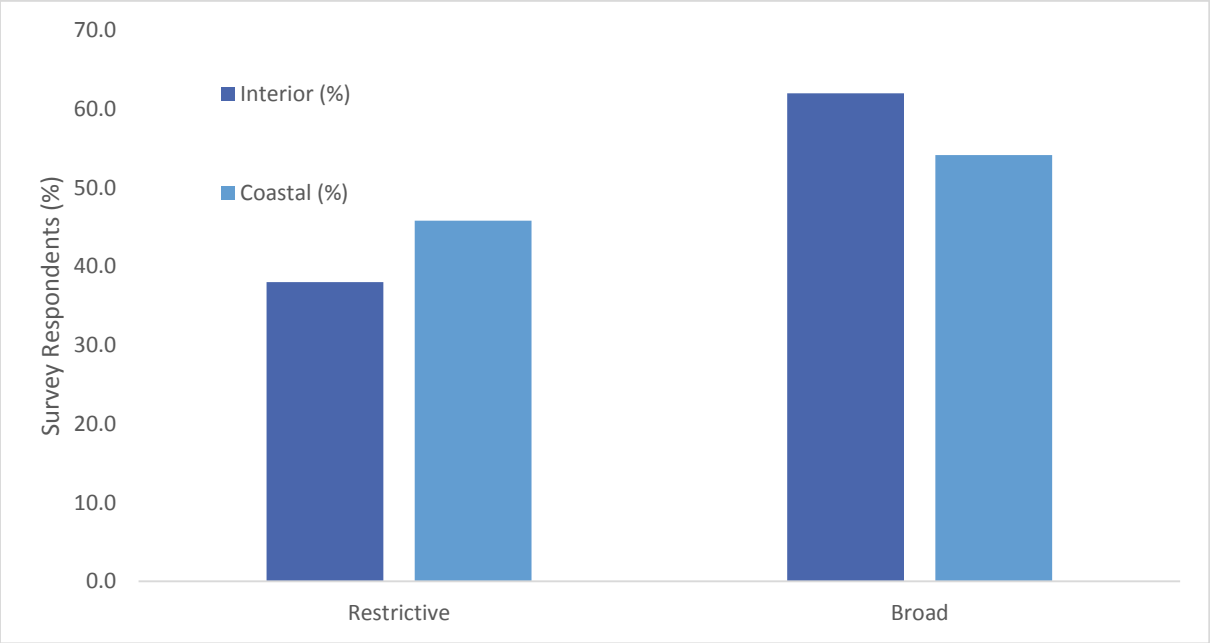

Figure 4: Question 2: If you are following the Riparian Management Area Guidebook (1995) guidelines, do you find them overly restrictive or too broad? Number of responses: Interior 50 and Coast 24.

