Hinton Wood Products
A division of West Fraser Mills Ltd.

Natural Disturbance Strategy

for the 2014 DFMP

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EXECUTIVE SUMMARY

This document describes Hinton Wood Products' (HWP) Natural Disturbance Strategy, which will form the basis of our 2014 Detailed Forest Management Plan (DFMP). Most of the major natural disturbance related strategies and targets set in the 2014 DFMP, and described in this document, have been informed and/or influenced from natural disturbance research and science that has taken place in the Foothills area of Alberta over the last 20 years. The DFMP is a strategic plan for HWP's Forest Management Area (FMA) that sets out overall resource management values, objectives, indicators and targets, and identifies appropriate strategies for achieving them.

To begin, this document first outlines and describes the research that has taken place in the Foothills of Alberta, primarily focusing on natural disturbance research from the Foothills Research Institute (FRI), which is located in Hinton Alberta and began operations in 1992. All common natural disturbance definitions and terminology are explained in detail – in many cases this terminology did not exist before the research took place.

Major findings from this FRI natural disturbance research are briefly outlined chronologically (Table 2) and then are described in more detail in subsequent sections. This includes research into: fire event and patch size, structure retention after fires, disturbance in riparian zones, disturbance rates and fire cycles, temporal and age-class distribution, and large wood debris in riparian areas. A key concept from this research is that numerous components of a natural disturbance, such as event size, age-class distribution, patch size, and stand structure retention; all have a natural range of variation across the landscape. This natural range of variation is the outcome of natural disturbances (primarily fire).

Determining the Natural Range of Variation (NRV) provides a useful template for the management of forests such as those found in the Foothills, which have experienced relatively frequent stand-replacing natural disturbances. NRV describes the historical and present range of disturbance patch sizes, the landscape-level pattern of disturbance patches and events, and the range in disturbance severity, and thus describes the variability in forest cover composition and structure. A comparison of the natural range of variation with a selected range of desired future conditions allows HWP to manage the NRV and its associated values.

An overarching objective of HWP's DFMP will be to maintain forest and stand conditions close to those that have prevailed historically (NRV), by designing managed disturbances (i.e. cutblocks) combined with natural disturbances (i.e. fire, insects) so that the effects on the ecosystems making up HWP's FMA are similar to those of the historical disturbance regimes for this area.

After describing the natural disturbance research and its major findings and concepts, this document outlines HWP's strategy for incorporating this natural disturbance science into our Detailed Forest Management Plan (DFMP). This includes an overview of the four major models that will be used in the DFMP (e.g. LANDMINE, NEPTUNE, etc.) and a detailed description of the major targets and strategies that HWP will implementing to address the following natural disturbance metrics: seral stage distribution, patch size, patch cover type, patch age, old interior forest, stand structure retention, coarse woody debris, and unsalvaged natural disturbance targets.

Also included in this document and its associated appendices is a detail description outlining HWP's strategy for managing the ecological values and functions associated with riparian zones – this is called the Riparian Management Strategy (Appendix 2). The major underlying principle of HWP's Riparian Management Strategy (RMS) is that natural disturbance occurs in riparian areas at similar rates to upland areas, so both upland <u>and</u> riparian areas need to be managed based on natural disturbance principles – excluding riparian areas from disturbance (the current practise) may have undesirable long term ecological consequences.

HWP also believes that riparian areas need to be identified based on their ecological and morphological characteristics, not the width of the stream, which is the current practise. As part of HWP's Riparian Management Strategy, HWP has proposed a new erosion-based methodology (developed at FRI) for identifying and classifying streams (Appendix A in the RMS) and has also developed a new methodology for determining the ecological and morphological riparian areas associated with these watercourses (Appendix B in the RMS). All of HWP's FMA has been classified based on these two methodologies.

A major philosophy of the RMS is that some limited and careful disturbance must be introduced back into riparian areas, as there has been no appreciable disturbance in these areas for 60 years. HWP recognizes that, due to the sensitive nature of riparian zones, even careful disturbance has some risk. For this reason, HWP is developing a program to monitor and measure the impact (if any) of implementing the Riparian Management Strategy. This monitoring program was modelled from similar programs used by Alberta Cows & Fish and the BC government (to monitor effects of harvesting on riparian areas). This monitoring and measuring program is not described in this document, as it is still in development and there has been and continues to be significant involvement from the Alberta government.

This Natural Disturbance Strategy concludes by providing an overview of a number of special issues (e.g. caribou, Athabasca rainbow trout, olive-sided flycatcher etc.), as well as future issues that may need to be contemplated by both the provincial government and the Company as part of future DFMP submissions

While this Natural Disturbance Strategy is based on the principle that approximating the variability of natural forest patterns is the best way to ensure long term conservation of forest values, this strategy must also be balanced with societal values, economic constraints, changing expectations, and scientific knowledge. Through the implementation of this Natural Disturbance Strategy, HWP seeks to strike a balance that is scientifically sound, affordable, and acceptable to society.

HWP's Natural Disturbance Strategy

1.0 Introduction

This document is intended to provide a detailed overview and description of Foothills natural disturbance science and research, as well as describe the overall strategy that Hinton Wood Products (HWP) has in integrating this science and research into our long term forest management planning and our short term operational plans.

To begin, this document will first outline and describe the research that has taken place in the Alberta Foothills, primarily focusing on natural disturbance research from the Foothills Research Institute, which is located in Hinton Alberta. Major findings from this research will be described. Also included, is a section that explains, in more detail, some of the more common natural disturbance terms – in many cases this terminology did not exist before the research took place.

Implementing long term harvesting plans based on approximating the natural disturbance patterns of a region has become a widely accepted and adopted practice across much of western Canada. However, as will be discussed in more detail in this document, there are certain assumptions and limits to adapting a natural disturbance paradigm, and so although it's not perfect, we still believe it is the best strategy to implement in order to maintain a wide range of important ecosystem and biodiversity related values.

After describing the natural disturbance research and its major findings, this document will outline HWP's strategy for incorporating this natural disturbance science into our Detailed Forest Management Plan (DFMP). This will include an overview of the four major models that will be used in the DFMP and an outline of the major targets and/or strategies that HWP will implementing, including a detailed description of HWP's strategy for riparian management.

The document will end by providing an overview of a number of special issues (e.g. caribou), as well as future issues that may need to be contemplated by both the provincial government and the Company as part of future DFMP submissions.

2.0 Natural Disturbance

2.1 Overview

Natural disturbance is a term used to describe a type of disturbance to the forest landscape that is not human caused. For example, harvesting, roads, railways, pipelines, and agriculture are not natural disturbances; however, natural disturbances do include such phenomena as: fire, wind, insects, floods, and landslides. In the Foothills of the Rocky Mountains, fire has historically been the dominant type of natural disturbance, with wind and insects playing a more minor role.

In the absence of modern human intervention (i.e. effective firefighting), landscapes in the Foothills evolved over time in the presence of fire. Fire was the main agent of disturbance and the patterns on the landscape were for the most part determined by fire frequency, fire size, and fire shapes. Therefore, it follows that fire played the largest role in determining the type, abundance, and age of vegetation found in the Foothills. It also follows that the vegetation, fauna, water quantity and quality, and various other biodiversity values have evolved and adapted to a landscape determined by fire.

In the early 20th century, some timber extraction (e.g. railway ties, building materials, etc.) was taking place, as was a limited amount of fire suppression; however, it really wasn't until the 1950s that industrial scale forestry and effective firefighting were brought to bear in the Alberta Foothills. Since that time, fire suppression has become increasingly more successful and harvesting has replaced fire as the main agent of disturbance on the forested land (protected areas and inoperable areas excluded).

About 20 years ago, research into natural disturbance started to become more prevalent and the concept of emulating, or more accurately, approximating, natural disturbance patterns began to take hold. The concept was fairly simple and intuitive – if we can create landscapes that are similar in make-up to natural landscapes (i.e. before significant human influence), then the flora and fauna that evolved within those landscape patterns will also be conserved. However, while the concept is simple, determining what natural landscape patterns might look like is a great deal more complicated. To do this, research was required – research to answer such questions as: what is the natural makeup of vegetation on the land; how much old forest do you need; how much young forest should there be; what is the natural range of disturbance sizes and shapes; and how much forest within a fire doesn't burn. All these questions and more needed to be thought about and answered.

At the same time, another even more basic question needed to be answered – was approximating natural disturbance an appropriate method of conserving biodiversity values; in other words, was it the right thing to do? HWP believes that answer to be yes. Over the past 20 years, research into natural disturbance has become increasingly more sophisticated, and in general, the science is showing us that the closer we can get to approximating natural disturbance, the better off we are at conserving other values. Major sustainable forest management certification schemes, as well as provincial governments, have all adopted some form of natural disturbance approximation as part of their forest management framework.

Is there another better alternative? We don't think so. There is broad consensus that approximating natural disturbance regimes is a better strategy than simply managing for individual species or values, as often managing for individual values results in a myriad of conflicting rules and regulations. That is not to say that managing for individual species or values isn't still an important part of a Detailed Forest Management Plan – it is, however; these individual values are managed on top of a framework of approximating landscape and stand level natural disturbance patterns.

It must also be pointed out that approximating natural disturbance may mean different things to different stakeholders. In federal or provincial parks, for example, maintaining natural disturbance patterns might mean aggressively fighting some fires, while letting others burn; or it may mean purposely lighting fires in a more controlled way (i.e. prescribed burning).

For Hinton Wood Products, and our nearly one million hectare Forest Management Area (FMA), approximating natural disturbance patterns has become a core guiding principle. It will drive decisions at the highest planning level, such as the Spatial Harvest Sequence in our Detailed Forest Management Plan, to decisions made on the ground in operational plans like the Forest Harvest Plan. To summarize, for HWP, managing the landscape based on natural disturbance principles means the following:

- Harvest patterns, block sizes, stand structure retention and seral stage targets are all managed based on natural disturbance research, with the primarily goal being maintaining these attributes within their natural range of variability wherever possible.
- Both upland <u>and</u> riparian areas (where feasible) need to be managed based on natural disturbance principles – excluding riparian areas (the current practice) may have undesirable long term ecological consequences.
- Riparian and upland areas need to be identified based on their ecological and morphological characteristics.

- Approximating the variability of natural forest patterns is critical, but this strategy must be balanced with societal values, economic constraints, changing expectations, and scientific knowledge. HWP seeks to strike a balance that is scientifically sound, affordable, and acceptable to society.

The following sections describe the terminology of fire-related natural disturbance, including a brief history of natural disturbance research in the Foothills and a more detailed summary of some of the major findings.

2.2 Natural Disturbance Terminology

In order to better understand and discuss fire and related natural disturbance concepts, a consistent use of terms is required. The following sections will define and describe the main terminology used by HWP in this document:

2.21 Natural Regions and Subregions

Natural Regions are the largest mapped ecological units in Alberta. They are defined geographically on the basis of landscape patterns, notably vegetation, soils and physiographic features. The combined influence of climate, topography and geology is reflected by the distribution of these features. Wildlife distribution patterns, and particularly certain species that favour specific habitats, are also sometimes useful in delineating Natural Regions (Downing D.J. and Pettapiece W.W. 2006).

Table 1 – *Natural Regions and Subregions on HWP's FMA.*

Natural Region	Natural Subregion
Rocky Mountain	Alpine
	Subalpine
	Montane
Foothills	Upper Foothills
	Lower Foothill

Natural Subregions are subdivisions of a Natural Region, generally characterized by vegetation, climate, elevation, and latitudinal or physiographic differences within a given Region. Table 1 outlines the Natural Regions and Subregions on the Hinton FMA.

2.22 Landscape

The term "landscape" has many meanings at many different scales. In this document, the word "landscape" refers to an ecosystem large enough to allow observation and understanding of the interaction of disturbance, geomorphology, and topography with the biota. In other words, a large collection of forest stands, whose common link is their dynamic relationship to both disturbance and land features. In the Foothills of Alberta, a landscape may be anywhere from 100,000 to 1,000,000 hectares.

2.23 Event and Patches

Fires in the boreal forest are referred to as "disturbance events". Larger fires tend to take place over a relatively short period of time, and leave behind a patchwork of burnt and unburnt patches. Figure 1 illustrates the concept of the fire event, which consists of a number of different patches within a single rough outer boundary.

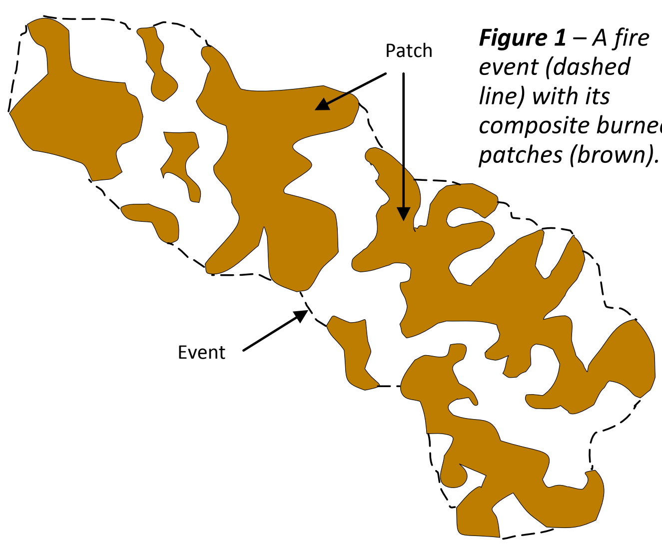


Figure 1 *– A fire event (dashed line) with its composite burned patches (brown).*

There is a three-step process used to determine that actual shape of the event. First, boundary lines are drawn on the outermost edges of all areas that are disturbed. Second, apply a 250 metre exterior buffer to all patches – this connects adjacent patches closer than 500 metres to each other. Lastly, apply a 250 metre interior buffer to the polygon formed from Step 2. (Andison D.W. September 2006)

2.24 Patch shape

"Shape" is the relationship of the length of the perimeter of a patch relative to its area. Circles are the simplest shapes and thus have a "shape index" of one. As patches become more convoluted, the amount of perimeter per area increases, and the shape index climbs (Quicknote #9. 2001. Andison). Edge is a different component of patch shape, as edge measures the perimeter of the outside of the patch as well as any internal islands.

2.25 Island and Matrix Remnants

There are two major types of residual material within a fire; "island remnants" and "matrix remnants". Matrix remnants are always undisturbed and include features such as corridors, bays, and peninsulas that are within the greater event area, but are still physically connected to the surrounding forest matrix. Matrix residuals can include both forested and non-forested areas. It is not possible to define matrix remnants without first defining the disturbance event.

Island remnants patches are both physically disconnected from the matrix (and thus completely surrounded by disturbed forest), or connected to a disturbed patch, but partially disturbed (i.e. burned). Island remnants are usually defined and described at only the disturbance patch scale. Figure 2 illustrates the concept of the island and matrix remnants.

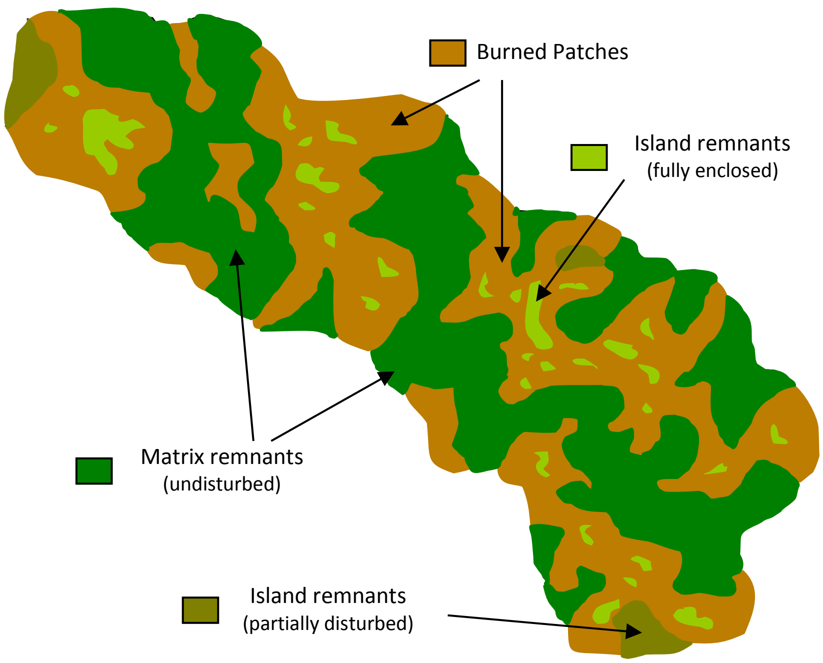


Figure 2 *– The various types of fire remnants are illustrated – island remnants (both fully enclosed and connected to the forest matrix but partially disturbed) and matrix remnants.*

2.26 Fire and fire cycle

There are two types of fires: wildfire and prescribed fire. In this document, the term "fire" is always synonymous with "wildfire". When discussing prescribed fire, the term "prescribed fire" will always be used.

The fire cycle is the average number of years it takes for a specified area to burn the number of the hectares equal to that area. For example, the portion of the Lower Foothills Natural Subregion that is within HWP's FMA is approximately 300,000 hectares in size – historically, it has taken between 65 and 75 years to burn 300,000 hectares within this area; therefore, the fire cycle is 65-75 years. It's important to note that this does not mean the each hectare of the entire 300,000 hectare Natural Subregion is burned during the fire cycle, as some fires may burn in the same place more than once.

2.27 Disturbance rate

Different areas have difference disturbance rates, which can vary depending on factors such as climate, vegetation, and geography. The disturbance rate is expressed as a percentage of a specified area burned during a given time period.

2.28 Seral Stages

In ecological terms, a "sere" is the series of biotic communities formed by the process of ecosystem development called succession. In forested landscapes, the various vegetation communities that occupy disturbed sites and make up a sere are called "seral stages." Seral-stage communities consist of vegetation types that are adapted to the site's particular set of physical and biotic conditions. In the unmanaged forested landscape, various natural disturbance agents (such as fire, windthrow, floods, and insects) are responsible for creating forests containing a full range of stand ages (B.C. Ministry of Forests Research Branch. 1998)

The individual forest stands that make up a landscape evolve in a complex and diverse manner. However, there are some general patterns of development that appear across a wide range of forest types and locations. For example, following a natural disturbance such as fire, forest renewal in the Hinton FMA typically takes place through a series of five successional stages, which can be described as follows (B.C. Ministry of Forests Research Branch. 1998) (Franklin J, Spies T, et al. 2002) (Morgantini and Kansas 2003) and is illustrated in Figure 3:

1. **Young or Establishment** (e.g. early/young seral) – This seral stage is characterized by a site that starts off largely free from competition. The site is then colonized by herb, shrub, and tree species, which are well adapted to exposed conditions, and germinate from seed banks (e.g. cones) or disseminate from nearby seed sources.

2. **Pole or Thinning** (e.g. mid-seral) – This seral stage is characterized relatively rapid height growth (and biomass accumulation) and by the closing up or consolidation of the tree canopy, which provides more shade and tends to exclude shrubs, herbs, and tree species intolerant of shade. There is tree mortality from self-thinning and some natural pruning of lower tree branches. As the height of the forest increases, two relatively distinct layers emerge: an upper layer of canopy trees and a sparse lower layer of dying or surviving shrubs and herbs.

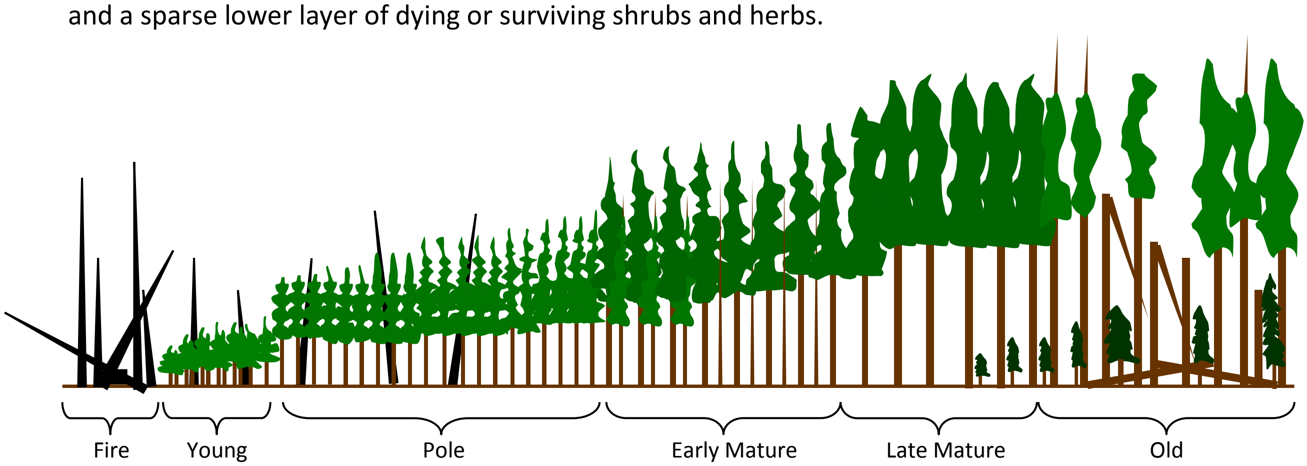


Figure 3 *– Typical seral stage development in a fire-origin forest.*

3. **Early Mature** (e.g. early mature seral) – This seral stage is characterized by high live-tree stem density composed of mainly relatively short and small diameter trees. They exhibit low variation in stand height and diameter. Coarse Woody Debris (CDW) volumes and densities are very low. Snag density and basal area are also low in early mature stands. At this stage, structure in the form of snags and CWD from the previous seral stage is on its way out, and the stand has not yet progressed to the point that additional dead material is being generated. Early mature stands do not support stand structural attributes indicative of old forests.

4. **<u>Late Mature</u>** (e.g. late mature seral) – This seral stage is characterized by a slowdown in height growth (until maximum height is reached) and diverse and gradual changes to the stand structure and vegetation processes. For example, tree size, live biomass, and diversity of tree sizes peak; while, CWD declines to its lowest amount. The trees of the young seral stage slowly die out, while canopy gaps may infill with new trees and understorey release increases. In general, there is a shift from density dependent to density-independent causes of overstory tree mortality, and the development of decadence in overstory trees.

5. **<u>Old (e.g. old seral)</u>** – As the stand continues to age, there is an increase in the mortality of individual or small groups of canopy trees. This final seral stage, therefore, is characterized by a shift of the stand to a pattern of small, patchy disturbances that create gaps of various shapes and sizes. This in turn allows resources to be released for new trees in the understorey layers. The increased decadence in overstory trees also results in an accelerated generation of coarse woody debris.

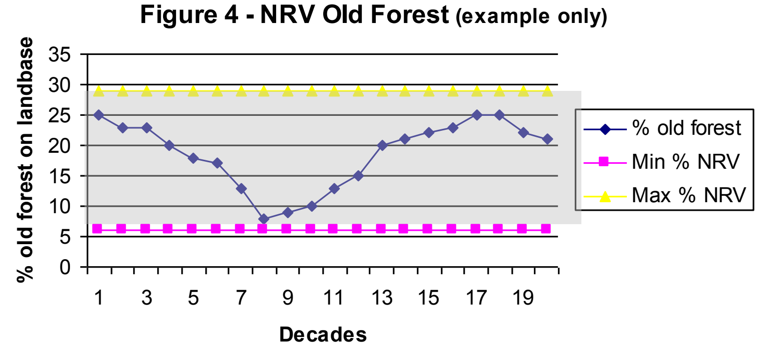
2.29 Natural Range of Variation

Natural disturbance can be thought of as a having a natural range of variation (NRV), which is the outcome of natural disturbance. The NRV focuses on the landscape and stand-level patterns of ecosystem conditions that have resulted from past natural disturbances. The NRV can account for the historical, current, and possible future range of variation on the land.