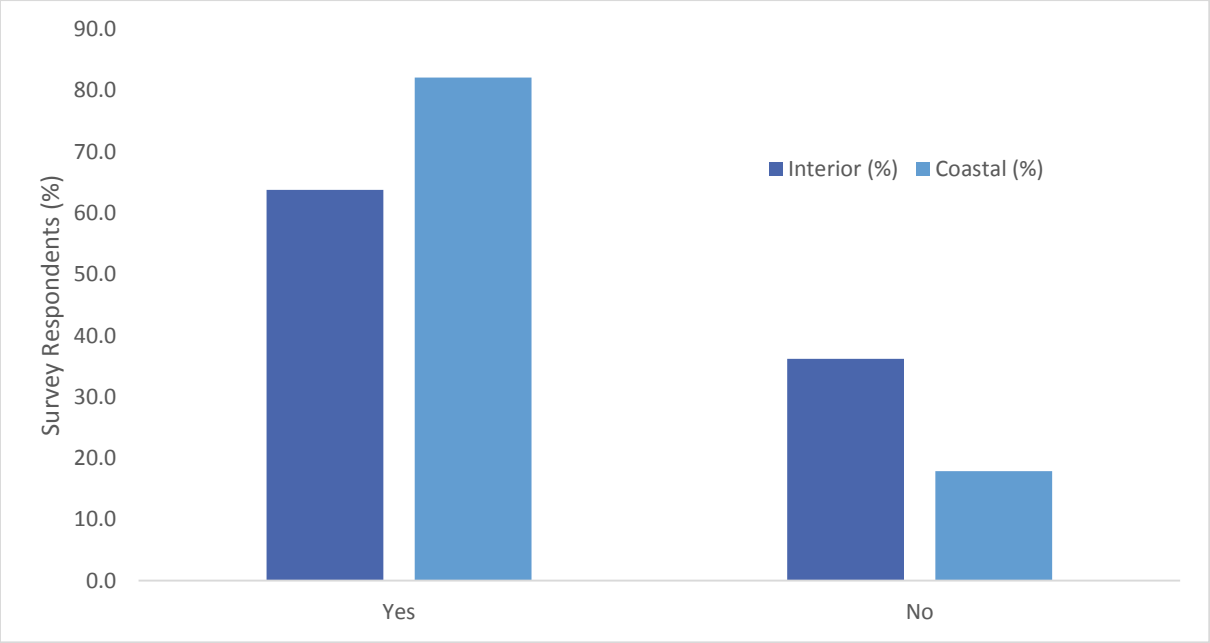

Figure 5: Question 3: Do you follow the Riparian Management Area Guidebook (1995) from the FPC? Number of responses: Interior 58 and Coast 28.

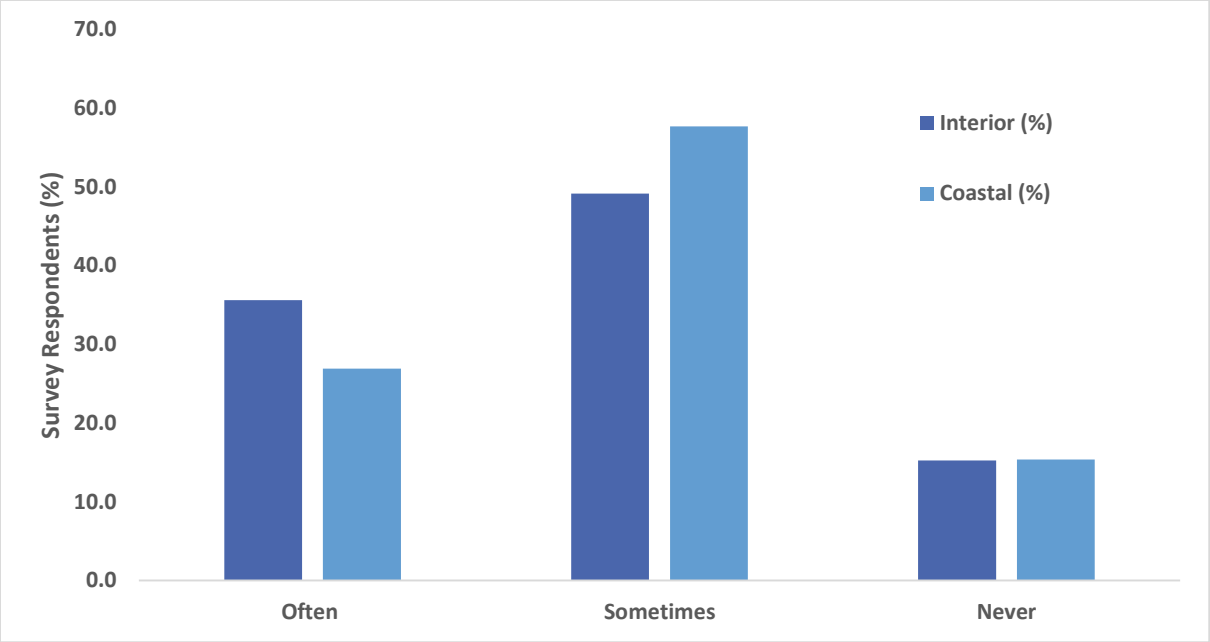

Figure 6: Question 9: Are trees harvested in the riparian management zone when it is expected that retention trees will become windthrow post-harvest? Number of respondents: Interior: 59 and Coast: 26.