The natural range of variation provides a useful template for the management of forests, such as those found in the Foothills, which have experienced relatively frequent stand-replacing natural disturbances. It describes the historical and present range of disturbance patch sizes, the landscape-level pattern of disturbance patches and events, and the range in disturbance severity, and thus describes the variability in plant community composition and structure. Social, cultural and economic considerations can then be used to select an acceptable portion of this range. (Perera A, Buse L, Weber M, et al. 2004). A comparison of the natural range of variation with a selected range of desired future conditions allows HWP to manage the NRV and its associated values.

An overarching objective of HWP's DFMP will be to maintain forest and stand conditions close to those that have prevailed historically (NRV), by designing managed disturbances (i.e. cutblocks) combined with natural disturbances (i.e. fire, insects) so that the effects on the ecosystems making up HWP's FMA are similar to those of the historical disturbance regimes for this area.

Figure 4 - NRV Old Forest (example only)



Remaining within the NRV and providing variation over time is thought to be a good way to increase the chance that managed forests will function ecologically the way natural forests do. In some situations, the landscape may already be out of the NRV – in these cases, HWP would want to manage the landscape over time to move back it into the NRV. Figure 4 illustrates the concept of NRV – the NRV is the shaded grey area in the graph between the minimum percentage landbase that would be in old forest (the pink line) and the maximum percentage of the forest that would be old forest (the yellow line). This is an example only.

2.3 Natural Disturbance Research History

In order to build a long-term plan like a DFMP, which is predicated on natural disturbance principles, a significant amount of research and science has to first take place. This is because plans built on approximating natural disturbances, like fire; need to be based on past conditions of the forest landscape. This can only be done with some degree of accuracy through research and modelling.

HWP recognized this research need and in 1996 was one of the founding partners of the Foothills Research Institute's (FRI) Natural Disturbance Program. A collaborative program between industry and government, the Natural Disturbance Program was developed to understand and describe how natural forces like fire, insects, disease, flooding, and wind have created historical patterns in the Alberta Foothills. It is an extensive effort that has entailed many studies, some of which extend well beyond the Foothill Research Institute's borders.

The main assumption driving this research program is this: in the absence of information on alternatives, using natural disturbance patterns to guide management is one of the best possible means of achieving ecological sustainability. Therefore, the main research focus is on patterns and the disturbance processes responsible for those patterns. (Andison D.W. 1999).

To understand how natural disturbances have shaped historical patterns in the Foothills, we first had to understand the processes causing natural disturbances. Understanding these processes is well beyond the ability of one study, and that is why the Natural Disturbance Program continues 16 years after its inception (it is now called the Healthy Landscapes Program). The original question HWP asked of the Natural Disturbance Program was this: "How much old forest should there be on the Hinton FMA?" This one simple question led to other questions (e.g. what's the NRV of each seral stage by vegetation type?), which in turn led to more complex questions (e.g. how do you describe a fire event?), and today, 16 years later, we are still asking questions and are still learning more about natural disturbance.

For example, the Natural Disturbance Program has completed studies of natural disturbance patterns at very broad landscape scales (like disturbance cycles and sizes) and has also explored questions at intermediate scales (like residual patterns) and fine scales (like fire disturbance edge architecture). Additionally, in the past seven years, the Natural Disturbance Program has identified and prioritized research projects by using a long-term research plan that dovetails project data, results, and conclusions. For instance, the final report on natural disturbance in riparian zones involved data from four individual projects at four different scales.

Research at FRI into natural disturbance within HWP's own FMA, has helped the Company immensely, in better assessing our forest activities in relation to natural ranges of variability. This thorough understanding of natural disturbance processes has not only helped provide support for ecologically-sound strategies within our own FMA, but has also helped inform regional and provincial forest management guidelines and policy as well.

To discuss all of the FRI research that has taken place over the last 16 years is too large of task for this document, but instead we summarize in Table 2 some of the significant projects and findings coming out of the Natural Disturbance Program and discuss these findings in more detail in section 2.4.

Table 2 – *A summary of Natural Disturbance Research from FRI*

Year	Research Reference	Summary of research findings
1996	Simulating the impact of landscape-level biodiversity guidelines (Andison D.W. and Marshall P.L. 1999)	LANDMINE is a spatially explicit, pixel-based, empirical Monte-Carlo landscape simulation model that was developed to test the sensitivity of various disturbance regime parameters on pattern for landscapes dominated by stand-replacing disturbance events. It is used to simulate fire events and to create NRV.
1998	Temporal patterns of age-class distributions on Foothills landscapes in Alberta (Andison, D.W. 1998)	Forest vegetation information for the Alberta Foothills was summarized as frequency distributions by age-class, and the distributions were compared to the percentage of the area in the current, and the pre-industrial landscapes.
1999	Assessing Forest Age Data in Foothills and Mountain Landscapes of Alberta (Andison D.W. 1999)	A validated, contiguous, stand origin map was completed for the Hinton FMA. This is a formidable (and rare) advantage for landscape and pattern analyses.
2000	Landscape-Level Fire Activity on Foothills	Disturbance rates and fire cycles by ecological natural subregions for Jasper

Year	Research Reference	Summary of research findings
	and Mountain Landscapes of Alberta (Andison D.W. 2000)	Park and the Hinton FMA were determined.
2002	Disturbance in Riparian Zones on Foothills and Mountain Landscapes of Alberta (Andison D.W. and McCleary K. Feb. 2002)	Fires burn through the vast majority of the riparian zones studied, and the majority of island remnants occur nowhere near riparian zones. The chances of a given riparian zone surviving or coinciding with the edge of sequential fire events were extremely small in the study area.
2003	Patch and Event Sizes on Foothills and Mountain Landscapes of Alberta (Andison D.W. March 2003)	Most disturbance patches and events are very small but large patches and events account for most of the land disturbed.
2003	Age Analysis of Large Woody Debris in Riparian Zones of Foothills Landscapes of Alberta (Daniels L.D. and Powell S.R.E. Oct. 2003)	To be ecologically sustainable, forest management must account for impacts on the amount and type of woody debris in riparian forests, since it will influence stream morphology, aquatic habitat, and biodiversity for the next century.
2003	Disturbance Events on Foothills and Mountain Landscapes of Alberta (Andison D.W. Nov. 2003)	A fire event was specifically defined. The paper focuses on the general questions of composition and structure of a disturbance event.
2004	Island Remnants on Foothills and Mountain Landscapes of Alberta (Andison D.W. Nov. 2004).	The rules used to objectively define island remnants are detailed, along with examples, some new terminology, and summaries of the pattern and composition of island remnants in west-central Alberta.
2006	NEPTUNE – a "Novel Emulation Pattern Tool for Understanding Natural Events" (Forestry Corp, Andison D.W. et al. 2006)	This model provides objective evaluation of individual or cumulative disturbance activities in the western Boreal Canada against historic fires. With NEPTUNE, the user can evaluate how close and in what ways human disturbance activities vary from, or match, historic events.
2011	Temporal Dynamics of Large Wood Debris in the Foothills of Alberta (Daniels L. D., Jones T.A., Bataineh M., et al. January 2011).	Findings emphasized the importance of natural disturbances in riparian forests as a key driver of in-stream LWD dynamics; illustrated that fire and harvesting impact LWD dynamics differently, providing opportunities for innovative silviculture: confirmed the importance of standing timber zones surrounding streams, particularly as a source for LWD recruitment in harvested and burned landscapes; and provided ecosystem-specific baseline data to ensure long-term success of forest management and stream restoration through action and monitoring.

2.4 Natural Disturbance Research – Major Findings

This section of the document will outline and discuss some of the major research findings coming out of the Natural Disturbance Program at FRI over the last 16 years.

2.41 Natural Subregion Area Summary

Table 3 summarizes the breakdown between forested and non-forested areas by Natural Subregion within HWP's FMA. It should be noted that these tables include all the data for non-FMA land within the FMA boundary (e.g. Switzer Park, Hinton townsite, etc.), do not include the Montane subregion (as it's too small), and that the small area of forested "Alpine" subregion (12,175 ha) was included with the Subalpine category. (Andison D. July, 2000)

Table 3 – *Area by Natural Subregion for the Hinton FMA*

	Upper Foothills		Subalpine		Lower Foothills		Total
	ha.	%	ha.	%	ha.	%	
Forested	520,352	89%	242,628	94%	260499	88%	1,023,479
Non-Forested	66,995	11%	14,472	6%	35154	12%	116,621
	587,347		257,100		295,653		1,140,100
Percentage	51%		23%		26%		100%

2.42 Disturbance Rates and Fire Cycles

Table 4 outlines the historical disturbance for the Hinton FMA area (as described in Table 3) in 20 year increments up until 1950, when industrial scale harvesting and effective fire suppression began. Also described in Table 4 is the historical fire cycle by Subregion for the Hinton FMA. (Andison D. July, 2000)

Table 4 – *Disturbance Rate and Fire Cycle for the Hinton FMA*

20-Year Period	Percent of Forest Burnt in each 20-year Period by Subregion		
	Subalpine	Lower Foothills	Upper Foothills
1811-1830	4%	6%	1%
1831-1850	28%	67%	47%
1851-1870	4%	55%	36%
1871-1890	27%	52%	51%
1891-1910	23%	11%	22%
1911-1930	15%	11%	8%
1931-1950	<1%	2%	2%
Average 1810-1950	14.6%	29.1%	23.9%
fire cycle (yrs)	110-140	65-75	80-90

From this data we can note a number of interesting things about the Hinton FMA, such as:

- The ecological Natural Subregions appear to be a valuable means of stratifying the landscape, as the differences between the rates of burning through time for each area suggest that fire is acting differentially at this scale. These differences can be related to climate, tree species dominance, and even historical lightning strikes.
- The Subalpine Subregion has a generally cooler and wetter climate, which aligns well with its fire cycle, which is significant longer than the other two lower and dryer Subregions.
- It suggests that the Lower Foothills has had more extreme fire behaviour than the Upper Foothills area. On average, over the last 140 years, over 29% of the Lower Foothills forest burnt in any single 20-year period, compared to just under 24% for the Upper Foothills (Table 4). These roughly translate to 69 and 84-year fire cycles for the Lower Foothills and Upper Foothills areas respectively over the last 140 years.
- Variability in disturbance rates at even very large scales is a natural phenomenon.
- Fire control has been the most influential cultural process at landscape and regional scales in the last 60 years.

2.43 Natural Range of Variability Age-Classes

As part of the 1999 HWP Forest Management Plan, HWP asked that FRI's Natural Disturbance Program complete a modelling exercise as a means of developing natural ranges of age-class variability.

The right computer model can create many different, equally possible, landscape snapshots, and thus many different, equally possible, age-class distributions. The LANDMINE is a computer model that was designed to do this (see section 3.21 for a more detailed discussion of LANDMINE). LANDMINE computer simulation allowed HWP to see how the impacts of allowing the range of 20-year burning rates (as outlined in Table 4) to play out over space and time.

In 1999, to run the model, age-classes were grouped into four seral-stages – Young, Pole, Mature, and Old (see section 2.28 for definitions). Since these seral stages can be achieved at different ages for different forest-types, the age breaks will vary. The results from the LANDMINE modelling were summarized by the four seral stages for all pine-dominated stands, all spruce-dominated stands, all mixedwood stands, and all hardwood-dominated stands. The results were also summarized for different-sized areas beginning at 30,000 hectares, then 60,000, 120,000, 240,000, and finally 480,000 for the Upper Foothills.

Full results can be seen on pages 12-20 on Andison's 2000 Report "Landscape-Level Fire Activity on Foothills and Mountain Landscapes of Alberta Report". Examples of the data generated from pine, spruce, and hardwood stands (based on a 240,000 hectares sized units) are shown in Figure 5a-d on the following page. Also included in the figures are the "snap-shots" of the actual age of the seral stage for 1950 and 1998.

Results from the LANDMINE modelling offered the following insights:

- The most dominant feature of the historical frequencies of the different seral-stages is the wide range of variation. Fire activity occurs in such a way that highly variable levels of different seral-stages could and did occur over the last 200-300 years.
- The 1950 and 1998 landscape "snapshots" are for the most part well within these NRV ranges, suggesting that at the broadest scale, the 1998 landscape was almost as "natural" as any that occurred over the last few centuries, including 1950 (with two exceptions noted below).
- The existing (1998) amount of Old Hardwood is extremely high in both the Upper Foothills (Figures 5b) and Lower Foothills landscapes. The corresponding amount of Young Hardwood (Figures 5a) is virtually zero in both cases, which is rare according to the model. Effective fire suppression combined with a low harvesting rate has likely resulted in Young and Old Hardwood amounts that are out of (or at least near the upper range) or their NRV.
- The high abundance of Mature Spruce in the Lower Foothills and Upper Foothills zone (Figure 5d) is also near the outer limits of NRV. Although 70% Mature Spruce does happen; according to the model, it is a relatively rare occurrence. If disturbance rates are not increased, the Mature Spruce will soon become Old Spruce, resulting in that seral stage being out of its NRV.

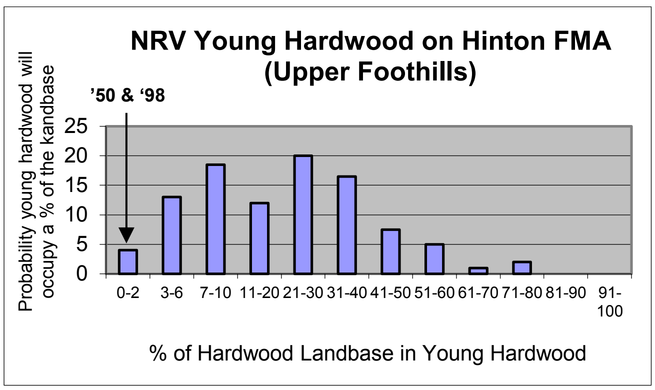


Figure 5a – *NRV for Young Hardwood in the 240,000 ha unit size for the Upper Foothills. Actual percentage landbase in Young Hardwood is indicated for 1950 and 1998.*

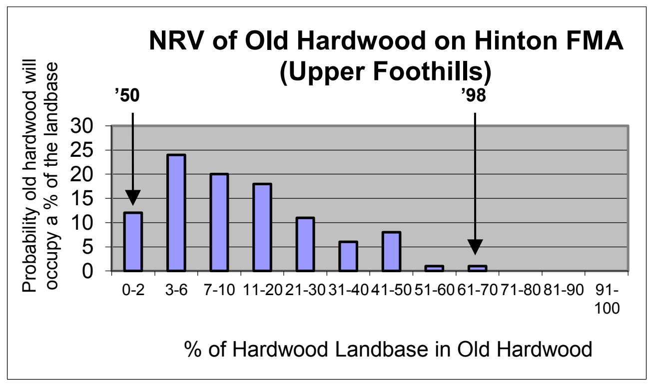


Figure 5b – *NRV for Old Hardwood in the 240,000 ha unit size for the Upper Foothills. Actual percentage landbase in Old Hardwood is indicated for 1950 and 1998.*

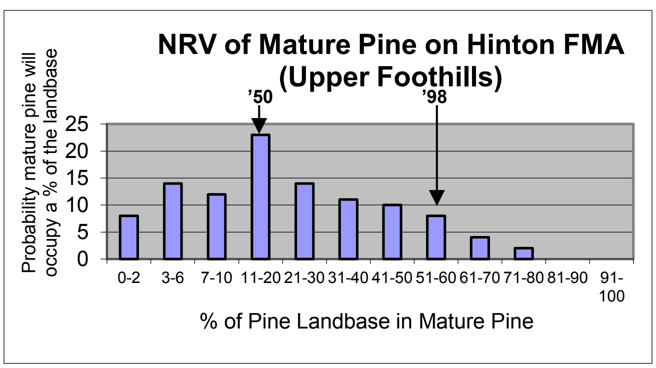


Figure 5c – *NRV for Mature Pine in the 240,000 ha unit size for the Upper Foothills. Actual percentage landbase in Mature Pine is indicated for 1950 and 1998.*

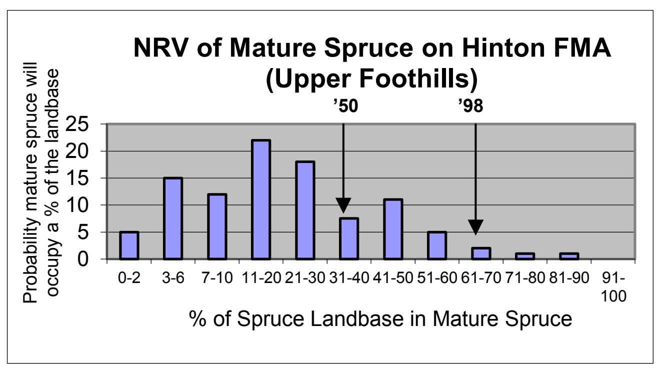


Figure 5d – *NRV for Mature Spruce in the 240,000 ha unit size for the Upper Foothills. Actual percentage landbase in Mature Spruce is indicated for 1950 and 1998.*

- In the situations depicted in Figure 5a, 5b, 5c, and 5d where the current (i.e. 1998) seral-stage status is at the far range of its NRV, the most likely reason is effective fire control activities, combined with a lack of other disturbances such as fire or harvesting. The forest is getting too old.
- As landscape size increases, the variation decreases. In some cases, the probability distribution can even become "normal". An example of this is shown in Figure 6 for the Old Spruce seral stage

for the Subalpine Subregion. At the 30,000 hectare unit size (red bars), the percentage of Old Spruce ranges from zero to over 70%, with only a vague central tendency. At 240,000 hectares (blue bars), the range of Old Spruce is limited to 8-50%, with a clear central tendency around 15%.

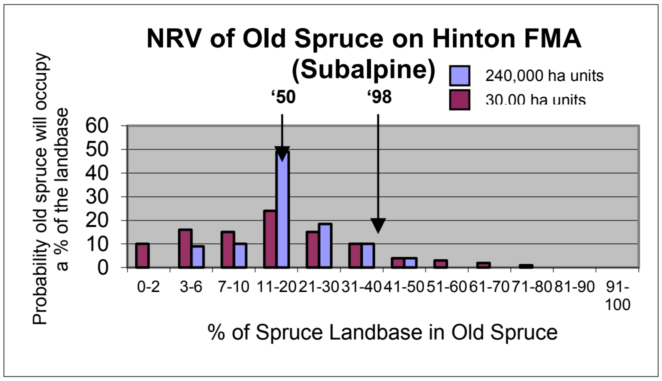


Figure 6 – *NRV for Old Spruce in the 30,000 ha and 240,000 ha unit size for the Subalpine. Actual percentage landbase in Old Spruce is indicated for 1950 and 1998.*

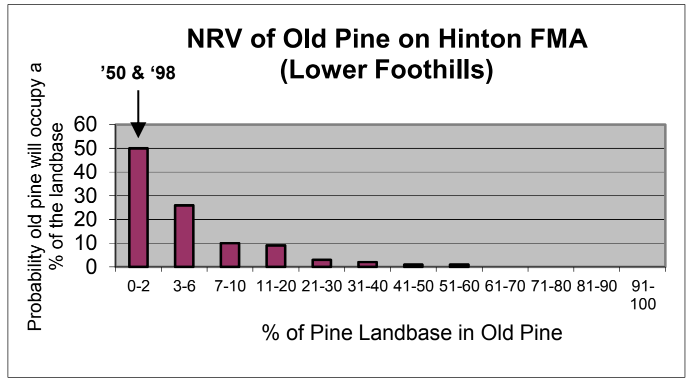


Figure 7– *NRV for Old Pine in the 30,000 ha unit size for the Lower Foothills. Actual percentage landbase in Old Pine is indicated for 1950 and 1998. Over half the time only 2% of the pine-dominated stands would normally be "Old" in these areas.*

- Modelling shows that "stable" age-class distributions would not be theoretically possible for Natural Subregion areas less than 5-10 million hectares in size, so practically speaking, "stable" age-class distributions should not exist in this part of Alberta.
- The smaller the unit size measured, the less likely there was to be very much old forest. For example, over 1/3 of the time, 30,000 ha areas of pine-dominated landscapes had less than 2% Old forest on the Upper Foothills.
- In the Lower Foothills, no more than 2% of the pine-dominated stands were "Old" over half of the time in 30,000 ha areas (Figure 7). These results are saying that chances were pretty good that at any one point in time over the last few hundred years, fire activity was such that little or no Old Pine existed at this scale.

2.44 Patch and Event Sizes

From the air, the most apparent characteristic of a Foothills forest landscape is the mosaic of different patch types. These patches are defined by various attributes such as: age, tree species, density, and height, as well as non-vegetative features such as lakes, bogs, and meadows.

Due their specific characteristics, some patch types last longer than others. For example, most naturally occurring non-forested patches today were probably present in the same form 200-300 years ago.

Unlike non-forested patches, forested patches tended to change more over time. This change was largely because of an active disturbance regime, which included fire, floods, wind-throw and insect and disease outbreaks. For example, before active and effective fire suppression, the average time to burn an area equivalent to the size of the landscape (the "fire cycle") was between 65 and more than 140 years within different Natural Subregions on the Hinton FMA.

HWP is very interested in the size and attributes of events and patches because, as part of our DFMP, we are developing management strategies based on the principle of approximating a natural disturbance regime, which would include the strategies that incorporate information about the variability in event and patch size.

Research on disturbance event and patch sizes was carried out by FRI's Natural Disturbance Program. In March 2003, a report titled "Patch and Event Sizes on Foothills and Mountain Landscapes of Alberta" (Andison D.W.) was released, which described in detail key attributes of natural-caused forest patches across the landscape over time (in Japer National Park, HWP's FMA and Alberta Newsprint Company's FMA area) and compared those attributes to patches created by cultural activity such as harvesting (and effective fire suppression). In addition, another FRI report released in November 2003 titled, "Disturbance Events on Foothills and Mountain Landscapes of Alberta" described further research findings into the nature and morphology of fire events.

There are a number of interesting and revealing findings from this research that will help guide HWP's management strategy for the DFMP. These finding include the following:

- Disturbance events are composed of one or more disturbance patches. Forest management strategies should differentiate between events and patches as their size distributions are distinct.
- A small number of very large fires account for most of the area disturbed on a given landscape. The exact proportions of fires of different size-classes vary by Natural Subregion. (Andison. March 2003)
- The size distribution of disturbance patches is fairly typical of fire-dominated landscapes – there were a small number of large disturbance patches (i.e. 2,000 to over 10,000 hectares) and a large number of small disturbance patches. For example, on average, disturbance patches over 2,000 hectares account for 0.6% of the disturbance patches but 43% of the disturbed area.
- The three Natural Subregions (Upper Foothills, Lower Foothills, and the Subalpine) that make up the operable portion of HWP's FMA have some significant differences in terms of their patch sizes and distribution. As shown in Figure 8, the largest disturbance patches occur in the Upper Foothills landscape, where more than half of the disturbed area is in patches greater than 10,000 hectares. The Subalpine landscape is also dominated by very large disturbance patches. In contrast, the Lower Foothills landscapes are dominated by smaller disturbance patches.
- The patterns of sizes and numbers of disturbance events are similar to the numbers and sizes of individual patches (see Figure 9). As with the disturbance patch data, most disturbance events are very small, but most of the disturbed event area is made up of very large disturbance events. However, a far greater proportion of disturbance events are large relative to individual disturbance patches. (Andison. March 2003)
- These patch-event size differences reflect the manner in which fires burn across landscapes. The fact that there are proportionally more large events than there are large disturbance patches follows logically from the fact that events are comprised of patches. The fact that the ratio of small to large disturbance patches is higher than the ratio of small to large events means that events include a higher proportion of smaller patches. (Andison. March 2003)

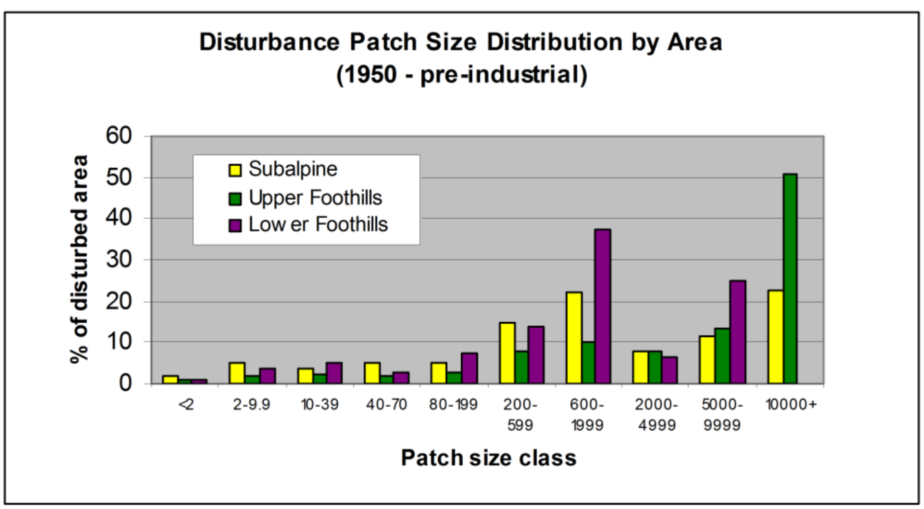


Figure 8 – *The distribution of patch sizes by Natural Subregion in 1950; representing a pre-industrial and pre effective fire suppression snapshot in time.*

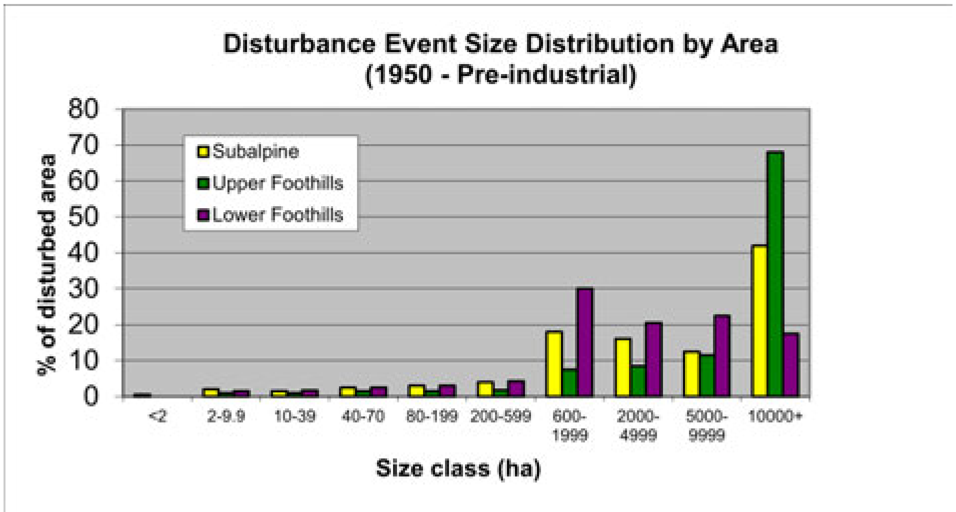


Figure 9 – *The distribution of event (i.e. fire) sizes by Natural Subregion in 1950; representing a pre-industrial and pre effective fire suppression snapshot in time.*

- Since the 1950s, fires have been suppressed on the Hinton FMA, and natural disturbance has been replaced with cultural disturbances including activities such as harvesting, road-building, oil & gas development, and open-pit mining. The impact of this moving away from natural disturbance is evident in the disturbance patch size distributions. (Andison. March 2003)
- In general, since 1950, there has been a significant shift from large natural disturbance patches to small cultural ones. For example, disturbed patches in the Upper Foothills of less than 40 hectares in size in 1995 accounted for an average of 34% of disturbed area; compared to just over 3% in 1950 (Figure 10). This 35% represents about 88% of the number of disturbance patches. In fact, of the over 17,000 disturbance patches in the 1995 dataset, only 192 are larger than 80 hectares, and 34 larger than 200 hectares. (Andison. March 2003)
- The spike of area in the 10-40 ha patch size in 1995 was consistent across all natural landscapes in the region, and represented the most common size range of harvest cutblock approved by Alberta at that time. Clearly, if the goal is approximate natural disturbance there need to be more large cultural events with larger disturbance patches. (Andison. March 2003)

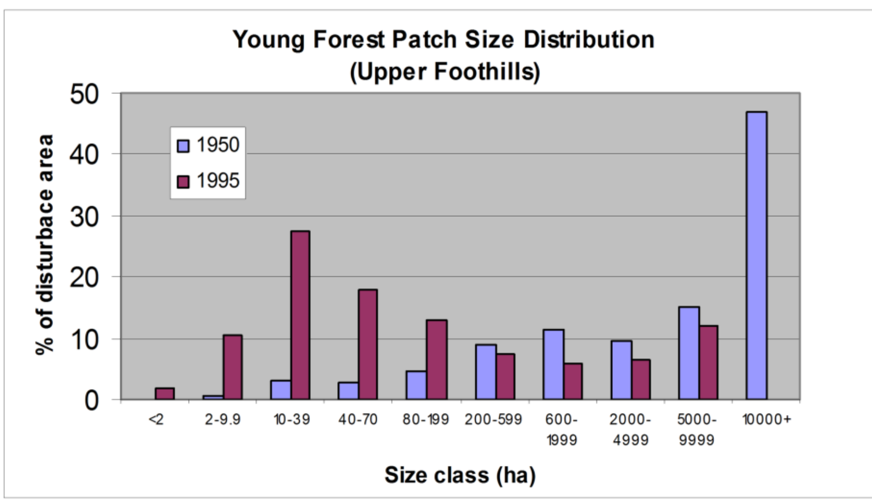


Figure 10 – *The young forest patch size distribution in the Upper Foothills Natural Subregion in 1950 (pre-industrial) and 1995 (post-industrial).*

- The actual area burnt or disturbed within a fire event averages only about 69% of the event, leaving an average of 31% of events as un-burnt “matrix remnant”. This is distinct from, and additive to “island remnants”. (Andison, November 2003)
- About 35% of all events have only a single disturbance patch. Another 26% have between two and five disturbance patches, and another 15% have between six and ten disturbance patches. Generally, as the size of the disturbance increases, the number of disturbance patches increases. (Andison, November 2003)

- Events tend to be dominated by a single large disturbance patch, which accounts for an average of 73% of the disturbed area. The numbers of smaller disturbance patches of different sizes can be roughly predicted. (Andison. November 2003)
- Disturbance patches are more convoluted in shape than events, and their complexity increases with increasing size. (Andison. November 2003)

2.441 Old Forest Patches

Old forest has ecological, economic, and social value and it is, therefore, essential to consider how old forest is arranged in space. In order to allow results of Andison's 2003 report on patch size to be more universally applicable, he defined old forest as simply the oldest 15% of the landscape. Using this definition, findings from this report with respect to old forest patch size and distribution included the following:

- There are far more small old forest patches relative to small disturbance patches. On average, the percent of old forest area in patches less than 40 hectares in size is about 12% (Figure 11), compared to about 5% for disturbance patches less than 40 hectares. In addition, most of the area of old patches is made up of larger patch sizes (i.e. 80 hectares and larger). (Andison. March 2003)
- The 12% area of old patches that are less than 40 hectares in size represent about 97% of the total number of old forest patches (Figure 11). In addition, 4.8% of the old forest area is in patches less than two hectares (Figure 11), which represents about 88% of all old forest patches by density (Figure 12). (Andison. March 2003)
- It's estimated that about 90% of the old forest patches smaller than 10 hectares are residual islands left within fires. Thus the majority of old forest patches in total are island remnants. However, most of the area of old forest is of non-island origin, and in much larger patches. This fact emphasises the importance of maintaining a full range of old forest patch sizes across large areas. There is a risk of only managing old forest in large patches – by not including island remnants in the definition of old forest, we may be ignoring many other ecological benefits of these small old forest patches. (Andison. March 2003)

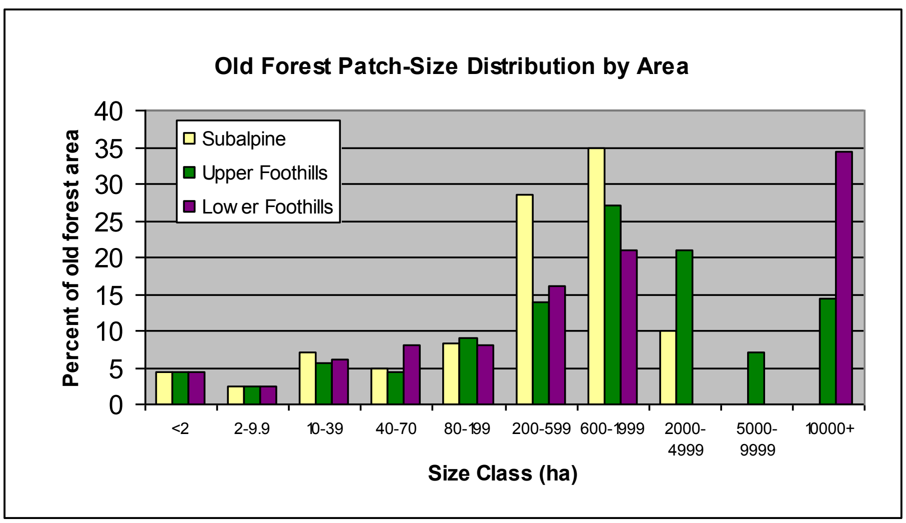


Figure 11 – *The pre-industrial (1950) distribution by area of old forest patches (by size class) for the Subalpine, Upper Foothills, and Lower Foothills Natural Subregions.*

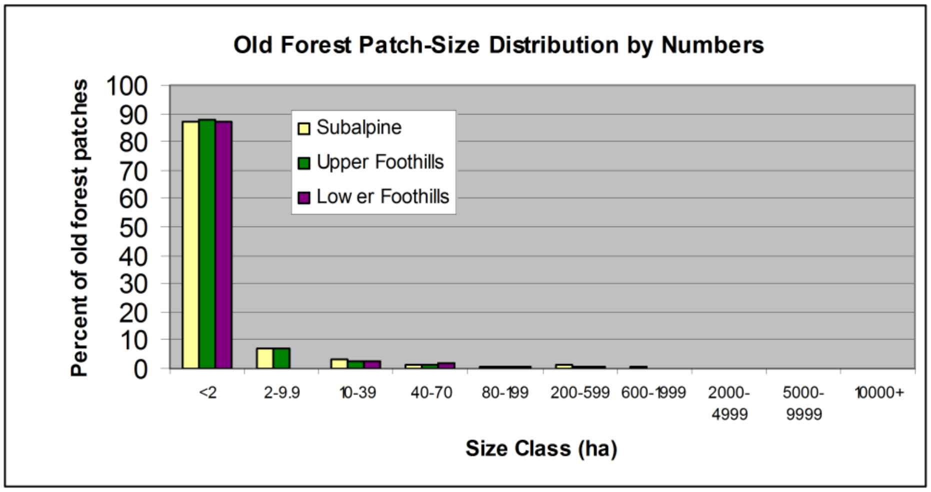


Figure 12 – *The pre-industrial (1950) distribution of the number of old patches for the Subalpine, Upper Foothills, and Lower Foothills Natural Subregions.*

- In all three Foothills East landscapes, the size-class of old forest patches has shifted downwards over 45 years of development resulting in old forests that are more fragmented than they were in 1950. Figure 13 shows how the size of old forest patches has changed since 1950 in the Upper Foothills Natural Subregion – similar changes have also taken place in the Lower Foothills and Subalpine Subregions. (Andison. March 2003)

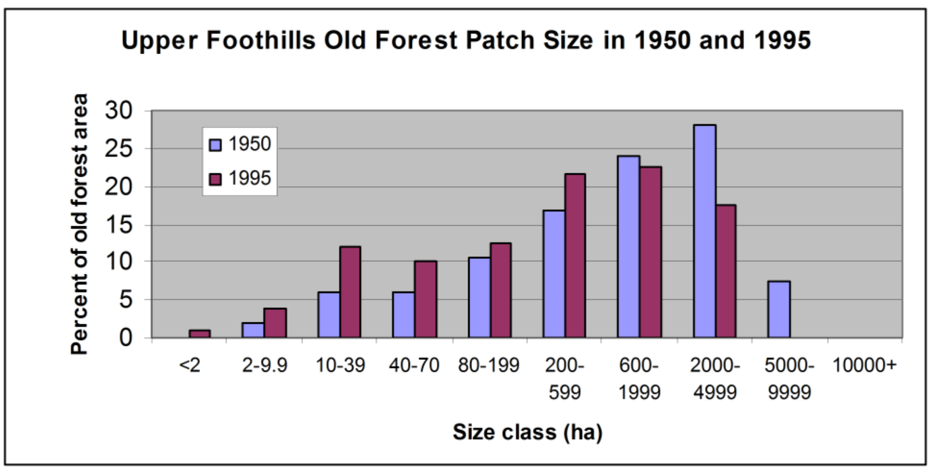


Figure 13 – *The old forest patch size distribution in 1950 (pre industrial) compared to 1995 (industry and effective fire suppression).*

- Fragmentation will be a characteristic of old forest in the Foothills area for several decades to come. Efforts should be made to mitigate fragmentation through harvest design.

2.45 Matrix and Island Remnants

Fires are complex events that leave a mosaic of patterns on the landscape. Understanding the morphology of a fire was one of the tasks undertaken by researchers at the Foothills Research Institute. One of the important areas of study was to find out what was happening within the fire event itself – this research led to new terminology and definitions for describing the smaller unburned areas within the larger fire event and fire patches. FRI produced two reports describing the unburned portions of a fire; the first was titled, "Disturbance Events on Foothills and Mountain Landscapes of Alberta" (Andison 2003)" and the second was titled, "Island Remnants on Foothills and Mountain Landscapes of Alberta" (Andison 2004).

Researchers defined two major types of unburned area within a fire - "island remnants" and "matrix remnants". Matrix remnants are the unburned corridors, bays, and peninsulas within the greater event area, but are still physically connected to the surrounding unburned forest matrix. Island residual patches are physically disconnected from the matrix, and thus completely surrounded by burned forest or connected to a disturbed patch, but partially disturbed (i.e. burned). (Andison. 2001. Quicknote #10)

Additional findings from the research into matrix and island remnants include the following:

- Corridor matrix remnants are not only more dominant than bay matrix remnants, but they tend to be the largest matrix residual patches within an event. (Andison 2003)
- Matrix residuals account for between zero and almost 50% of the total area of a fire event, and average 22%. Matrix residuals include both forested and non-forested areas. (Andison 2003)
- Single large remnant patches are uncommon in disturbance events. Undisturbed remnant patches tend to be more evenly distributed by size within events. (Andison 2003)
- An average of 10-11% of the disturbed area of fire events or patches in the Foothills is classified as island remnants, although the average is largely meaningless as a representative target. The range of island remnant area is 0- 30% of the area of the fire or event, and 0-50% of the disturbed patch. (Andison 2004)
- The proportional area in islands does not significantly increase as the event size increases.
- Variation in the percent island remnant area for disturbed patches is at least as variable within fires as it is between fires. (Andison 2004)
- Undisturbed islands only account for 16% of island area, moderately disturbed islands account for 74%, and heavily disturbed islands account for 10%. However, as events or disturbed patches become larger, the proportion of island area that is moderately disturbed declines, while the proportion of island area that is undisturbed and highly disturbed increases. (Andison 2004)
- Islands less than two hectares in size account for an average of 27% of the area in islands, and an average of 91% of the number of islands. This relationship also changes as fire / event size increases – larger fires have significantly more large islands. (Andison 2004)
- Islands have highly convoluted shapes relative to all other disturbance spatial elements. This, plus the fact that most islands are very small, means that interior area is rare in island remnants. (Andison 2004)

2.46 <u>Riparian Areas and Natural Disturbance</u>

Riparian zones are an important feature of any landscape. Often these areas contain higher levels of biodiversity, are more sensitive to disturbance, and provide corridors for animals to move through. Typical forest management practices around riparian areas have been to apply some type of “buffer” or exclusion zone around these areas, which varies in accordance to the size and type of water body (e.g. small stream, river, lake, etc.).

Although buffers have been the standard practice, clearly riparian zones are disturbed naturally on some level historically, and there is widespread understanding that fires, in the absence of fire suppression, burn through riparian zones in northern forests on a regular basis. Research at the Foothills Research Institute wanted to try to understand exactly to what degree, how, where, and why, riparian zones are influenced by natural disturbances. In other words, research was trying to determine if fire was any more or less severe, frequent, or predictable in its behaviour in riparian zones, as compared to the upland portion of the Foothills landscape.

It is important to note that in this research, riparian zones were defined as terrestrial areas adjacent to any water body such as creeks, rivers, streams or lakes and so varied depending on the circumstances. Riparian zones were not defined using administrative boundaries (i.e. fixed-width buffers) as outlined in the provincial Operating Ground Rules.

There was also research conducted regarding the age and function of large woody debris (LWD) in stream channels, to try to quantify the role of LWD into stream channels and the requirements for LWD recruitment.

There were a number of interesting and pertinent findings from the above noted research into natural disturbance within riparian zones, including the following:

- There is no evidence of a clear relationship between the age of forests and riparian zones – even when differentiated by stream order. Research shows that fire most likely burns as often through all types of riparian zones as it does through the rest of the landscape. A consistent relationship between riparian zones and forest age would suggest that riparian zones survive fire more often than other parts of the landscape; however, results from the research showed an inconsistent relationship (i.e., some riparian areas being older, while others are younger), which strongly suggests that the main reason for any observed differences in age is probably not the presence or absence of the riparian zones. (Andison D.W. and McCleary K. Feb. 2002)
- If riparian zones affect fire behaviour at a landscape level, one would expect to find that over large areas, fire edges occur more often at, or close to, riparian zones. The results from the research were variable, but overall, there is weak, but consistent evidence to suggest that fire edges tend to form at riparian areas more often than the expected (relative to the landscape average). The data also suggested that the most probable conditions for fires forming edges at riparian zones are at wider streams, and on steeper slopes. However, the issue is not resolved, and many questions remain unanswered. (Andison D.W. and McCleary K. Feb. 2002)
- There is weak evidence to suggest that island remnants differ in burned riparian areas as compared to burned upland areas. Specifically, research showed some evidence that:

  1. Island remnants occur in riparian zones in higher proportions than expected.
  2. This tendency decreases as the width of the riparian zones increases.
  3. As the amount of riparian area in a fire increases, the proportion of island remnant area in riparian zones increases.
  4. As the amount of non-forested area within a fire increases, the proportion of island remnant area in riparian zones decreases.
  5. Riparian zones of higher order (i.e. larger) streams are more likely to have islands than those of lower order streams.
  6. The proportion of high-survival islands (i.e. islands with the lowest mortality of trees) in riparian zones is higher than the proportion of low-survival islands (relative to the whole fire).

  It's important to note that the research is showing that there are certain pattern relationships that are more probable than others, but the probabilities are in most cases only slightly higher than expected elsewhere on the landscape. (Andison D.W. and McCleary K. Feb. 2002)
- Research confirmed what common sense and experience would tell us – riparian zones in the Foothills tend to have less pine and less aspen than upland. Additionally, both live and dead tree densities are lower, and in particular the density of small trees (< 30cm in diameter) is much lower in riparian zones. This supports the idea that riparian zones are unique terrestrial habitat.

  There may be a weak association between the site topography and width of a stream, and whether or not a fire crosses or stops at a riparian boundary. However, there was no relationship between fire behaviour in the riparian zone and tree species, tree density, soil moisture, site type, or even the Rosgen stream classification. The conclusion was that fire behaviour in riparian zones is probably largely driven by fire weather conditions. (Andison D.W. and McCleary K. Feb. 2002)

- There was evidence that about 15% of riparian zones have higher than expected levels of surviving veterans, which are trees that are older than the majority of the trees in the stand and have likely survived a previous disturbance that killed most other trees in the stand. This deduction is supported by analysis of variables related to the presence of veterans, which suggests that veterans tend to occur on wetter sites, in wider riparian zones or higher-order streams. It was also found that white spruce is heavily favoured as a veteran tree species in riparian island remnants. (Andison D.W. and McCleary K. Feb. 2002)

- There was higher than expected levels of fire ingress found in riparian areas and those with ingress tended to be small stream orders and steep riparian-upland transition zone slopes. This finding was significant because it suggests that fire is a mechanism by which riparian zones are "cleaned" of understory trees, and as previously, noted tree densities are lower in riparian zones as compared to upland forests. In other words, disturbance in riparian zones may be maintaining a part of the unique habitat characteristic of riparian zones. (Andison and McCleary Feb. 2002)
- In general, research findings suggest that fire behaves at least marginally differently within riparian zone habitats compared to the rest of the landscape. However, the results also suggest that predicting where or when a particular fire might stop, or leave an island within a riparian zone is not likely to be successful. Most riparian zones burn as often, and as severely as their upland counterparts, and local fire weather conditions are in all likelihood the main variable determining their fate. In other words, disturbance by fire is a common phenomenon, and therefore presumably important process for all riparian zones in the Foothills. (Andison D.W. and McCleary K. Feb. 2002)
- The universal protection of riparian zones from disturbance (through the use of buffer zones and fire protection) will inevitably lead to changes in the short and long-term structure, composition, and dynamics of both the terrestrial and aquatic systems therein. This raises a number of concerns (Andison D.W. and McCleary K. Feb. 2002):

    1. Buffer zones will lead to the decline of the proportion of young riparian forest. Presumably young riparian forest is no less important as habitat than old riparian forest.
    2. The amount of old riparian forest will continue to rise increasing the risk of natural disturbance (through fire, insects or disease).
    3. The ecological functions that fire provides to both the terrestrial and aquatic systems will not be maintained. Ingress will not be controlled, coarse-woody debris will not be sustained, and habitat opportunities will not be created (as they were historically through disturbance).
    4. Finally, by restricting disturbance activities to only the upland portion of the landscape, we may severely limit our opportunities to otherwise emulate more "natural" disturbance patterns. In fact, it is possible that on more complex landscapes, the net effect of fixed-width riparian buffers will be increased fragmentation.

- Understanding the role large woody debris in stream channels has important implications for the short-term and long-term management of riparian zones. Research suggests that to be ecologically sustainable, forest management must account for impacts on the amount and type of woody debris in riparian forests, since it will influence stream morphology, aquatic habitat, and biodiversity for the next century. (Daniels L.D. and Powell S.R.E. Oct. 2003)
- Research in the Alberta Foothills has shown that nearly 100% of all large wood debris that interacts with a stream channel originates within 10.2 metres of the channel (McCleary. 2005).
- Management decisions that alter LWD abundance and dynamics could have long term implications for the structure and function of riparian environments, in-stream habitat, and biodiversity. Because fire and post-fire stand development are important processes causing tree mortality and LWD recruitment into streams, fire exclusion in the Foothills of Alberta may significantly alter LWD dynamics. Any harvesting, that removes wood from riparian zones <u>where LWD is important</u>, could cause different effects than natural disturbances such as fire, which generates LWD.
- In general, LWD is not critically important for channel formation and function on small non-fluvial watercourses; however, as streams increase in size, LWD becomes very important in maintaining the productivity and habitat of the stream. Paradoxically, as streams pass a certain size threshold, LWD becomes less important, as the volume of water simply washes LWD away.
- Evidence from boreal forest indicates that removing LWD from certain streams by logging riparian forest can have negative impacts on biophysical processes, habitat, and the biodiversity

of streams. Creating zones that protect riparian forest and streams from direct impacts due to logging and that provide a source of LWD for streams over time is important. (Powell S.R., Daniels L. D., Jones T.A., February 2009)

2.5 Natural Disturbance Implementation History

Fire is the dominant natural disturbance throughout most forested areas in Alberta. Research into natural disturbance over the past two decades have provided a wealth of information about the role fire plays at both a landscape and stand level. Forest managers and land managers over the past decades have attempted to incorporate knowledge on both fire regimes and impact of fire on ecosystems into sustainable forest management practices. Thus emulating, or more accurately approximating, natural disturbance has become a well-accepted practice and principle of sustainable forest management in Alberta and indeed North America. There is little question about this being the right thing to do, the questions are more about what's the best way to go about it.

Currently, all three western provinces are adapting forest management practices to better approximate natural disturbance. In Alberta, the primary natural disturbance is fire, but in other provinces wind, insects, and disease also play a large role. The Planning Standard for Alberta, released in 2006, contains specific requirements to set natural disturbance targets such as seral stage, patch size and shape, old interior forest, and stand level structure retention.

The three major sustainable forest management certification systems in North America, CSA, SFI, and FSC, also all contain the requirement to address key elements associated with managing based on a natural disturbance model. This includes the requirement for old forest maintenance, stand structure retention, seral stage targets, interior forest maintenance, and other similar features associated with managing for natural disturbance.

In summary, designing a forest management strategy to approximate natural disturbance regimes within the range of their natural variability is now a well-accepted and relatively common practice utilized by forest managers throughout North America.

2.6 Major Assumptions

The premise of the natural disturbance model is that the many species inhabiting the forest, through natural selection, have developed adaptations for maintaining viability in the face of disturbances such as fire. Based on this premise, the hypothesis is that that biodiversity can be maintained while allowing industrial use of the forest, if industrial practices are made to approximate natural disturbances.

In practice, it is not the actual disturbance process that the natural disturbance model seeks to approximate, but the forest structure and pattern resulting from disturbance and subsequent forest regeneration. The operational goal is to maintain forest structure and patterns, along with ecological processes, within the natural range of variability. The assumption is that the key to maintaining biodiversity is not necessarily the strict emulation of fire (or other disturbances) but the maintenance of habitat diversity, however that may be achieved. (Alberta Centre for Boreal Studies. 2000)

Adapting the natural disturbance model is a key component of HWP's DFMP. HWP is making a number of other major assumptions that are central to our Natural Disturbance Strategy – these include the following:

- HWP can only control what it can control – we have very limited ability to control what other tenure holders (e.g. energy or mining companies) can do within our FMA. Rather than guess what other tenures holders will do, HWP has chosen the strategy of updating the DFMP every ten years (or sooner if required) to show and take into account the impact on the landbase from other tenure holders. Strategies and cut levels are adjusted at that time.
- HWP acknowledges that fire is a chemical process while harvesting is a mechanical process. There are significant differences between fire and harvesting, especially in the early years. However, as cutblocks regenerate, over time these differences become smaller and smaller. The overall goal is

to create forest patterns at the landscape and stand levels that are similar to patterns fire would create. HWP is trying to approximate natural disturbance patterns, not imitate them exactly.

- There is redundancy built into the biological system. For example, not all Coarse Woody Debris (CWD) or Large Woody Debris (LWD) created from a fire is necessary to meet biodiversity requirements. Harvesting also creates CWD (upland) and LWD (riparian) to a lesser degree either directly from logging debris or indirectly through residual trees falling down (e.g. blowdown).
- HWP understands that there is no natural analog to roads; however, we will manage the road footprint. In other words, we will set natural disturbance targets as if roads are not there and will reduce the road footprint separately.
- HWP is mainly only able to influence the active (i.e. operable) landbase; where harvesting can take place. The passive landbase (where harvesting doesn't take place) represents a significant portion of the FMA – over time strategies will have to be developed, with ESRD in the lead, to determine how disturbance can be brought back into the passive landbase. Prescribed fire is one obvious option, but other options may exist.

3.0 HWP Natural Disturbance Strategy

3.1 Overview

The overall guiding principle of the Hinton Wood Products' Natural Disturbance Strategy is to maintain natural forest patterns and ages across the landscape. That means all our decisions – protected sites, access, harvesting, and all other aspects of forest stewardship – are based on maintaining forests similar to those produced by nature. We do this by understanding and approximating the disturbances that have shaped the forest landscape over time, so that new forests develop characteristics that are similar to natural forests. This approach is designed to safeguard the important values of healthy forests (Andison et al. 2009), including biodiversity conservation.

Approximating the variability of natural forest patterns is critical, but this strategy must be balanced with societal values, changing expectations, and scientific knowledge. We seek to strike a balance that is scientifically sound, affordable, and acceptable to society.

Figure 14 on the following page provides an illustration of exactly how HWP will be using natural disturbance research in the development of the 2014 DFMP. Conceptually, HWP wants to determine the natural landscape condition and pattern before harvesting or effective fire control took place (generally accepted as pre-1950) and then implement harvest plans that will, over time, maintain or move toward a future forest condition that is similar to the natural forest condition (i.e. pre-industrial).

This pre-industrial landscape condition is determined by using actual data collected about the landscape (i.e. through research at FRI into historic burn information) and then developing a model that provides numerous different scenarios for how the landscape pattern might have looked due to forest fires. This model is called LANDMINE and is described in more detail in section 3.21. The purpose of LANDMINE is to provide the Natural Range of Variation (NRV) for each forest seral stage (e.g. young, old, et.) by major vegetation class (e.g. pine, spruce, mixed wood, etc.). The model will provide this NVR information for upland sites, riparian areas, and wetland sites separately.

In addition to determining the NRV by seral stage, HWP also needs to know about the specific characteristics of fires in order to best emulate the patterns they create on the land. Determining fire event distribution and characteristics was also a major focus of research for FRI's Natural Disturbance Program. Another model, called NEPTURE was developed – more detailed information about this model is described in section 3.22. The NEPTUNE model allows HWP to compare past, present, and future disturbance designs (i.e. harvesting) to historical natural disturbance pattern on the landscape.

HWP then will create a current (e.g. 2012) snapshot of the forest landscape condition – by looking at this information, HWP will be able to determine how the landscape needs to change over time to maintain, or move it toward, a natural forest condition. In order to do this, targets will be set as part of the VOIT (Value, Objective, Indicator, and Target) process – targets will be set for landscape conditions such as seral stage NRV, patch size, and stand structure retention.

These targets then inform another model called Woodstock – more detailed information about this model is described in section 3.23. Based on the directions HWP provides to Woodstock, this model will tell us what area, age, and vegetation type (e.g. spruce, pine, mixed-wood, etc.) HWP needs to harvest to meet the targets. The outputs from Woodstock are then provided to another model called Stanley (see section 3.24 for more detail about this model), which then goes about finding where on the ground HWP can harvest in order to meet outputs from Woodstock. In other words, Stanley implements spatially the outputs from Woodstock. This spatial output from Stanley results in a Spatial Harvest Sequence (SHS), which shows on the ground where HWP is proposing to harvest over the next 20 years.

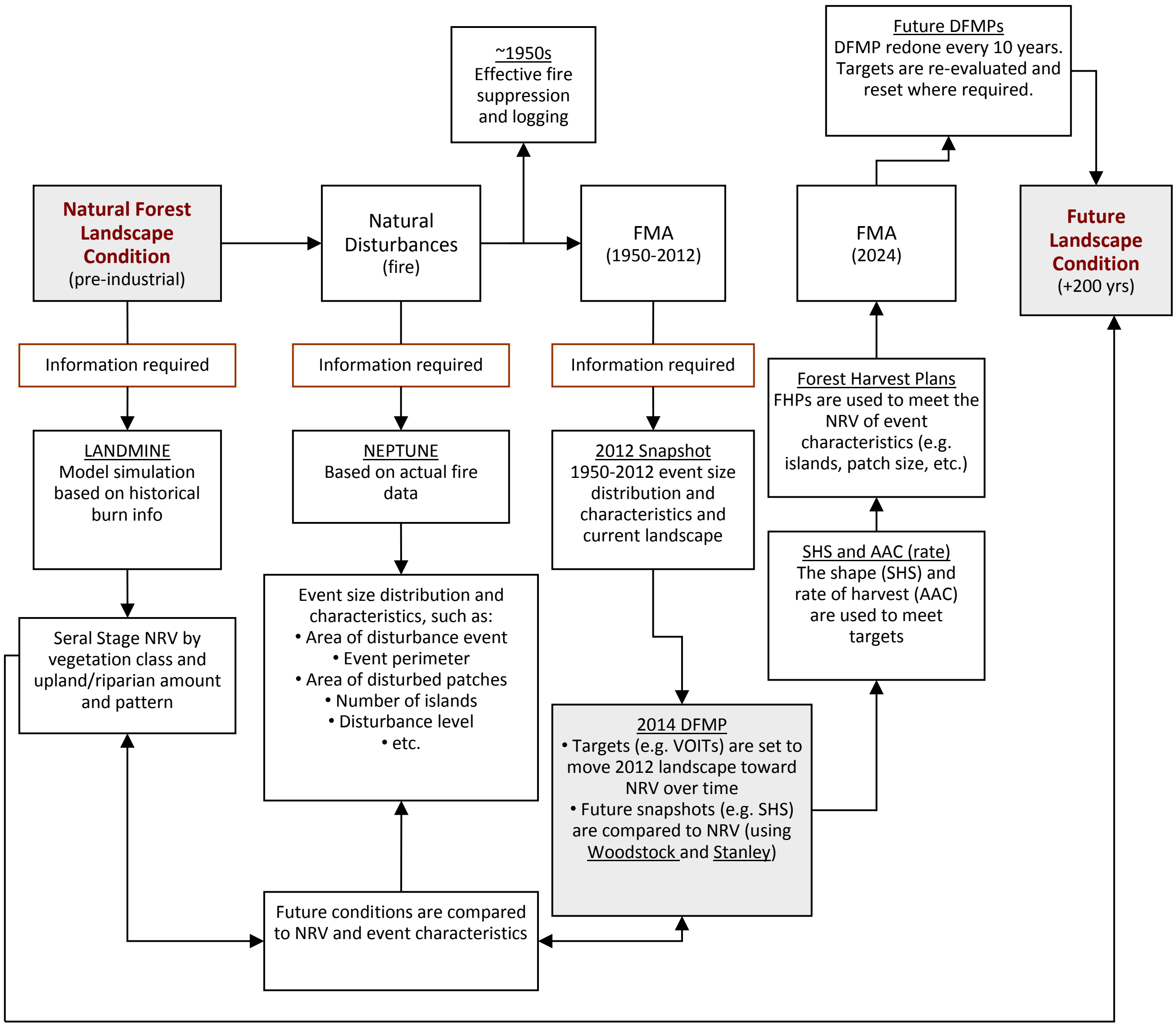


Figure 14 – *This flow-chart diagram illustrates HWP's overall goal in the development of a DFMP using natural disturbance research and modelling. HWP wants to, over time, move the forest landscape from its current landscape pattern into a pattern more representative of how it would have looked before effective fire-suppression and industrial forestry took place (i.e. pre-1950).*

The spatial outputs from Stanley can then be compared to the natural forest landscape condition (i.e. NRV) produced by the LANDMINE model and also compared to the fire event size distribution and characteristics produced from the NEPTUNE model. At this point, numerous outputs from Stanley can be run and compared – the one that best meets the set targets and constraints is chosen. The first 20 years of this output becomes the SHS used in the DFMP.

For some NEPTURE outputs, such as the number of islands and the area of islands, the spatial resolution of the SHS is too coarse – these variables are addressed at the Forest Harvest Plan (FHP) stage. As part of the FHP process, NEPTUNE can be used again to see how closely the layout mimics fire event characteristics. Changes to layout, based on outputs from the SHS and NEPTUNE, such as adding or subtracting islands or patches, can be made, further refining the process.

DFMPs and the accompanying 20 year SHS are redone every 10 years. At this time, targets are re-evaluated and refined where required, as is the SHS. The overall goal is to move toward (or maintain) the forest landscape in a natural forest landscape condition.

3.2 Models Used

The following sections describe the four models that will be used to inform each component of the DFMP (as they related to the HWP's Natural Disturbance Strategy):

3.21 LANDMINE

The natural range of variation (or NRV) of natural landscapes is an important input for forest management planning. Understanding how old forest or habitat levels (for example) varied over decades and hundreds of thousands, or even millions of hectares prior to significant human influence can help identify risks to species and other values, and provide a benchmark for sustainable landscape conditions. In a perfect world, this requires the ability to "see" landscapes dating back several hundreds, or even thousands, of years. Unfortunately, historical spatial data prior to 1950-60 in the boreal does not exist, and since then, fire control has biased landscape patterns. Even if we could recreate a "natural" landscape image, it would not necessarily represent historic conditions. What we know about historical landscape patterns suggests they varied tremendously. For example, estimates of the area burned during the 1919 fire season in Alberta range from 5-15 million hectares.

Alternatively, historical NRV conditions can be created through simulation modelling. The concept is simple; use knowledge of historical fire regimes (which is available) and spatial data to create multiple historical landscapes. Note that we are not trying to re-create *actual* historical landscapes, but rather 1-200 different possibilities. Also note that one of the benefits about this type of modelling is that if any of the fire regime inputs are in doubt, one can try running the model with different assumptions. Each set of new assumptions equals a "scenario".

The LANDMINE model was designed specifically for this purpose in mind. LANDMINE is a spatially explicit, pixel-based, empirical Monte-Carlo landscape simulation model that was developed for landscapes dominated by stand-replacing disturbance events. In order to be run, LANDMINE requires certain data and information about the landscape on which the model is being run. Required information into the LANDMINE model includes the following:

1. Spatial Data: The LANDMINE model's resolution is a 4 hectare pixel. HWP must supply the model with spatial data with UTM X and Y coordinates for the centre of each 4 hectare pixel. For each pixel, all cultural features such as roads, harvest blocks, well-sites, and towns must be removed. LANDMINE generates NRV, which by definition includes no culturally modified disturbances. This single landscape is not part of the NRV data, but rather is used to initiate the model.
2. Age Strata: HWP must provide the age strata we would like to use, remembering that seral stages are used as proxies for the changing roles of biological diversity vales provided by forests as they change over time. See section 3.311 Table 5.
3. Vegetation Strata: HWP must provide required vegetation strata for the LANDMINE model. These strata are generally 5-10 different forest cover types, such as pine, spruce, mixed wood, etc. The Company is responsible for coding each pixel to the vegetative strata requirements. See section 3.312 Table 8.

4. Scale of Reporting: The Company must determine the scale that it wants the LANDMINE model to report on. Typically there is more than one scale that is reported on. Common reporting scales include the FMA scale and the Natural Subregion scale. See section 3.313.
5. Patch Sizes: LANDMINE can capture 64 size classes of old forest patch sizes. HWP must determine if there are any size class breaks that are of particular interest from a fine-filter or value-based perspective. Old large (e.g. >5,000 ha.) patches are a common requirement. See section 3.32.
6. Succession Assumptions: LANDMINE has a succession module that uses a matrix of transition probabilities – the details that are defined by client. For example, old hardwood turns to spruce after a certain number of years. Typically, over hundreds of years and 1,000,000 hectares, the differences between having the succession model turned on or turned off are not significant enough to warrant the complexities involved. Therefore, HWP has turned off the LANDMINE succession model for use in this DFMP; however, there will be some level of checking to see what the magnitude of the effect is. For example, how many stands got old enough (200-400+ years) where having succession on might have made a difference?
7. Maximum Age: As pixels continue to age in the LANDMINE model, they can reach a "maximum" before being sent back to zero years in the absence of fire. The Company must define this maximum age. For this DFMP, HWP will use 400 years of age as the maximum age a pixel can reach; if any pixel gets to that age it should be reset to zero. LANDMINE will track how often stands are reset to zero.
8. Historical fire regime assumptions: Historical fire regime assumptions drive the LANDMINE model. The better the assumptions, the more realistic the NRV. The historical fire regime assumptions are based on data collected in the Foothills. Three separate historical fire regime curves for the three largest Natural Subregions (Lower Foothills, Upper Foothills, and Subalpine) on the FMA will be used in the LANDMINE model. A sensitivity analysis will also be carried out to see how changes to the historical regime affect the analyses and determination of NRV.

The LANDMINE model runs (in this case) in 10-year time steps and involves the following steps:

1. Picks an area to burn: The amount of area burned on a given landscape varies widely from one decade to the next. Decadal fire area estimates are converted into an equation (or graph), and then a random number generator is used to pick an amount of area to burn for each new model run. Typically, in the boreal, the model burns anywhere from zero to >50% of a 1 million ha landscape in any 10-year period.

   a. Starts a fire: Sometimes, not all parts of a landscape have the same probability of burning. For example, the Lower Foothills experiences far greater fire activity historically than the Subalpine. This is controlled in the model by changing the ignition probability from one area to another (based on lightning strikes).

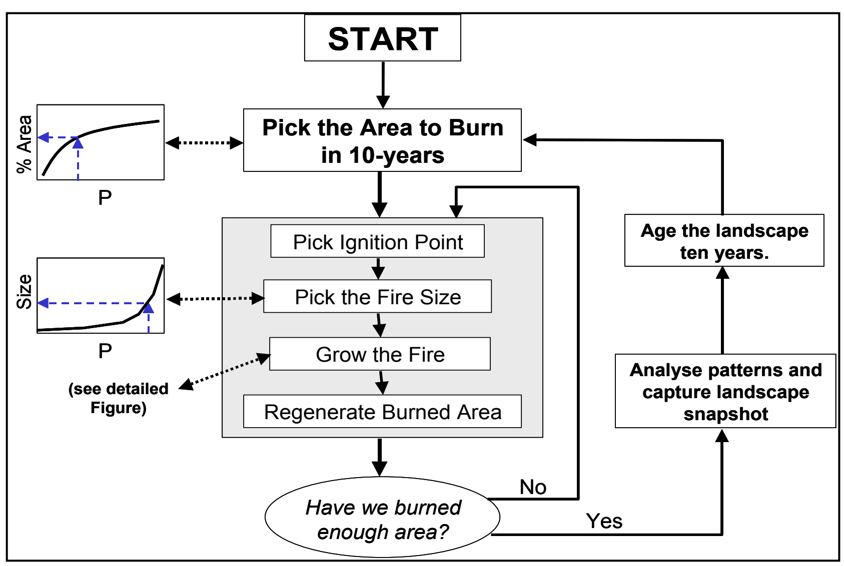


Figure 15 – *The basic outline of how the LANDMINE model works.*

b. Picks a fire size: Fire size distributions are fairly well documented for the boreal, and easy to generate for a local landscape (fire sizes differ between the Lower Foothills and Subalpine for example). As above, these data are converted into an equation(s), which allow each individual fire size to be picked from a graph. A single time step may have only one fire, or several thousand of them. The classic historical pattern of many very small fires and the rare very large ones becomes evident as one watches fires burn on a computer screen.

c. Grows the fire: LANDMINE uses a "walking" dispersal algorithm to spread fire from one pixel to another in such a way that fire movement responds probabilistically to various input layers such as fuel-type and topography (see Figure 16 below). Fire movement thus favours uphill movement, older forest, conifer over hardwoods, and upland over wetland. Controlling layers can be added on available data and modelling objectives. Fire movement can be calibrated to create different fire shapes, residual arrangements, and even spot fires, to match empirical data as available.

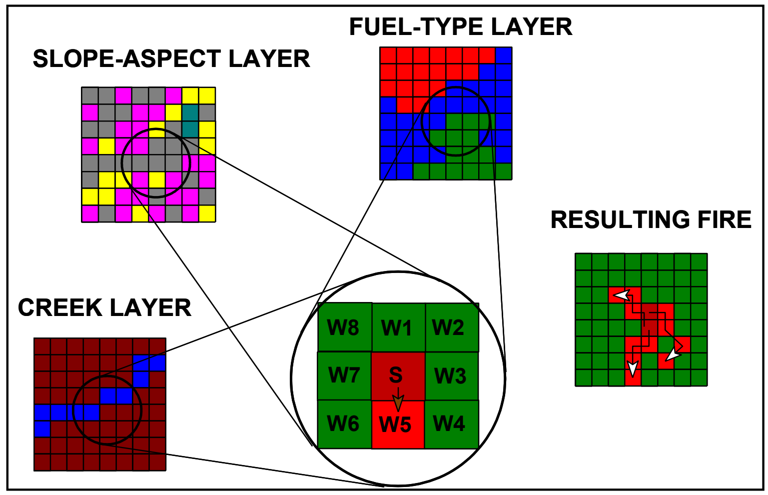


Figure 16 – *Walking dispersal algorithm; the fire responds probabilistically to various input layers such as fuel-type and slope-aspect.*

d. Regenerates the burned area: When the fire reaches the required size, it stops spreading, and regenerates to young forest according to the regeneration rules defined by the Company.

e. Is the run done? The model tests to see if the required area has burned from step (1), and if not, it goes back to step (a) above.

2. Take a "picture" of the landscape: The landscape at the end of each 10-year run is the landscape data we are after, so we measure and record key patterns (e.g. the amount of old pine forest), and even capture an image of the landscape as a visual record.

3. Age the landscape: The last step is to age the entire landscape 10 years in anticipation of the next model run. Local forest succession rules as defined by the Company (see section 3.21) are coded and adopted. Then the model returns to step #1 and makes another run.

Each of the steps listed above are *stochastic*, meaning that LANDMINE never burns the fire, or even creates the same landscape, twice. That makes it a powerful *landscape disturbance model* (i.e., it is good for exploring and capturing long-term burn pattern trends), but not necessarily a good *fire behaviour model* (i.e., it is not very good, nor was it meant to be, at predicting the local movements of individual fires).

A typical modelling scenario (recall that a "scenario" is one set of input assumptions) involves 1-2,000 runs (10 to 2000 years). A significant portion of modelling time is required for data verification, and model calibration and validation. The final 100 runs in the set are used to create NRV. Running for a sufficient period of time is needed to erase the effect of the starting landscape.
The Company defines the pattern metrics of interest during the modelling objective phase. This list might include the percent of old pine-dominated forest, the landscape area in acceptable caribou habitat, the proportion of all wetlands that have been disturbed in the last 20 years, or the relative frequency of old forest patches greater than 1,000 hectares. Each metric is summarized, often as a

frequency distribution, but the raw data is also available. Frequency distributions are nice because they allow one to visually compare estimated NRV to past or current landscape conditions.

3.22 NEPTUNE

The New Emulation Planning Tool for Understanding Natural Events (NEPTUNE) was developed as a way of assessing cultural disturbances (both existing and planned), such as harvesting, and comparing these disturbances to historical disturbances for a given landscape. The objective of the tool is to provide an automated way to analyze various disturbance (i.e. harvesting) scenarios and compare the results against historical disturbance events.

In order to use NEPTUNE, an analysis of the historical disturbances for the landscape of interest must first be performed – the Foothills forest in the Hinton area is one of the few landscapes in which a detailed analysis of the historical disturbances has taken place. Because this has been completed, any number of disturbance scenarios can be run against the same historical landscape analysis.

The first prototype of NEPTUNE was created in 2005. ESRD became a partner in this project (through the Foothills Research Institute) in 2006.

FRI research focused on the concept of “disturbance event” and “disturbance patches” as being the most recognizable aspect of natural disturbance to humans. NEPTUNE was built to be able to generate these same types of special features (i.e. events and patches) for anthropogenic disturbances.

As previously discussed in section 2.23, a disturbance event is a grouping of disturbances that happened close enough together in both time and space to be considered a single occurrence. For example, five cutblocks all harvested within 400 metres of one another and logged within a five year period could be treated as a single “disturbance” on the landscape. However, in order to compare such anthropogenic disturbances to historical disturbances caused by fire, these disturbance events need to not only encompass the disturbances themselves but also the undisturbed areas between them. Because the boundary for a forest fire will include both burned and unburned areas, the boundary drawn for a human-caused disturbance event, such as logging, must also contain both the disturbed and the undisturbed areas between them. Each event shape generated by NEPTUNE is given a unique event number.

Within each forest fire event or anthropogenic disturbance event, the individual, contiguous disturbance polygons are called “disturbed patches” (see section 2.23). Each disturbed patch may include areas which are completely disturbed, partially disturbed or entirely undisturbed. Disturbed patches are the building blocks of disturbance events. Each disturbance patch is also given a unique number by the model.

Within each disturbed patch, there can be various levels of disturbance from total to none. Within NEPTUNE disturbance levels are categorized as either “fully disturbed”, “partial island”, or “intact island”. Undisturbed areas between patches are considered to be “matrix remnants”. Matrix remnants are not found within a disturbed patch and are always connected spatially at some point to the surrounding the event boundary.

The NEPTUNE model includes two distinct types of processing. First, the spatial disturbance boundaries must be analyzed to generate the appropriate “disturbance events” and ‘disturbed patches’. This is a fairly complex analysis and requires the use of advanced GIS functionality.

Second, once the spatial analysis is complete, the output attribute data (i.e. the attributes of the “disturbance events” and “disturbed patches” such as area, perimeter, or number of islands) must be analyzed to produce the required output. This analysis includes the results of the NEPTUNE disturbance model data itself and a comparison to the historical data.

From the output attribute data, a number of different graphs are created by NEPTUNE which assess the size of various types of features and the relationships between them. Graphs can be generated both for the disturbance scenario itself and as a comparison between disturbance scenario and the historical attribute values of the landscape.

In summary, NEPTUNE is an ArcGIS Tool that automates the conversion of shape-files of disturbances into the new spatial language, and compares patterns to NRV for:

- Event size – The area of the disturbance events in hectares
- Estimated disturbance event size distribution
- Event shape index
- The percent of the area of event in matrix remnant
- The number of disturbed patches relative to event area
- The size of largest disturbed patch as a percent of net disturbed area
- The disturbed patch shape
- Percent area of disturbed patches in island remnants by patch
- The percent of event area in island remnant
- Sizes of island remnants by numbers
- The percent area of event as residuals remnants (matrix plus island)

The only output format is frequency distributions graphs. The model is currently calibrated for west central Alberta and western Saskatchewan.

3.23 Woodstock and Stanley

The bulk of the timber supply analysis work will be completed through an optimization software platform called *Remsoft Spatial Planning System (version 2012.12)*. The two most heavily used components within the platform will be *Woodstock* and *Stanley*. *Woodstock* is an optimization model development system in which all inputs and actions are specifically defined by the user. This flexibility is one of the key reasons HWP has used the *Remsoft Spatial Planning System* (RSPS) for previous timber supply analyses. When coupled with a Linear Program (LP) solver, *Woodstock* is a powerful tool that can identify optimal management strategies while simultaneously maintaining several other management goals within pre-defined target ranges.

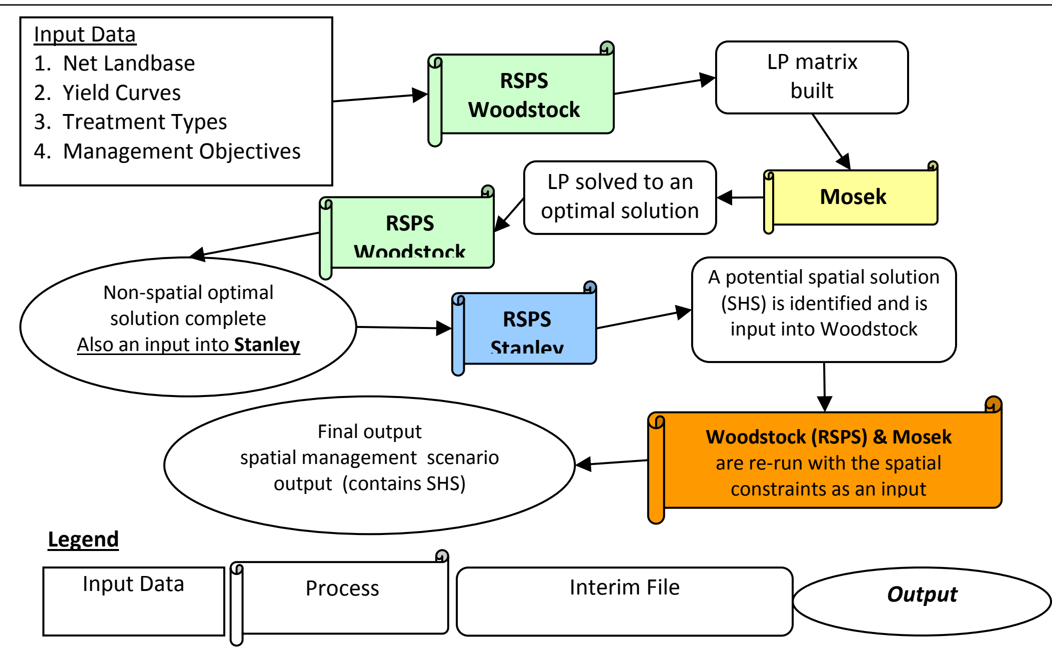


Figure 17 – *Summary of Timber Supply Analysis Process*

Woodstock uses the input data to build an LP matrix to output to a software package called *Mosek 6.0* which solves large-scale mathematical optimization problems (Figure 17). After *Mosek* is run, the optimized outputs are then input back into *Woodstock* for the final calculation and display of the non-spatial results. Although *Woodstock* and *Mosek* complete a large portion of the timber supply analysis process, they cannot evaluate the impact of spatial dynamics (issues such as isolated stands and minimum block sizes). Therefore, *Stanley* will be used to ensure that the desired adjacency and proximity relationships are maintained to produce a spatially explicit solution. Stanley outputs the Spatial Harvest Sequence (SHS) and *Woodstock* and *Mosek* are then used again to recalculate the final spatial management scenario with the SHS used as an input. In Alberta, the RSPS platform has a well-established track record as it has been an accepted tool for forest management plans since the 1990s. Over half of all the currently approved forest management plans in Alberta used the RSPS for at least a portion of the timber supply analysis. HWP's 2010 Mountain Pine Beetle amendment used this very same process and was approved. More detailed information on *Remsoft* and *Mosek* is available online at: http://www.remsoft.com and http://www.mosek.com.

3.3 Natural Disturbance Targets/Strategies

The following is a discussion on the targets and associated strategies HWP has proposed to implement in order to incorporate our overall Natural Disturbance Strategy (described in this document) into our 2014 DFMP.

3.31 Seral Stage

Forests constantly change in response to disturbances, which vary by type and size. Disturbance types include non-biological processes such as forest fires, winds, and floods, and biological processes such as reproduction, growth, death, and decay. Disturbance sizes range from very small events that affect individuals to very large events that may kill most of the trees and other species in very large areas. Then the process of succession starts – trees and other species become established and compete for resources until another disturbance occurs.

Broad trends in landform and climate govern the types of forests that can occur in a region. Alberta forest types are categorized into areas called Natural Regions. Within these, disturbance regimes and species response shape forests into patterns that tend to repeat themselves over time. The most noticeable pattern is the mosaic of forest ecosystems that vary in size, age (time since disturbance), and the species community that lives in each ecosystem.

Representation of a full range of seral stages is part of a "coarse-filter" biodiversity conservation strategy. Species can usually be classified as either habitat specialists (associated with specific seral stages or structural features) or habitat generalists (associated with a broad range of seral stages or structural features). The community associated with each seral stage changes through time in response to succession processes and reflects the adaptations of both generalist and specialist species. Therefore, the area of each seral stage is an important indicator of availability of the habitat that individual species are associated with. The assumption is that seral stage representation within the NRV is likely to conserve biodiversity and ecological resilience. Seral stage representation is also important for conservation of other forest values. For example, the old seral stage is often associated with high recreation and scenic values.

3.311 Defining the Seral Stages

Section 2.28 provides the ecological definitions for each of the five seral stages HWP will be monitoring, measuring, and managing; they are – young, pole, early mature, late mature, and old. While these definitions are relatively straight forward (there is some general agreement in the science community about what attributes make up old forest), defining each seral stage remotely (i.e. through forest inventories such as AVI) is more difficult. The most common method is to identify the seral stage by examining the stand's age.

The most problematic seral stages to define are the mature and old seral stages, but particularly the old. The mature seral stages are characterised by the reduction in height and diameter growth, until the time when the mortality rates of mature trees begin to increase significantly, creating canopy gaps. The old seral stage is characterized by canopy gaps, dead trees (standing and fallen), and the presence of additional tree age cohorts resulting from canopy gap dynamics. The US Forest Service has defined old forest as the later stage in forest development which may be distinctive in composition but are also distinctive in structure from earlier (e.g. young and mature) successional stages (Moir 1992). An extensive literature review by Hunter and White (1997) concluded that there is no evidence of the existence of distinct thresholds between mature and old forest. Forest succession and development is a continuum of changes in structures and composition where no specific age can provide an unambiguous threshold on which to base a definition (Hunter and White 1997).

Having said that, in order to manage for different seral stages, forest managers need some way to define each seral stage without having to visit each separate stand. Research in the Alberta Foothills has shown that stand age plays the greatest role in the prediction of old forest attributes in pine stands (Morgantini and Kansas 2003). As part of their research, Morgantini and Kansas measured 27 different attributes (e.g. snag basal area, live trees height, downed wood debris volume, and regeneration density) and then looked for those attributes that best predicted old forest characteristics. Age played the greatest role. Of the 26 other attributes examined, only elevation and the percent composition of pine appeared to have any appreciable effect on old forest, in that high elevations tended to support lower old forest attributes and the breakup of the original pine cohort contributed greatly to down wood material and snags (both old forest attributes). Morgantini and Kansas concluded that the onset of old growth attributes in pine stands, although variable, tends to occur between 160 and 180 years of age.

Using the 160-180 year age range as a guide to where old forest begins, HWP has developed a matrix that defines seral stages based on a combination of stand age, average mean annual increment (MAI), and volume per hectare – all of this data was derived from HWP's extensive network of Permanent Sample Plots (PSP).

In addition to this information, HWP also reviewed other Alberta forest companies with approved DFMP's based on the current Planning Standard. Their definitions of seral stage varied quite widely, but there were some common threads, including: using peak MAI as a proxy for defining mature and old stand types and using volume/ha data as a means of defining old stands (i.e. when vol/ha starts to drop, the stand is becoming old) and young stands (e.g. 20 -80 yrs).

HWP is also making the assertion that stands that are logged, reforested, and tended will reach maturity at a younger age and may also start exhibiting characteristics of the different seral stages at a younger age than fire-origin stands. This assertion is backed up by the GPYPSY model (based on input from HWP's PSP data) – which shows higher volumes per hectares at lower ages for harvest-origin stands on the FMA. Separating seral stage age breaks based on stand origin accounts for accelerated stand development in harvest-origin stands.

Using all this information, HWP has developed five seral stages, which are based on the criteria outlined below in Table 5. These criteria are proxies for determining at what age different stands will start exhibiting different seral stage characteristics.

Table 5 – *Seral Stage Definitions*

Seral Stage definition	General Description of Seral Stage	
	Fire-origin	**Harvest-origin***
Young	Starts with a major disturbance and continues until regenerated trees have dominated the site and crown closure occurs. This usually occurs around 20-30 years of age post disturbance.	Starts with harvest and continues until regenerated trees have dominated the site and crown closure occurs. This usually occurs around 20-30 years of age post disturbance.
Pole	Young crown closure to when stand volume is equal to 100 m3/ha	Young crown closure to when stand volume is equal to 100 m3/ha
Early Mature	Volume/ha > 100m3/ha	Volume/ha > 100m3/ha

Seral Stage definition	General Description of Seral Stage	
	Fire-origin	Harvest-origin*
Late Mature	10 years post peak Mean Annual Increment (MAI)	10 years post peak Mean Annual Increment (MAI)
Old	10 years post peak highest vol/ha	Old fire-origin equals old harvest-origin

*If harvest-origin age is slightly older than fire-origin – default to fire-origin age.

3.312 Defining Seral Stage Thresholds

Using the definitions described in Table 5, HWP then determined the age range thresholds of each of the above noted seral stages, using information derived from the yield curves found in the 2010 Beetle Plan (technically an amendment to HWP's 1999 FMP). Empirical yield curves (i.e. those derived from HWP's PSP's) for fire-origin stands were used to determine the age at peak MAI, peak volume/hectare and age at 100 m3/ha. The harvest-origin peak MAI, peak volume/hectare and age at 100m3/ha stand age were obtained using the GYPSY derived yield curves.

In order to test the assumption that harvest-origin stands become mature faster and exhibit old forest characteristics sooner, the volume/hectare of both the fire-origin and harvest-origin stands were compared at the late mature and old forest stages. In each case, harvest origin stands contained a higher volume/hectare at a younger age than the fire-origin stands, which can be interpreted to mean stand attributes are at least as well developed in harvest-origin stands as fire-origin stands at similar ages. Because there was no data suggesting otherwise, HWP took a cautious approach and assumed that harvest-origin stands would produce old growth characteristics no earlier than fire-origin stands.

Table 6 on page 31 shows the fire-origin yield curves used and how the seral stage ages were derived for early mature, late mature, and old. Table 7 on the same page shows the harvest-origin yield curves used and how the seral stage ages were derived for early mature, late mature, and old.

Table 8 below summarizes the ages being used for each of the five seral stages based on whether or not the stand was fire-origin or harvest-origin. The cover type (i.e. vegetation strata or forest type) is also further defined.

Table 8 – *Cover Type Descriptions and Seral Stage Age Thresholds*

Cover Type	Description	Coniferous Composition	Stand Origin	Seral Stage				
				Young	Pole	Early Mature	Late Mature	Old
Pine Leading	Pl, Pl-Sb, Pl-Fb, Pl-Sw	80% or greater	Fire-origin	0-20	21-69	70-119	120-159	160+
			Harvest-origin	0-20	21-49	50-99	100-159	160+
Spruce Leading	Sw, Sw-Pl, Sw-Fb, Se, Se-Sb, Fb	80% or greater	Fire-origin	0-20	21-49	50-99	100-159	160+
			Harvest-origin	0-20	21-49	50-99	100-159	160+
Wetland Spruce	Sb, Lt, Sb-Lt, Sb-Se	80% or greater	Fire-origin	0-30	31-89	90-109	100-189	190+
			Harvest-origin	0-30	31-89	90-109	100-189	190+
Mixed Wood	Aw-Sw, Aw-Pl, Sw-Aw, Pl-Aw	<80% and >20%	Fire-origin	0-20	21-59	60-109	110-149	150+
			Harvest-origin	0-20	21-49	50-99	100-149	150+
Deciduous	At, At-Pb, Pb-At, Pb	20% or less	Fire-origin	0-20	21-59	60-109	110-149	150+
			Harvest-origin	0-20	21-59	60-109	110-149	150+
Vegetated non-forested	n/a	Meadows, etc.	n/a	n/a	n/a	n/a	n/a	n/a
Non-vegetated, non-forest	n/a	Lakes, rock, etc.	n/a	n/a	n/a	n/a	n/a	n/a

3.313 Defining disturbance unit size and NRV

Under natural disturbance regimes, forest composition by cover type and seral stage fluctuates within a natural range of variation (NRV). Forest type and seral stage composition within a landscape of a specified size vary between lower and upper limits defined by types and rates of natural disturbances. In general, the smaller the unit size, the larger the natural range of variability.

For the 2014 DFMP analysis, the NRV within the FMA will be defined for the following disturbance unit sizes:

1. Gross FMA – All area within the outside perimeter of the FMA boundary, not including non-FMA land (e.g. Obed Mine, Switzer Park, Town of Hinton, etc.).
2. Contributing landbase – All areas within the outside FMA perimeter that actively contribute to the Annual Allowable Cut (i.e. operable land with no deletions)
3. Passive landbase – All areas within the outside perimeter of the FMA that are not available for harvest due to numerous factors such as steep slopes, wet soils, other tenures, etc.
4. Riparian, Wetland, and Upland – In 2013, a project was completed that digitally mapped all the riparian areas on the Hinton FMA (Green-Link - Kristoff and Paranich 2013) based on ecological and morphological characteristics of the riparian areas. Details of the methodology used in this digitizing project can be found in Appendix B of Appendix 2. This digitizing project resulted in a number of different types of riparian area (see Figure 18) within the FMA for which NRV will be calculated:

    A. *Riparian* – A riparian area associated with either a fluvial or seepage-fed water channel as defined by the Erosion Based Channel Classification (McCleary 2013), found in Appendix A of Appendix 2. In addition, a third category of riparian area called "complex" was also classified by Green-Link (Kristoff and Paranich 2013) – this was riparian that was too complex to classify as being associated with either seepage-fed, fluvial or wetland. This "complex" classification represents a very low percentage of all the riparian area classified and a NRV analysis will not be carried out for this category.
    B. *Wetland* – HWP possesses an FMA-wide ecosite inventory call the Ecosite Land Classification (ELC) (Downing, 2004). To assist with the Green-Link riparian delineation project, wet sites were provided as a guide to the interpreters of the riparian project. Any isolated wet sites which were not associated with a riparian area were given a wetland call.
    C. *Upland* - Neither riparian nor wetland.

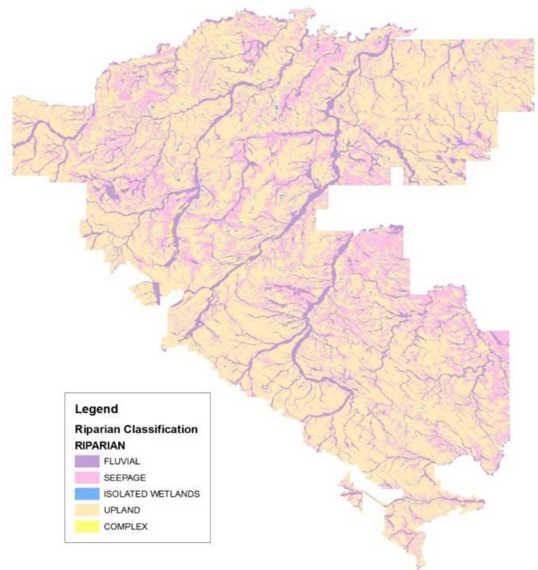


Figure 18 *– Riparian classification on the FMA*

NRV will be determined for the upland, riparian, and wetland separately using the stochastic landscape disturbance model "LANDMINE" (see section 3.21).

3.314 Strategies, Targets and Forecasts

HWP's main target will be to keep the total gross and net FMA area of each of the five seral stages within their NRV for the upland, riparian, and wetland over the 200 year planning horizon at the scale of the FMA (as outlined in Table 9). This will be accomplished through the implementation of the Spatial Harvest Sequence. Where this cannot be accomplished, HPW will explain why, and where appropriate, outline a strategy to move a seral stage back into NRV over time. This will be a DFMP target, which will be met through the implementation of the Spatial Harvest Sequence.

Table 9 *– Natural Range of Variability (NRV) Data to be collected by Cover Type and Seral Stage*

Cover Type	Seral Stage	NRV - Upland				NRV - Riparian				NRV - Wetland				Status* Current Year (2012)					
		Low Range		High Range		Low Range		High Range		Low Range		High Range		Upland		Riparian		Wetland	
		ha.	%	ha.	%	ha.	%	ha.	%	ha.	%	ha.	%	ha.	%	ha.	%	ha.	%
For each of the 5 cover types (e.g. pine, spruce, etc.)	Young																		
	Pole																		
	Early Mature																		
	Late Mature																		
	Old																		
	Total																		

Table 6 – *Summary of calculations used to derive seral stage ages for fire-origin stands*

Yield Strata	Yield Strata Definition	Summarized Definition	Harvest Origin (hectares)	peak MAI		E. Mature	L. Mature age	Peak Vol/ha	Age at Peak Vol	Old
				peak MAI	year	Yr. Volume >100m3/ha	10 post Peak MAI year			10 yrs past Peak Vol/ha
E-B8-GH	Pl leading, good site, high density	Pine leading	79,758	2.405	120	60	130			n/a*
E-B8-GL	Pl leading, good site, low density		17,672	1.992	90	60	100	231.5	150	160
E-B8-MH	Pl leading, med & poor sites, high density		121,277	1.700	110	70	120			n/a*
E-B8-ML	Pl leading, med & poor sites, low density		25,396	1.303	80	80	90	146.3	150	160
			244,103	Weighted avg.:	109	**67**	**119**			**160**
E-B7-GH	Sw leading, good site, high density	White spruce (Sw) leading	5,713	2.277	90	50	100	259.0	150	160
E-B7-GL	Sw leading, good site, low density		10,099	1.872	80	60	90	208.2	140	150
E-B7-MX	Sw leading, med & poor sites		28,336	2.104	90	50	100	240.0	150	160
		Total:	44,148	Weighted avg.:	88	**52**	**98**	235	148	**158**
E-B9-XX	Black spruce - all sites, all densities	Wet	4,777	1.135	100	**90**	**110**	158.6	180	**190**
E-B2-XX	Deciduous/pine, all sites, all densities	Mixed Wood	11,880	2.229	110	60	120	273.4	140	150
E-B3-XX	Deciduous/other conifer, all sites, all densities		9,983	2.904	70	45	80	268.1	110	120
E-B4-XX	Sw/deciduous & Sb/deciduous, all sites & densities		5,141	3.141	120	60	130	406.5	140	150
E-B5-XX	pine/deciduous, all sites, all densities		14,170	2.423	110	60	120	409.8	150	160
			41,174	Weighted avg.:	102	**56**	**112**	336	136	**146**
E-B1-XH	Pure Deciduous, high density	Pure deciduous	30,931	2.243	100	60	110	262.3	140	150
E-B1-XL	Pure Deciduous, low density		9,174	1.542	110	80	120	207	150	160
			40,105	Weighted avg.:	102	**64**	**112**	249.7	142.3	**152**

*There was no drop off on the volume/ha on this yield curve

Table 7 – *Summary of calculations used to derive seral stage ages for harvest-origin stands*

Yield Strata	Yield Strata Definition	Summarized Definition	Harvest Origin (hectares)	peak MAI		E. Mature	L. Mature age	Peak Vol/ha	Age at Peak Vol	Old
				peak MAI	year	Yr. Volume >100m3/ha	10 post Peak MAI year			10 yrs past Peak Vol/ha
G-B8-XX	Pl leading, all sites, all densities	Pine leading	76,615	3.254	90	**50**	**100**	n/a*	n/a*	**160**
G-B7-XX	Sw or fir leading, all sites, all densities	Sw leading	12,336	2.530	100	**60****	**110****	n/a*	n/a*	**160**
G-B5-XX	Pine/deciduous, all sites, all densities	Mixed Wood	3,424	3.682	90	53	100	409.8	150	160
G-B4-XX	Sw/deciduous & Sb/deciduous, all sites & densities		2,315	2.876	100	59	110	353.8	160	170
			5,739	Weighted avg.:	**94**	**55**	**104**	387.0	154	**164**

*There was no drop off on the volume/ha on this yield curve
**Where the harvest-origin age is older than the fire origin age, HWP defaulted back to the fire-origin age.

Tables showing the status of each of the five seral stages and how that compares to NRV will be developed at Year 0 (2012), 10, 50, 100, and 200 years for the gross and net landbase. Maps will also be created showing the status of each seral stage at 0, 10, and 50 years for the gross and net landbase.

In addition to the total area specified in the target, we are also interested in the broad spatial and temporal distribution of seral stages. To examine this, seral stage amounts will also be forecasted and reported by cover type for the FMA and by amount and cover type for Natural Subregions within the FMA. These amounts will not be DFMP targets.

The percentage of each seral stage will also be forecasted and reported for 27 watersheds (Figure 18). These amounts will not be DFMP targets.

The Targets and other forecasted amounts by category will also be presented in charts and graphs that show the natural range of variation for each seral stage, including the pre-industrial (1950) condition, the current (2012) condition, at the forecasted condition as various points in time.

3.32 Patch Size, Patch Cover Type, and Patch Age

Forests constantly change in response to disturbances, which vary by type and size. Disturbance types include non-biological processes such as forest fires, winds, and floods, and biological processes such as reproduction, growth, death, and decay. Disturbances are typically made up of patches (see section 2.44) that range in size from very small patches that affect individual trees to very large patches that may kill many of the trees in very large areas. Patches are usually defined by their size, cover type (e.g. pine, spruce, etc.), age since disturbance, or a combination of these three attributes.

Representation of patches and their patterns in amounts similar to those found in natural forests is part of a coarse-filter biodiversity conservation strategy. The size and shape of patches, the age of patches, the amount (i.e. number) of patches, and the forest cover type within patches are all important aspects of habitat quality for many species. While all patch data is important, patch age, and in particular, old seral patches, are often thought of as being especially important (see section 2.441). This is because old forest patches tend to contain a wider range of biodiversity values than other seral stages, and because on average, there are fewer hectares of old forest patches as compared to the other seral stages, as they take longer to create, and as time goes by, become more and more susceptible to natural disturbance. Old forest patches can be looked at or counted in two ways – strictly by age (i.e. number and hectares of old patches regardless of cover type) or by age and cover type (e.g. number and hectares of old pine patches).

Because patch age, size, distribution, cover type, and number of patches are all important patterns created by natural disturbances, HWP is interested in determining the NRV for all of these patch size characteristics and approximating these patterns through forest harvesting.

LANDMINE has the ability to capture and report on 64 different size classes of forest patches broken down by numbers, age, cover type, and seral stage. However, tracking 64 different patch sizes is too complicated, time consuming, and isn't necessarily providing any additional useful information compared to tracking and reporting on a smaller number of patches.

In general, it can be said that on today's landscape finding and maintaining larger patch sizes is more difficult than finding and maintaining smaller patch sizes (i.e. <100 ha.). This is primarily due to the success of modern day fire control, and because the harvesting that has replaced natural disturbance typically does not create large openings (i.e. openings >100 ha in size). Since 1950, there has been a significant shift from large natural disturbance patches to small cultural ones. As previously noted, disturbed patches in the Upper Foothills of less than 40 hectares in size in 1995 accounted for an average of 34% of disturbed area; compared to just over 3% in 1950. (Andison. March 2003). For this reason, HWP has decided to focus more on counting and reporting on larger patch sizes. For the 2014 DFMP, HWP will track and report on the seven patch sizes as described in Table 10.

Table 10 – *Patch Sizes for Reporting in HWP's 2014 DFMP*

Patch Sizes		
• <100 hectares	• 100–500 hectares	• 500–1,000 hectares
• 1,000–2,000 hectares	• 2,000–5,000 hectares	• 5000–10,000 hectares
• 10,000-50,000 hectares	• 50,000+ hectares	

1.321 Strategies, Targets and Forecasts

HWP's main target will be to have a distribution of harvest area sizes that will result in a patch size pattern over the 200 year planning horizon, for the entire FMA, that approximates patterns created by natural disturbances (i.e. within NRV). The NRV for patch sizes will be determined through the LANDMINE model based on the eight patch sizes noted above in Table 10, categorized by seral stage (e.g. old patches) and by seral stage and cover type (e.g. old pine patches), as shown in Tables 11 and 12 below:

Table 11 – *Patch Size NRV to be Collected for Each Seral Stage*

Seral Stage	Patch size class (ha)	Minimum # of patches	Maximum # of patches	Minimum total area of patch size class	Maximum total area of patch size class
For each seral stage (e.g. old)	<100				
	100–500				
	500–1,000				
	1,000–2,000				
	2,000–5,000				
	5000–10,000				
	10,000-50,000				
	50,000+				

Table 12 – *Patch Size NRV for to be Collected Each Cover Type AND Seral Stage*

Seral Stage & Cover Type	Patch size class (ha)	Minimum # of patches	Maximum # of patches	Minimum total area of patch size class	Maximum total area of patch size class
For each seral stage and cover type (e.g. old pine)	<100				
	100–500				
	500–1,000				
	1,000–2,000				
	2,000–5,000				
	5000–10,000				
	10,000-50,000				
	50,000+				

Where patch sizes are out of NRV, an explanation will be provided, and where possible (or if desired), a strategy to move patch size back into NRV will be developed. The overall goal will be to adjust residual patch characteristics to more closely resemble residual patches produced by fires; keeping in mind that the larger patch sizes (i.e. larger cutblocks) may be difficult to create (i.e. due to other issues such as social acceptability, wildlife, aesthetics, water quality, etc.). In addition, removing the existing pattern of small patches (due to small cutblocks) from the landscape by creating larger cutblocks will take many decades (probably at least a rotation) to come to fruition. HWP's general strategy will be to create larger blocks with shapes and size approximating natural disturbance where the existing landscape allows (i.e. where there has been no previous harvesting). Where the exiting landscape already has a pattern of small patches, then the strategy will be to harvest the remaining patches and create larger opening at the next rotation.

Tables will be created showing the status of each of the eight patch size classes and how they compare to NRV at 0, 10, and 50 years for the FMA. Maps will also be created showing the status of patch size distribution at 0, 10, and 50 years.

The Targets and other forecasted amounts by category will also be presented in charts and/or graphs that show the natural range of variation for various patch data at the current (2012) condition and at the forecasted condition at various points in time.

3.33 Old Interior Forest

The ESRD Planning Standard requires the Company to determine the area of "Old Interior Forest" for each cover (vegetation) class for each subunit (e.g. Natural Subregion) and for the entire FMA. Old Interior Forest (OIF) is further defined in the Planning Standard, as follows:

- "A forested area >100 hectares in size located beyond edge effect buffer zone along the forest edge".

The Standard suggests, "using a common age definitions for all cover classes to prevent breaking up forest patches that have a common origin date". The Standard further defines: edge effect, required buffer zones, and forest edge. These definitions are as follows:

- Edge effect buffer zone: 60 metre buffer zone where adjacent area is non-forested or less than 40 years old; 30 metre buffer zone where adjacent forest stand is $\geq$ 40 years and less than mature forest; and no buffer zone where adjacent stand is mature forest.
- Forest edge: Any of the following: a) a linear disruption in forest cover greater than 8m in width, or, b) the line along which forest seral stage class changes.

This OIF definition is hard to grasp without seeing it visually. Figure 19 shows how the definition of OIF looks on a typical landscape. Old forest patches are first defined, and then buffers are placed inside the old patches depending on the adjacent cover type. When the adjacent cover is less than 40 years old, the buffering-in requirement is 60 metres. When the adjacent type is between 40 years old and whatever age the Company defines as "mature", the buffering-in distance is 30 metres.
For any adjacent cover types that are defined as "mature" there is no buffering requirement. The remaining area is then "Old Interior Forest" only if it is larger than 100 hectares in size and has no linear disturbances wider than 8 metres (essentially, nothing wider than seismic lines).

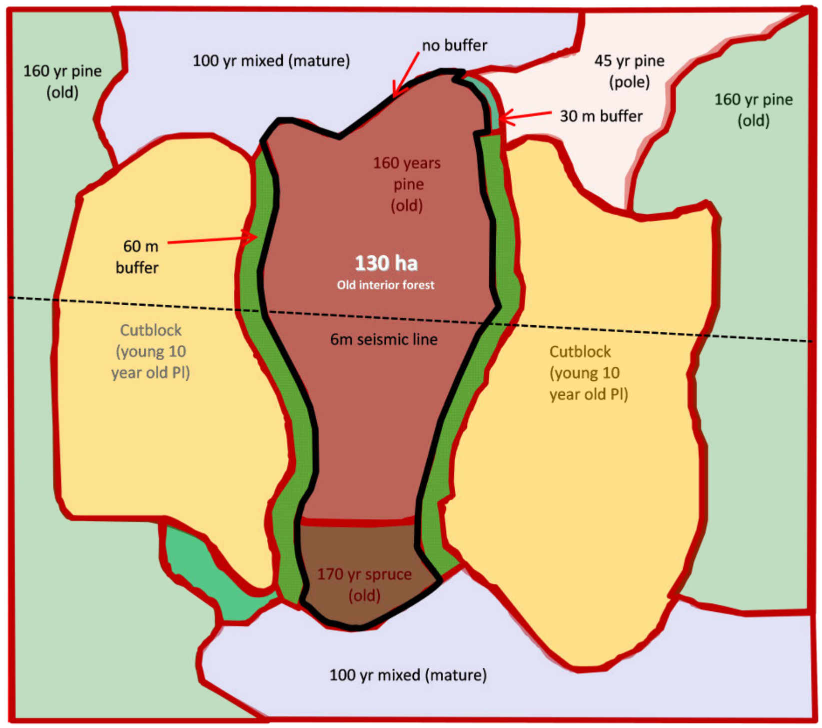


Figure 19 – *A 130 hectare patch of Old Interior Forest defined by the black line, with required buffers shown in green and blue cross-hatching.*

In Figure 19, the solid black line highlights a 130 hectare patch of old interior forest. However, if the 6 metre seismic line was instead a 10 metre road, then this would result in another 60 metre buffer (on each side of the road); and rather than having one 130 hectare patch of old interior forest, you would instead get a 78 hectare patch of old forest and a 48 hectare patch of old forest – meaning there would be no interior Old Interior Forest as defined by the Planning Standard and presumably the two areas would offer no old forest biodiversity benefits.

Hinton Wood Products contends that the requirement to calculate and set targets for Old Interior Forest should not be required of the Company based on both practical and biodiversity considerations.

Practical Issues

- The varying buffering requirements coupled with minimum patch sizes and maximum linear width make calculating the area of Old Interior Forest extremely complex and time consuming (i.e. expensive). This calculation has to be carried out by each cover type at the sub-unit and the FMA level.
- Developing a model that could then determine what a natural range of variation of Old Interior Forest might look like, also becomes extremely complex, as one needs to make the same calculations, but now over hundreds of different and distinct model outputs (i.e. in order to develop an Old Interior Forest NRV).
- HWP has no ability to control Old Interior Forest. For example, one road or pipeline (that HWP doesn't build) has the ability to take a 200 hectare patch of Old Interior Forest and reduce it to zero. The Company is leery of setting targets it has no control over.
- The edge effect buffer zone requires a 60 metre buffer for Old Interior Forest adjacent to stands less than 40 years old – this 40 year age does not fit in with any of the seral stage definitions commonly accepted for young forest (e.g. 0-20 years is the most common definition and what HWP is using). This means another level of complexity, as now rather than buffering Old Interior Forest along a seral stage boundary (i.e. <20 years), one must create another data set to show forests < 40 years old (i.e. in the middle of a seral stage age range).

Biodiversity Issues

- As far as HWP can tell; the definition of Old Interior Forest is quite arbitrary. We know of no specific species on our FMA that requires Old Interior Forest as specifically defined in the Planning Standard.
- By arbitrarily assigning value to Old Interior Forest, HWP runs the risk of, firstly, not being able to develop defendable targets, and secondly, not being able to retain what is currently there, as we have a very limited ability to control who builds roads, pipelines, and other linear feature on our FMA.
- The main biodiversity value one is trying to protect is patches of old forest – whether these patches are fragmented by linear corridors, patches < 100 hectares adjacent to 50 year old forests, or 1000+ hectare patches with no anthropogenic features, there is value in managing for old forest patches. By so tightly constraining the definition of these old forest patches, the value of old patches that don't meet the strict definition of Old Interior Forest are arbitrarily diminished.

3.331 Strategies, Targets and Forecasts

HWP believes that it is our responsibility is to manage patch size (regardless of linear disturbance), patch distribution, and patch age; keeping in mind that HWP has no direct control over linear disturbances caused by other land users (e.g. oil & gas). HWP takes the view that it is best to manage patch attributes and then work with other tenure holders to reduce or eliminate linear disturbances. HWP believes that oil and gas are short term users of the landbase and over multiple rotations we are better off managing for patch size, distribution, and age in the long term. The footprint issue should be dealt with separately through integrated landscape management practices.

HWP also acknowledges the value of old forest. Science tells us that all old forest provides value, regardless of patch size, and that maintaining a range of patch sizes is important. We believe that developing a NRV for old forest patches results in a more scientifically defendable target and a target that we have more control over. As discussed in section 3.32, HWP will develop NRV for old seral patches based on cover type (e.g. old pine) and based on age regardless of cover type (e.g. old spruce and pine), and set targets based on trying to keep old forest and old forest cover types within NRV.

From ESRD's point of view, they believe that linear features have some type of impacts to biodiversity – what exactly those impacts are and at what level they come into play is not known for sure. The Old Interior Forest VOIT is ESRD's way of acknowledging the impact of linear features, and tracking their impact over time. This will allow ESRD to see which way it's going (e.g. are linear features continually increasing and at what rate?) and who's primarily responsible for it (e.g. energy, forestry, etc.).

ESRD has agreed to calculate the amount of OIF on the Hinton FMA, including the Year 0, 10 and 50 year future forest condition maps as informed by the Timber Supply Analysis and Spatial Harvest Sequence in HWP's 2014 DFMP. This will allow ESRD and HWP to understand where OIF is going over time, and differentiate the effect of other users from forestry.

3.34 Stand Structure Retention

This section outlines the rationale and methodology behind HWP's strategy for stand structure retention. The overarching vision of HWP's strategy is to view the FMA landbase as representing a series of events (primarily fires) that took place before industrial development and effective fire suppression (i.e. <1950); and then try to approximate, through harvesting, the patterns of those pre-industrial natural events, in terms of the size and number of events, and the percentages, numbers, and size classes of the island and matrix remnants within these events. We are doing this to produce landscape and stand level conditions that are similar to what natural disturbances would have produced.

Fires in the boreal forest tend to take place over a relatively short period of time, and leave behind a patchwork of burnt and unburnt patches. Individual disturbance events (i.e. fires) are made of patches, island remnants and matrix remnants.

As discussed in section 2.44, the patterns of sizes and numbers of disturbance events are similar to the numbers and sizes of individual patches. As with disturbance patches, most disturbance events are very small, but most of the area burned is made up of very large disturbances events. In other words, there are many small fires and relatively few large fires (see Figure 20). Larger fires, while being rarer, tend to dominate the landscape in terms of area burned.

The exact proportions of fires of different size-classes vary by natural sub-region. The largest disturbance patches occur in the Upper Foothills landscape, where more than half of the disturbed area is in patches greater than 10,000 hectares.

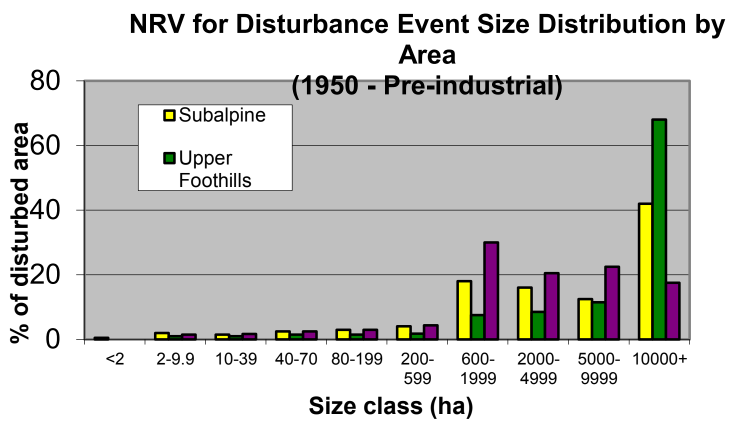


Figure 20 – *Most fire events are small, but the few large events account for the most area burned.*

In order to approximate natural disturbance patterns, HWP must understand the range in size and in numbers of fires (i.e. events), and then create harvest patterns that approximate the size and number of fires that would take place in the absence of fire control.

Figure 20 shows that before 1950 (i.e. before effective fire control) most of the area disturbed in fire events came from large fires. Since the 1950s, fires have been suppressed on the Hinton FMA, and the reduced rate of natural fire disturbance has been replaced with cultural disturbances; primarily harvesting. In general, since 1950 there has been a significant shift from large natural disturbance events to smaller cultural ones. Clearly, if the goal is to approximate natural disturbance there needs to be more large cultural events with larger disturbance patches.

However, to closely approximate the range of natural disturbance events over the long term, HWP would have to create some very large disturbances. It is not clear that this would be socially acceptable or even practically possible (due to AAC limitations). While HWP does have some ability to create large disturbance events by employing a two-pass harvest system over a 10-15 year old period, or by creating large events with a mosaic of harvested and unharvested area, it is unlikely that events such as these that are greater than 2,000 hectares would be socially tolerated, or even required from a biodiversity point of view. HWP's overall goal is to better approximate the range in sizes of natural disturbance events and the number of those events, while still maintaining social acceptability in terms of impacts to other values such as aesthetics, biodiversity, water quality, and recreation.

In addition to the range of sizes of the actual disturbance events (e.g. fire), what is left behind undisturbed within and adjacent to these disturbance events is also very important. As discussed in section 2.25, there are two major types of residual material within a fire; "island remnants" and "matrix remnants". Matrix remnants are always undisturbed and include features such as corridors, bays, and peninsulas that are within the greater event area, but are still physically connected to the surrounding unburned forest matrix. Matrix remnants can include both forested and non-forested areas. It is not possible to define matrix remnants without first defining the disturbance event. Island remnants patches are either physically disconnected from the matrix (and thus completely surrounded by disturbed area), or if connected to the matrix, they are partially disturbed (i.e. burned). Island remnants are usually defined and described at only the disturbance patch scale.

Once cultural events are classified into disturbance events, as described above, the next step is to classify all patches within the cultural disturbance events as disturbed patches (generally cutblocks), matrix remnant patches (usually unharvested areas between blocks) and island remnant patches (usually undisturbed areas surrounded by disturbance, such as wildlife tree patches left in cutblocks and/or partially disturbed areas either surrounded by disturbed areas or bordering disturbed areas).

Section 3.341 outlines HWP's strategy to approximate the number and size of natural disturbance events, as well as the HWP's strategy to approximate stand structure retention at the disturbance event scale in numbers and area similar to that left behind after natural disturbance.

3.341 Strategies

HWP will employ the following seven-step process to maintain a socially and biologically acceptable number and area of disturbance events, patches, matrix remnants and island remnants:

1. Determine the NRV for natural event size on the Hinton FMA – This work has already been completed by Dr. Dave Andison, program lead for the Foothills Research Institute's Healthy Landscapes Program (i.e. natural disturbance research). Andison examined the fire history (pre 1950) on the Hinton FMA using stand origin maps, 1950s-era aerial photography, and field sampling, and was able to determine the event sizes that occurred over the previous 100-200 years. This data was used to calibrate the LANDMINE model, so that LANDMINE would burn events on the landscape similar in size and distribution to what had occurred naturally (i.e. in the absence of effective fire control).
2. Determine the NRV of patches, island remnants and matrix remnants for fires – This work has also already been completed by Dr. Andison. As explained in section 3.22, the NEPTUNE model was developed through research at the Foothills Research Institute, and has been calibrated to west-central Alberta using research into actual historical fire events in which there was limited or no fire control. This model provides information on the historic number and area of patches, island remnants and matrix remnants within fire events in the Foothills area of Alberta.
3. Determine the number and size of cultural/ND events on the Hinton FMA for Year 0 (2012) – HWP will loosely organize all harvesting history (i.e. cutblocks) and natural disturbance events for Year 0 (2012) on the FMA into similar disturbance date events (i.e. identify individual blocks that should be amalgamated into events), based on grouping together into one event any blocks that are within approximately 25 years of age of one another and are within 500 metres of one another. There may be times when this rule doesn't apply due to geography or other factors. There may also be sometimes when it may make the most sense to stretch or shrink the 25 year age difference in order to produce a "best fit". In these cases, HWP will document our decisions so that they are transparent.

HWP acknowledges the difference between fires that burn in days to weeks and harvest events that occur from weeks to years. As previously discussed, our goal is to manage harvest events to approximate fire events, and what we are most interested in are the patterns in the future forest after all harvesting in a harvest event is completed.

When developing events, HWP will remove all roads and other cultural information as well – this is done so that the model will work in a way that we can compare apples-to-apples; that is, harvest events to fire events. The best way to do that is to remove the cultural footprint.

HWP may also map out existing in-block retention for all harvested blocks (accomplished using LiDAR).

Figure 21 illustrates an example of how HWP might group harvested area into different fire events based on cutblock age, proximity, and geography. Individual disturbance patches (i.e. cutblocks) identified by HWP are grouped together into events based on the rules provided by HWP. As previously noted, for the 2014 DFMP, HWP has directed the model to group together into one event any blocks that are within 25 years of age of one another and are within 500 metres of one another. Using these rules, NEPTUNE will buffer out (250m) and then buffer in (250m) all blocks meeting the age and adjacency requirements, which will create an overall event boundary and size. The resulting output will provide the area and boundary for of all of the cultural events in Year 0 (2012) producing a Cultural Range of Variation (CRV). See Figure 22.

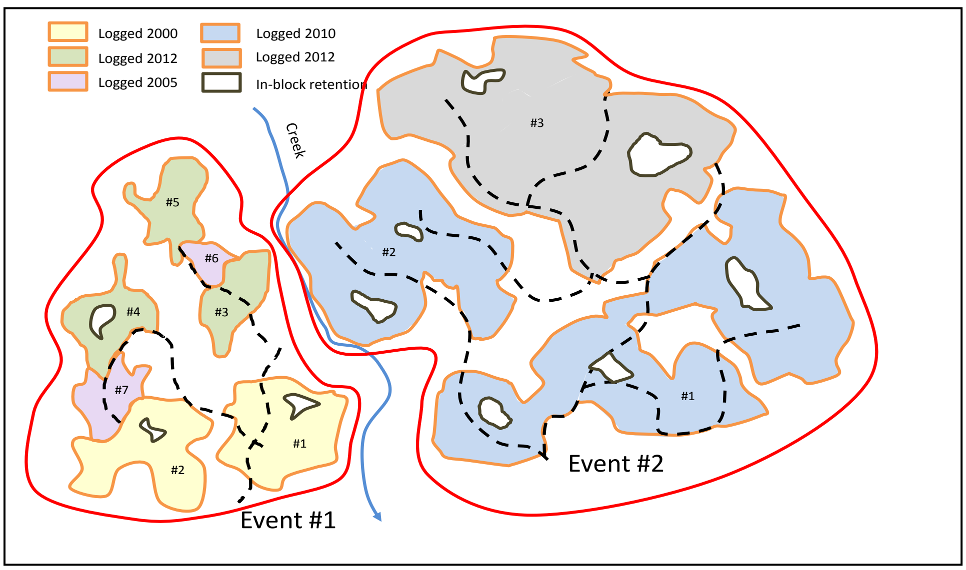


Figure 21 – *This is an example of the information that HWP will provide to the NEPTUNE model. Each block is colour coded, based on its year of harvest. Events are also roughly grouped. In this case, even though Event #2 block #2 is closer than 500 meters from Event #1 block #3 and is within 25 years of the start age (2012), block #2 has been grouped with Event #2 rather than Event #1, because Block #2 was logged in the same timeframe as the other blocks in Event#2 (i.e. 2010-2012 instead of 2000-2012). This produces 2 events, both with a date of 2012.*

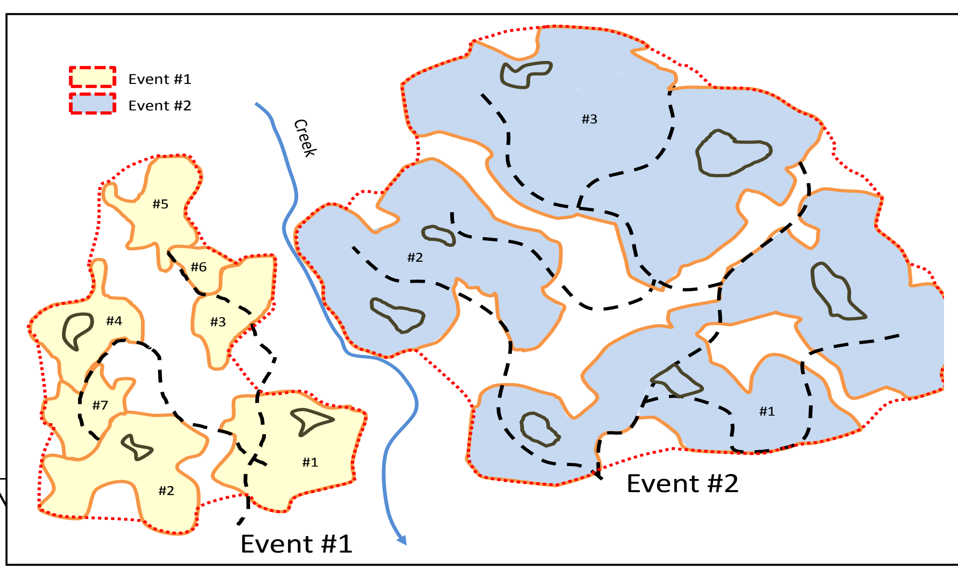


Figure 22 – *NEPTUNE categorizes cutblocks into discrete events based on the shapes and rules provided to it. There still remains the ability to amend event boundaries post hoc to take into consideration other factors, such as geographic boundaries, adjacent issues, etc. The age of the event will be on the harvesting age of the youngest cutblock (in this case both events are 2012).*

4. <u>Determine disturbance patches, matrix remnants and disturbance-surrounded island remnants for all cultural/ND events on the Hinton FMA for Year 0 (2012)</u> – All cultural events (e.g. harvesting) and natural disturbance events identified by NEPTUNE for 2012 will be run through the NEPTUNE model. NEPTUNE will provide, by event, information on patch numbers and patch size, matrix remnant numbers and size, and island remnant numbers and size, producing a Cultural Range of Variation (CRV) for patches, matrix remnants, and island remnants. See Figure 23.

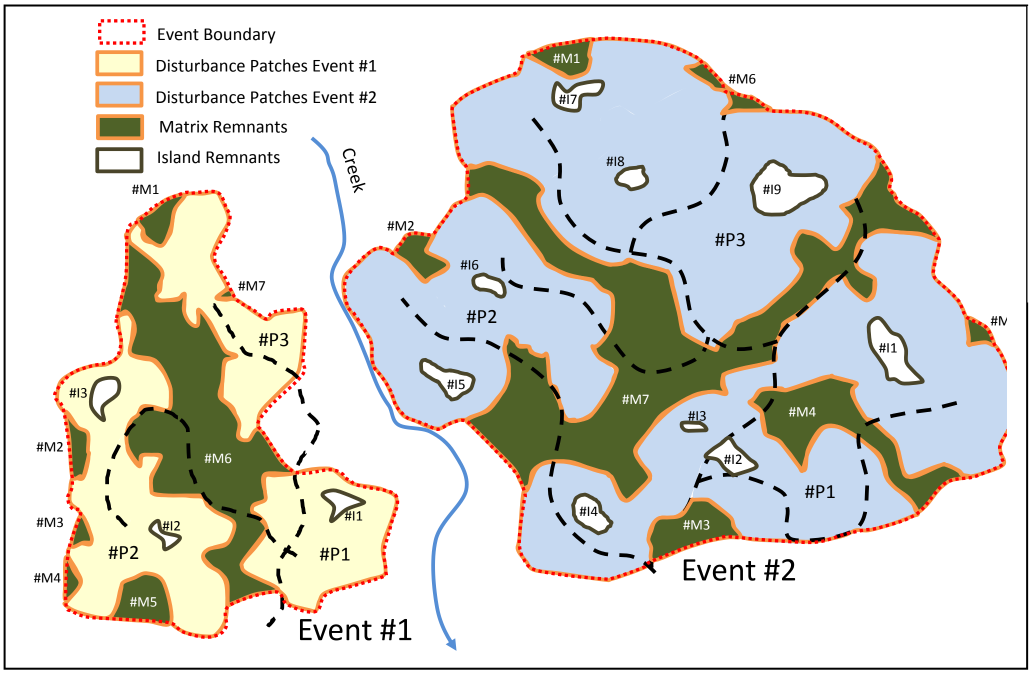


Figure 23 – *NEPTUNE will categorize each event into its component parts – disturbance patches, matrix remnants, and island remnants.*

From this NEPTUNE output, an Excel table of cultural events for 2012 will be created. The table will provide information similar to that in Table 13.

Table 13 – *Cultural/ND Events on the Hinton FMA for 2012 (example)*

Event #	Status*	Working Circle -	Year of original	Event Size	Harvest or ND	Disturbed Patches				Island Remnants				Matrix Remnants			% Island plus Matrix
	O, C, or P	Compartm	disturbanc	(ha)		Patch #	Blk. #	Area (ha)	Yr. harvested	Island #	Area (ha)	In-block (Y/N)	Pecent Islands	Matrix #	Area (ha)	Pecent	
1	C	1-4	2010	200.1	H	1-P1	1-4-0002	21.3	2010	1-I1	0.1	Y		1-M1	3		
							1-4-0003	15.3	2010	1-I2	0.3	Y		1-M2	6.5		
							subtotal	36.6						1-M3	13.2		
						1-P2	1-4-0004	15.2	2012	1-I3	0.5	Y		1-M4	6.5		
							1-4-0005	22.4	2012	1-I4	0.8	Y		1-M5	12.8		
							subtotal	37.6						1-M6	15.2		
						1-P3	1-4-0006	20.6	2012	1-I5	0.8	Y		1-M7	2.1		
							1-4-0007	14.9	2012	1-I6	2.1	Y		1-M8	1.4		
							1-4-0008	9.4	2012	1-I7	1.3	Y					
							subtotal	44.9		1-I8	0.2	Y					
										1-I9	5.3	N					
										1-I10	8.9	N					
				Grand totals Event #1				**119.1**			**20.3**	**6.1**	**10.1%**		**60.7**	**30.3%**	**40.5%**
3	C	2-4	2000	425.3	H	3-P1	2-4-0112	130.5	2005	3-I1	0.3	Y		3-M1	2.4		
										3-I2	1.2	Y		3-M2	1.3		
										3-I3	3.5	Y		3-M3	4.2		
						3-P2	2-4-0113	110.3	2000	3-I4	4.5	Y		3-M4	36.1		
										3-I5	0.4	Y		3-M5	19.7		
										3-I6	3.2	Y		3-M6	2.1		
						3-P3	2-4-0114	40.5	2012	3-I7	0.3	Y		3-M7	23.8		
						3-P4	2-4-0115	15.1	2012	3-I8	2.3	Y		3-M8	1		
										3-I9	10.4	N		3-M9	0.9		
										3-I10	11.3	N					
				Grand totals Event #3				**296.4**			**37.4**	**15.7**	**8.8%**		**91.5**	**21.5%**	**30.3%**

*O (Open – there is harvesting still to take place); C (Closed – all harvesting has been completed); P (Planned – harvested in the future)

5. Compare the number and size of events from 2012 with NRV of event sizes – The number and size of cultural events (and natural disturbance events) for 2012 as determined above by NEPTUNE (i.e. the CRV) will be compared to the NRV for the number and size of disturbance events for each Natural Subregion. See the example in Figure 24 below on how this data will be summarized. This will provide HWP with information to inform the Spatial Harvest Sequence. In other words, does HWP need larger events, more events, smaller events, etc.?

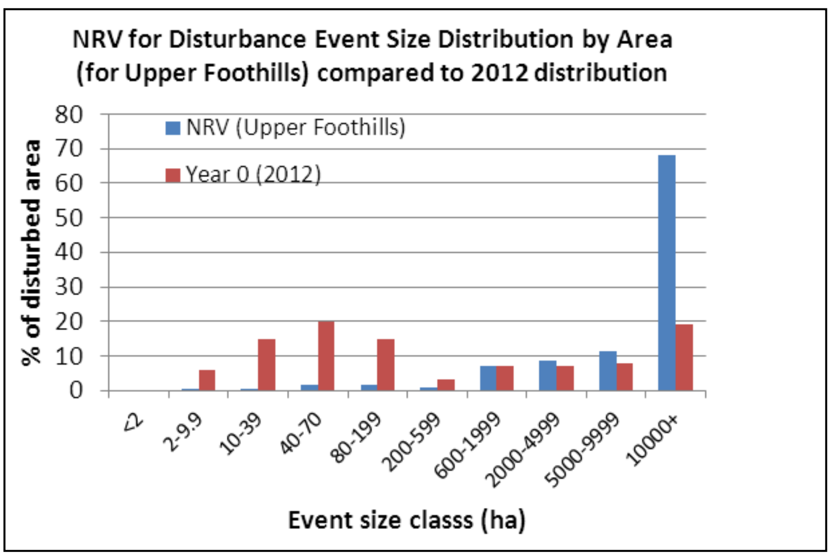


Figure 24 – *The NRV for disturbance event sizes in the Upper Foothills as compared to the CRV for the 2012 event size distribution. This is an example only.*

6. Compare the number and size of disturbed patches, matrix remnants, and island remnants for 2012 to NRV – For each disturbance event for 2012, NEPTUNE will determine the number and area of disturbance patches, matrix remnants, and island remnants (i.e. the CRV). This data will be summarized and compared to the NRV for west-central Alberta. Figure 25, 26 and 27 on the following page provide examples on how this data will be summarized. This will also provide HWP with information to inform not only our SHS but also our field layout at the Forest Harvest Plan stage. For example, outputs from NEPTUNE may tell us we need less matrix remnants,

more island remnants, or bigger disturbance patches, on the FMA as a whole or by Natural Subregion.

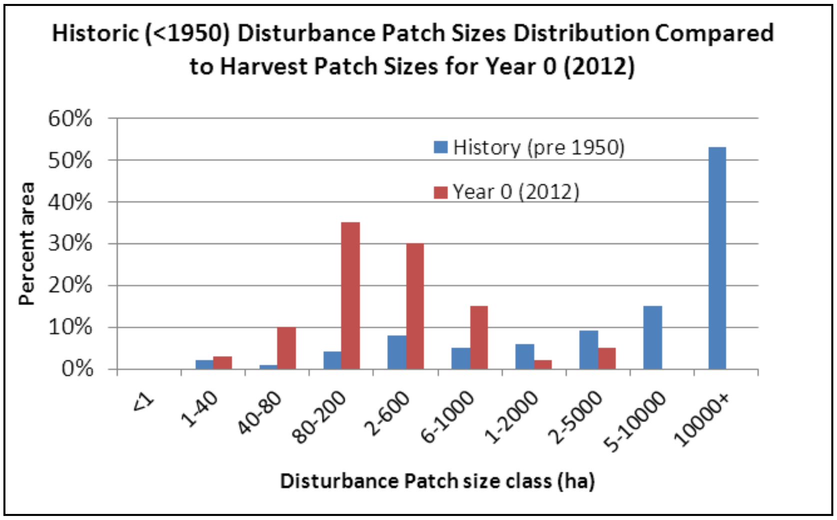


Figure 25 – *In this graph, the NRV for patch size from natural disturbances (i.e. without effective fire suppression) is compared against the CRV for patch size from cultural disturbances (i.e. harvesting) in 2012. This is an example only.*

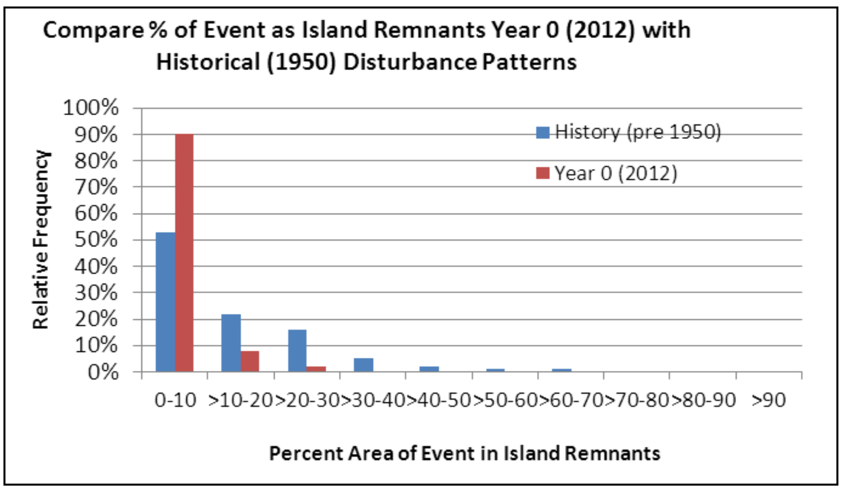


Figure 26 – *In this graph, the NRV for the percentage of island remnants from natural disturbances is compared against island remnants from cultural (and natural disturbances) that took place in Year 0 (2012). This is an example only.*

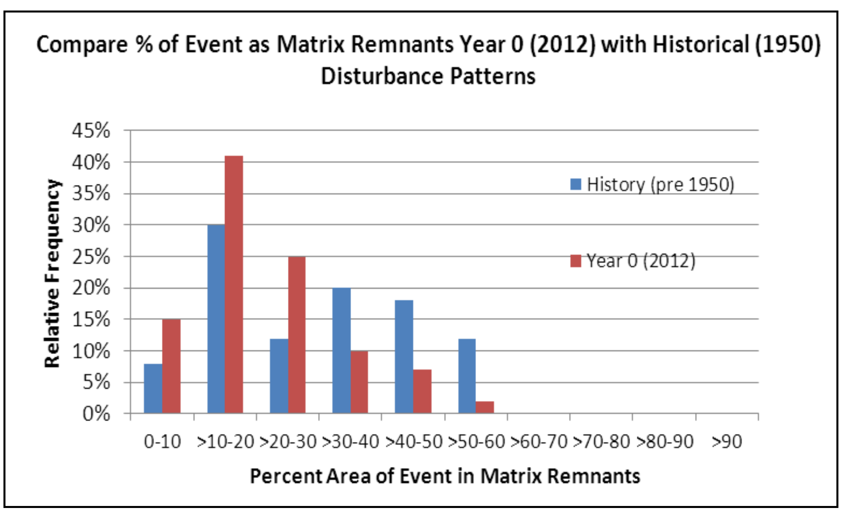


Figure 27 – *In this graph, the NRV for the percentage of matrix remnants from natural disturbances (i.e. without effective fire suppression) is compared against matrix remnants from cultural disturbances (i.e. harvesting) and natural disturbances (i.e. fire, blowdown events, etc.) that took place in Year 0 (2012). This is an example only.*

7. Create new events with the Spatial Harvest Sequence (SHS) – HWP will create a SHS that will show block locations for the next 20 years. These blocks will be grouped into events. Each event for the first five years of the SHS will be categorized into its main components – event size, disturbance patches, matrix remnants, and island remnants. There will be a running total kept in a table of all cultural events from 2012 to present, which will be updated as events are completed. There will be a number of open events that straddle the DFMP, which will be completed with implementation of the SHS. Any wildfires that occur will also be tracked as events in the same table. Graphs can be produced from this table that show various event metrics, such as patch size, island size, and matrix size, as they compare to NVR. Figures 28, 29, and 30 show examples of these types of graphs.

   The intent is that over time, the distribution of cultural events (i.e. the CRV, which also will include all natural disturbance events from 2012 forward) and their metrics will be similar to the NRV for natural disturbance events. Where there are inconsistencies; they will be explained.

   The resolution of the SHS is such that it normally does not include islands ribboned out within proposed cutting blocks, as this level of detail normally does not occur until the Forest Harvest Plan (FHP) stage of planning process. Therefore, one must be cognisant when looking at island remnants data generated from the SHS that islands will be somewhat underrepresented.

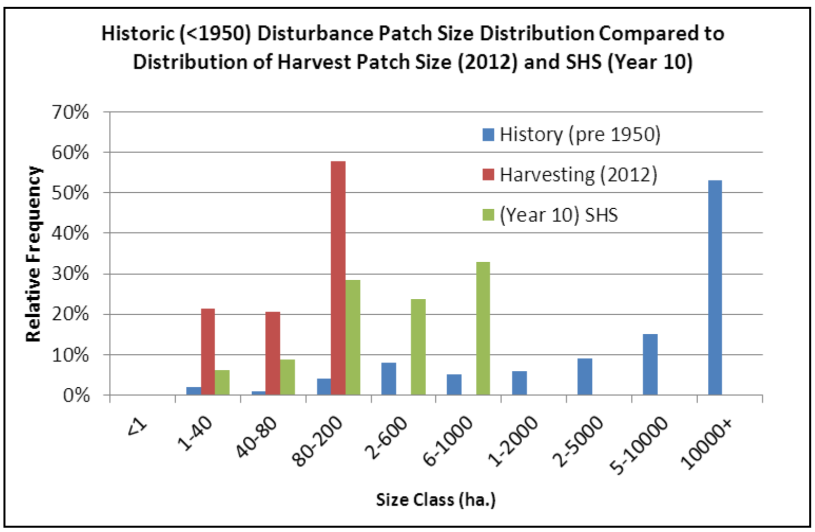


Figure 28 – *In this graph, the NRV for disturbance patches is compared against the Cultural Range of Variation (CVR) for harvesting on the Hinton FMA in Year 0 (2012) and Year 10 (i.e. 10 years from implementation of the SHS). For example, the graph shows that disturbed patches between 40 and 80 hectares naturally make up only 1% of disturbed patches on the landscape, while the same size of patches created through harvesting account for 21% in Year 1 and 9% in Year 5. This is an example only.*

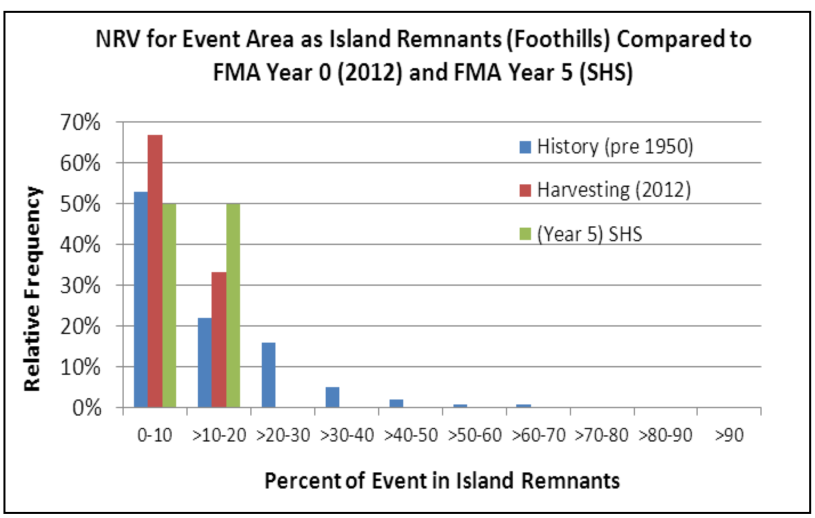


Figure 29 – *In this graph, the NRV for island area (as a percentage of the event area) is compared against the Cultural Range of Variation (CRV) of percent island area for harvesting on the Hinton FMA in Year 0 (2012) and Year 5 (i.e. 5 years from implementation of the SHS). For example, this graph shows that fire events contained 0-10% residuals 52% of the time, while harvested events contained between 0% and 10% residuals 65% of the time in Year 1 and 48% of the time in Year 5. This is an example only.*

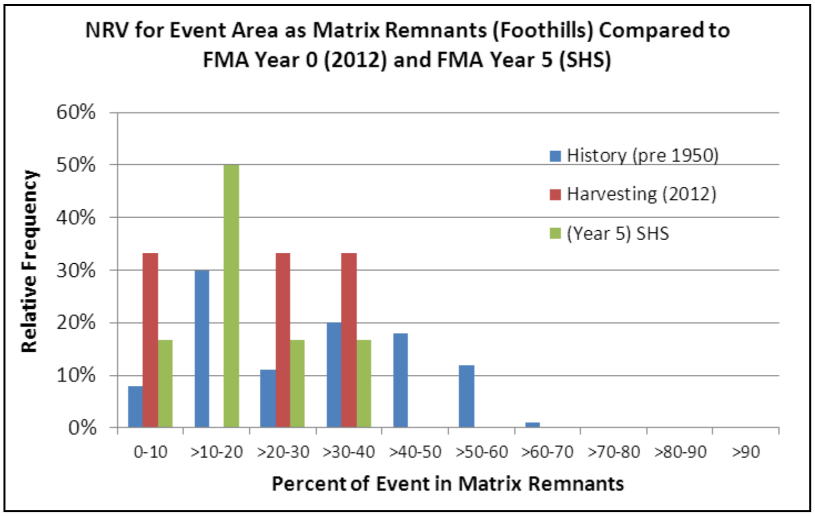


Figure 30 – *In this graph, the NVR for matrix remnant area (as a percentage of the event area) is compared against the Cultural Range of Variation (CVR) of matrix remnant area for harvesting on the Hinton FMA in Year 0 (2012) and Year 5 (i.e. 5 years from implementation of the SHS). This is an example only.*

The intent of this proposed seven-step process, which accounts for both island and matrix remnants (as well at patch size distribution and event size distribution), is to more closely approximate the patterns left from natural disturbance. Previous provincial and industry efforts around stand structure retention guidelines have focused on requiring a certain percentage of standing (often merchantable) forest to be left behind within cutblocks. Clearly, while in-block structure retention is an important part of stand structure retention (because in-block retention approximates islands remnants), ignoring (and not keep tally of) all matrix remnants is inconsistent with natural disturbance principles.

3.342 Targets and Forecasts

HWP will set the following five targets in the DFMP around disturbance events and their associated patterns (i.e. numbers and sizes) of undisturbed (or partially disturbed) matrix and island remnants. Disturbance patches are addressed in a separate VOIT and target (see section 3.32).

__Target #1__ – The numbers and sizes of cultural events (i.e. the CRV) will be maintained on the Hinton FMA within the Natural Range of Variability (NRV) for events, across the range of events sizes, and in approximately the same proportion. The overall goal will be to adjust event size and number characteristics to more closely resemble events produced by fires. Having said that, there may also be times when HWP may decide to deliberately remain outside NRV on events so we can stay within NRV on landscape conditions; or we may decide to alter event patterns outside of NRV for some other reason (e.g. caribou habitat, aesthetics, etc.). Where event sizes are out of NRV, an explanation will be provided, and where possible, a strategy will be developed to move event sizes and numbers back into NRV.

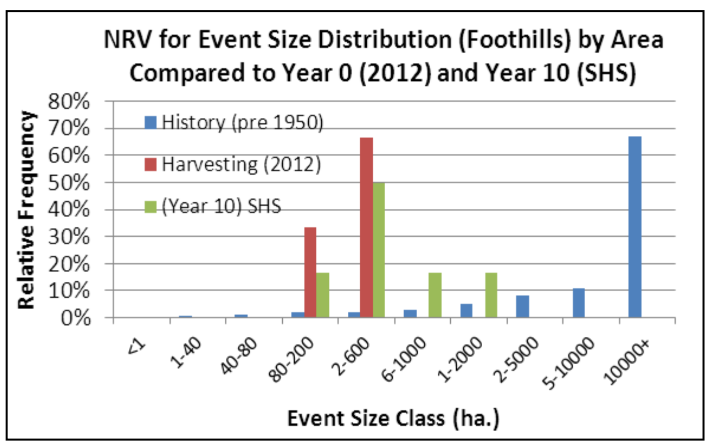


Figure 31 – *The NRV for event size distribution in the Alberta Foothills, compared to Year 0 (2012) and Year 10 forecast based on the Spatial Harvest Sequence (SHS). This is only an example.*

Tables and/or graphs will be

created showing the status of event size classes and how they compare to NRV at Year 0 (2012), 10, 50, 100, and 200 years for the FMA and for the three Natural Subregions (see Figure 31). Maps will also be created showing the status of patch size distribution at 0, 10, and 50 years.

Target #2 – The percentage of an event in island remnants will be maintained on the Hinton FMA within the NRV for island remnants, across the range of island remnant sizes, and in approximately the same proportion. The overall goal will be to adjust island remnant characteristics to more closely resemble the island remnants produced by fires. Having said that, there may also be times when HWP may decide to deliberately remain outside NRV on island remnants so we can stay within NRV on some other landscape conditions; or we may decide to alter island remnant patterns outside of NRV for some other reason (e.g. caribou habitat). Where island remnants are out of NRV, an explanation will be provided, and where possible, a strategy will be developed to move island remnants (as a percentage of an event) back into NRV.

Tables and/or graphs will be created showing the status of island remnants (as a percentage of an event) and how they compare to NRV at Year 0 (2012) and Year 5 for the FMA and for the three Natural Subregions. Graphs will also be created showing the status of island remnants distribution (i.e. the numbers of islands) at Year 0 (2012) and Year 5.

Target #3 – The percentage of an event in matrix remnants will be maintained on the Hinton FMA within the NRV for matrix remnants, across the range of matrix sizes, and in approximately the same proportion. Where matrix remnants are out of NRV, an explanation will be provided, and where possible, a strategy will be developed to move matrix remnants (as a percentage of an event) back into NRV. The overall goal will be to adjust matrix remnant characteristics to more closely resemble the matrix remnants produced by fires.

Tables and/or graphs will be created showing the status of matrix remnants (as a percentage of an event) and how they compare to NRV at Year 0 (2012) and Year 5 for the FMA and for the three Natural Subregions. Graphs will also be created showing the status of matrix remnants distribution (i.e. the numbers of islands) at Year 0 (2012) and Year 5.

Target #4 – The percentage of an event in island and matrix remnants (i.e. added together) will be maintained on the Hinton FMA within the NRV for island plus matrix remnants, across the range of remnant sizes, and in approximately the same proportion. Where the total of island and matrix remnants are out of NRV, an explanation will be provided, and where possible, a strategy will be developed to move island and matrix remnants (as a percentage of an event) back into NRV. The overall goal will be to adjust island and matrix remnant characteristics to more closely resemble the percentage of island plus matrix remnants produced by fires.

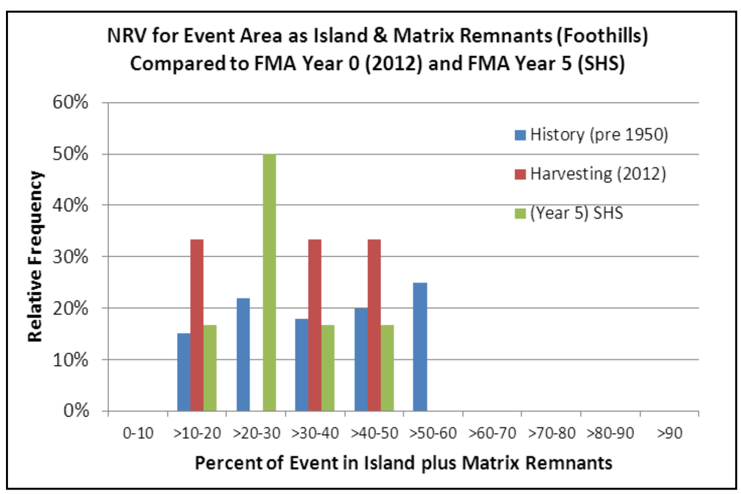


Figure 32 – *The NRV for island plus matrix remnants (as a percentage of an event) compared to island and matrix remnants from harvesting and the Spatial Harvest Sequence (SHS). This is an example only.*

Tables and/or graphs will be created showing the status of island and matrix remnants (as a percentage of an event) and how they compare to NRV at Year 0 (2012) and Year 5 for the FMA and for the three Natural Subregions (see Figure 32). Graphs will also be created showing the status of island and matrix remnants distribution (i.e. the numbers of islands) at Year 0 (2012) and Year 5.

Target #5 – Until HWP has a working stand structure retention database, as described in section in this document and Targets #1 through #4 are being adequately tracked, HWP will maintain its current target of retaining 1% of the harvest area within harvest openings on an FMA-wide basis, as described and prioritized in the current version of the Company's Operating Ground Rules. Once HWP can demonstrate to ESRD that the structure retention strategy described here and in the DFMP is up and running, the 1% target will be dropped. Structure retention will vary by block with some blocks containing zero structure and others containing greater amounts.

3.343 Tracking and Reporting

The challenge in implementing a structure retention system as described is section 3.341 and 3.342 is to track and report on results. In order to implement this system, the following three major types of information needs to collected, stored, and tracked:

1. The Natural Range of Variation (NRV) for event size and numbers, patch size and numbers, island remnant percentages (of events), and matrix remnants percentages (of events). This has been done through research as the Foothills Research Institute.
2. The current (i.e. Year 0 -2012) Cultural Range of Variation (CRV) for events, patches, islands remnants, and matrix remnants for any harvesting carried out in 2012. This includes any natural disturbances in 2012 as well.
3. The forecasted CRV for events, patches, islands remnants, and matrix remnants. This will be the combination of the Year 0 (2012) CRV and HWP's Spatial Harvest Sequence (SHS) at various points in time.

In determining the CRV and the SHS, HWP will develop a system that tracks the metrics of each event from 2012 into the future. All events will be numbered and within every event, unique identifying numbers will also be given to each patch, island remnant and matrix remnant. Island remnants entirely within a cutblock will also be counted separately from those islands created in between cutblocks. For each event, the area (hectares) and number of all patches, island remnants and matrix remnants will be counted.

All of this data will produce a table that will allow HWP planners to determine where the metrics for events, patches, island remnants and matrix remnants on the FMA sit at any point in time as compared to NRV. This will provide planners real time information on what they may need to be looking for while doing layout; for example, they may need to layout more small patches, more large patches, or less matrix remnants, etc.

The target is to main events, island remnants, matrix remnants, and island plus matrix remnants metrics within their NRV over time. It is recognized that over the shorter term, it is likely that some of these metrics might currently be outside or at the far range of their NRV – the goal is to move them back into NRV over time. Where metrics are outside NRV, an explanation will be provided, and where possible, the strategy will continue to be to move the metric back into its NRV over time. Sometimes, decisions will be made to keep a metric: for example, event size, outside its NRV at the far end, as we don't have the capacity to create events large enough to maintain large events (e.g. >10,000 ha.) within NRV.

Appendix 1 outlines the general framework for a tracking system. HWP would report annually in the Stewardship Report on the status of events, disturbed patches, island remnants, and matrix remnants.

Note:

In the fall of 2015, the GoA communicated to HWP that they did not accept HWP's contention that measuring the event size, island remnants, matrix remnants, and island + matrix remnants indicators would be more consistent with a NRV Strategy then simply keeping a percentage of merchantable volume within cutblocks (described in Target #5 above). Due to the amount of effort required in measuring these other four Targets, and given that GoA was not going to allow HWP to drop the percent merchantable retention within a cutblock requirement, HWP made the decision to drop Targets #1-4 as described above.

3.35 Ecological Values and Functions Associated with Riparian Zones

Riparian areas are a small part of the total landbase area but they contain and support many of the highest values or unique resources and ecological functions. Direct interaction between terrestrial and aquatic environments occurs in riparian zones (Oliver and Hinckley 1987). This relates to a high diversity of landforms, ecosystems, and disturbance processes in riparian areas. Riparian ecosystems reflect disturbance processes related to water movement and biological (e.g. beaver) processes as well as processes that affect upland ecosystems (e.g. fire, wind, and other biotic factors). The combination of landform diversity, ecosystem diversity, and disturbance diversity produces high biodiversity values in riparian areas.

Values on these lands for human use are also very high (recreation, aesthetics, timber, water, gravel, agriculture, wildlife, fish, etc.). Riparian areas also provide other ecological services that contribute to watershed and biological integrity and maintenance of ecological functions. They support exchange of biological material and energy flows between terrestrial and aquatic ecosystems. They serve as ecological corridors, facilitating movements of species through landscapes and they provide habitat to support the requirements of many species.

As described in section 2.46, research has shown that fires most likely burn as often through all types of riparian zones as they do through the rest of the landscape. Research also cautions that the universal protection of riparian zones from natural disturbance (through the use of buffer zones and fire protection) will inevitably lead to changes in the short and long-term structure, composition, and dynamics of both the terrestrial and aquatic systems therein. In addition, management decisions that alter Large Woody Debris abundance and dynamics, such as removing all disturbances from riparian areas, may have long term implications for the structure and function of riparian environments, in-stream habitat, and biodiversity.

Given their importance for multiple values and the different combinations of natural disturbance regimes that operate within riparian areas, these areas have typically been managed differently than upland areas – the normal practice being some type of buffer where all disturbance is excluded. Since operations began on the Hinton FMA in the 1950s, the Company has also protected riparian zones with buffers; however, HWP has also, in certain circumstances, (and with government approval) introduced disturbance into riparian areas through careful harvesting. Permission to do this was given on a case-by-case basis and normally involved bringing the block boundary to a slope break alongside a watercourse channel. This practise resulted in a variable buffer width that changed in response to the morphological characteristics of the channel.

3.351 Strategies, Targets, and Forecasts

Changes in HWP's Operating Ground Rules in 2009, removed HWP's ability for introducing any harvesting within riparian areas (as defined by the government) unless "otherwise approved in a DFMP". For this reason, HWP developed its own Riparian Management Strategy, which is being submitted with the 2014 DFMP for approval. HWP's entire Riparian Management Strategy is outlined in detail in Appendix 2; however, the nine main components/steps of HWP's Riparian Management Strategy are discussed more briefly in the following sections:

1. Channel Classification – HWP will identify the type of watercourse/waterbody (at the DFMP level using remote sensing technology) using a new watercourse classification system developed at the Foothills Research Institute. The current government system to identify watercourse channels is based primarily on channel width and permanence. Depending on the channel width, there will be a buffer of a certain width where no tree removal is allowed. HWP's proposed classification system is a surface erosion process-based system (i.e. channels

are defined based on what they do). Using this system, five erosion process categories were defined, resulting in four types of channels.

Table 14 highlights the difference in the government's classification system and the new process-based channel classification system HWP is proposing in its Riparian Management Strategy.

Table 14 – *HWP's Process Channel Classification versus Existing OGR Classification*

HWP's Process- Based Classification		**OGR Width-Based Classification**	
Terminology	**Definition**	**Terminology**	**Definition**
Upland	Carved by water in the past; no current water flow; no hydrophytic plants	Upland	All other area not classified as riparian.
Swale	Carved by water in the past or depression; no channel; current flow is by seepage; hydrophytic plants	Ephemeral or water source areas	Little or no channel, no riparian buffer required. Can be treated the same as upland.
Discontinuous channel	Water at surface; no continuous channel; flow by seepage; water does not shape channel	Intermittent	<0.4 m in width. Distinct channel development; Channel usually has no terrestrial vegetation.
		Transitional	Channel widths are between 0.4 and 0.7 metres. Flows all year but may freeze completely in the winter or dry up during periods of drought.
Seepage-fed channel	Continuous channel highly variable width; organic bridges and undercut banks; bed is soft unconsolidated and in-situ material; water does not move bed material or shape channel	Small Permanent	Banks and channel well defined. Channel width from ≥ 0.7 metres to 5 metres.
Fluvial	Continuous channel and flow; bed is fluvial materials; water shapes channel; typical pool/riffle structure	Large Permanent	Non-vegetated channel width exceeds 5 meters. Flows all year.

2. <u>Identify Riparian Areas</u> – In the government's OGR riparian area classification system, the riparian areas are designated based on a set width rather than ecological or morphological features (as outlined in Table 14). The actual ecological and morphological riparian area and the prescribed buffer-width riparian area often bear no similarity. Under HWP's Riparian Management Strategy, the Company identified and mapped the riparian areas across the entire FMA based on ecological and morphological features. Figure 33 below illustrates a common difference found between fixed-width riparian zones (as required by the government) versus riparian zones defined

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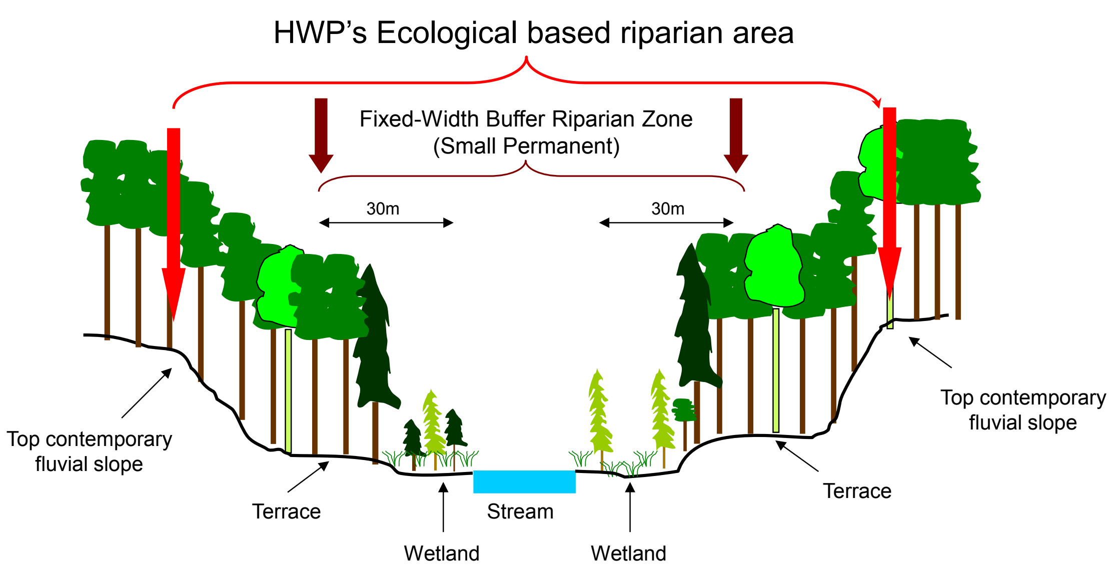

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Figure 33 – *An illustration of the difference between identifying a riparian zone based on stream channel width versus identifying a riparian zone based on ecological and morphological characteristics.*

ecological and/or morphological features, such as the top of a slope break.

As part of HWP's Riparian Management Strategy, ecological/morphological riparian area classification was carried out for the entire FMA by Green-Link Forestry Inc. using a combination of LiDAR data and 3D soft copy colour photo imagery (as well as other inventories such as Wet Areas Mapping and HWP's Ecological Land Classification).

3. Classify Riparian Areas into Vegetation and Operability Classes – After all watercourse channels are identified and all riparian areas are designated, the next step is to determine for all of the riparian zones what land is designated as passive (i.e. no timber harvest) and what land is designated as active (i.e. some form of timber harvest may be proposed at some time in the future). After the area that is unavailable for harvesting disturbance has been identified and netted out of the riparian area, the next step is to identify the vegetation classes and age of the remaining area available for disturbance.

4. Determine NRV – NRV will be calculated by LANDMINE for all riparian areas and broken down by vegetation type and seral stage for the gross, active (net), and passive FMA landbase. Based on this data, targets (in hectares) will be developed to keep riparian areas within their NRV or move them back into NRV.

5. Develop Stand-Level Riparian Disturbance Treatment Options – Silviculture prescriptions will be developed by HWP silviculturalists that will provide a range of acceptable treatments that will depend on the vegetation type, the ecological classification of the area (nutrient and moisture class) and the morphological characteristics (e.g. flood plain, terrace, etc.), as well as other factors. Prescriptions may vary from clear-cut (with reserve individual trees or patches) to partial cut systems like shelterwood (on floodplains) or selection with varying percentages of removal within the 10-metre channel-function zones.

6. Spatial Harvest Sequence – HWP will use timber modelling (*Woodstock and Stanley*) to create a Spatial Harvest Sequence (SHS). The SHS is for a 20 year period and is recalculated every 10 years as part of the DFMP. The SHS will set targets (hectares) for disturbance (based on LANDMINE modelling for NRV) within the ecologically defined riparian areas.

7. Field Checking– As part of the Forest Harvest Plan (FHP) development, each riparian area and stream classification will be field verified and adjusted as required. In addition, modelled block spatial locations are field checked and adjusted as required.

8. Careful Harvesting – Based on meeting NRV targets, careful harvesting will take place within HWP identified riparian areas, where ecological and morphological conditions are appropriate. A 10-metre channel function zone will be placed on all fluvial and seepage-fed channels. Within the 10-metre channel function zone, the following strategies will be employed:

   - For fluvial channels, all trees, vegetation, and regeneration will be protected that are currently, or may in the future (e.g. leaning trees), interact with the channel. Up to 50% of the trees that are not interacting with the channel can be removed from this zone. Proper watercourse crossing must be installed.
   - For seepage-fed channels, protect the watercourse (i.e. proper crossings) and also protect the vegetation, trees, and regeneration that are currently interacting with the channel. All remaining trees may be taken.

9. <u>Monitoring, Measuring, and Reporting</u> – The total hectares of riparian disturbance (i.e. through harvesting) as compared to the NRV targets will be reported in each Stewardship Report.

In addition, as part of developing a new Riparian Management Strategy, ESRD asked HWP to develop a monitoring and measuring program to ensure any unforeseen negative impacts of introducing disturbance back into riparian areas would be monitored and measured, so that appropriate actions could be taken quickly should issues arise.

HWP explored a number of different options in the development of a monitoring and measuring program, but ultimately decided the best course of action was to adapt an existing riparian monitoring evaluation to the specific circumstances found in the West Central Foothills of Alberta. The existing protocol that was adapted was from British Columbia and is called a Riparian Management Routine Effectiveness Evaluation (RMREE).

The goal of BC's RMREE was to monitor the condition of stream channels and their adjacent riparian management areas to determine whether standards and practices governed by regulation were achieving the desired result of protecting fish values by maintaining channel and riparian functions. In other words, were the "riparian forestry and range practices effective in maintaining the structural integrity and functions of stream ecosystems and other aquatic resource features over both short and long terms?" (Tripp et al, 2009)

The BC riparian evaluation arose out of a need to assess the effectiveness of riparian management practices, rather than compliance with a highly prescriptive set of rules. In BC, as in Alberta, there was an implicit assumption that compliance with legislation, regulations, and policy would lead to improved riparian management. Only rarely, however, has this assumption ever been tested. The BC RMREE was developed to provide a feedback mechanism; a test of the system – a quantitative way to assess the impact to riparian systems from forestry and range activities.

In 2013, HWP hired, Dr. Rich McCleary, a specialist in aquatic habitats, and the scientist behind the new process-based channel classification system that HWP adopted in the 2014 DFMP, to review BC's RMREE and adapt it for use in the West Central Foothills of Alberta. In consultation with Derik Tripp, the lead author of the BC RMREE, McCleary adapted and customized the RMREE as follows:

- To address the different stream terminology used in Alberta
- To recognize the different stream processes in the West Central Foothills
- To measure any detrimental changes in riparian function from the implementation of HWP's Riparian Management Strategy.

McCleary's riparian evaluation is called the, "*Properly Functioning Condition Assessment for Streams and Riparian Areas in the West Central Foothills of Alberta*", and in based around answering, through field sampling, 15 questions regarding the properly functioning condition of streams and riparian areas, adjacent or in the vicinity of harvesting.

Each of these 15 questions deals with different aspects of a properly functioning riparian area (e.g. sediment sources, blowdown, stream temperature, etc.). The questions can be either answered "yes" (properly functioning) or "no" (not properly functioning). Based on the answers to the 15 questions, riparian areas can be placed into one of four categories:

1. Properly Functioning (0-2 no answers)
2. Properly Functioning but at Risk (3-4 no answers)
3. Properly Functioning but at High Risk (4-5 no answers)
4. Not Properly Functioning (6+ no answers)

All “no” answers are investigated to determine the reasons why they have been answered “no”. For example, is there an issue with a road, or is the “no” answer the result of a natural condition (e.g. sandy soils)? The results of all assessments will be made available in the Five-Year Performance Stewardship Report associated with the DFMP.

Note:
In December 2014, after the HWP had submitted the 2014 DFMP, Alberta sent HWP a letter (dated December 1, 2014) noting that they would not allow the implementation of HWP’s Riparian Management Strategy in any stream identified in the Athabasca Rainbow Trout Recovery Plan as containing Athabasca rainbow trout or ecologically significant Athabasca rainbow trout habitat. In addition, Alberta asked that HWP establish a suite of reference streams in order to better set the thresholds associated with HWP’s proposed monitoring program (as described above). Until HWP’s Monitoring and Measuring Program was approved by Alberta, HWP would not be able to implement its Riparian Management Strategy. Alberta also outlined numerous other required changes in the monitoring program that HWP had to address.

Over the course of the next 10 months, HWP began the development of a Reference Stream Program and other calibration work. The Monitoring and Measuring Program questions were also modified to address Alberta concerns. Two additional questions were also added to the protocol that dealt directly with stream temperature and spawning gravel sedimentation. This is a work still in progress and will likely continue into 2016.

Target Summary
HWP’s primary target for maintaining the ecological values and functions associated with riparian zones is to implement, monitor, and be 100% consistent and compliant with HWP’s Riparian Management Strategy (as described above). The entire strategy is described in detail in an Appendix 2. A brief outline of HWP’s Riparian Management Strategy, including a monitoring and measuring program, is described above in section 3.34.

The NRV for riparian areas for the gross landbase of the FMA and of each Natural Subregion by seral stage and cover type will be forecast for 0, 10, 50, 100, and 200 years. Targets will be set to keep each cover type within its NRV for each seral stage over the term of the DFMP. Where this cannot be done, reasons will be given, and where possible, targets will be created to move the seral stages of riparian area (by cover type) back into their NRV over time.

A secondary objective and target for maintaining ecological values and functions associated with riparian zones is to be in compliance with all relevant legislation and regulations, as enforced by government, with an annual target of having zero non-compliance incidents. There is no forecast for this target.

3.36 Coarse Woody Debris

Long-term success for managing coarse wood debris (CWD) means retaining enough dead wood to sustain deadwood-dependent organisms (e.g. many fungi and invertebrates) and maintain ecological function driven by the input of dead wood. In developing a strategy for CWD, HWP used the following guiding principles (Lofroth. 1998) (BC Chief Forester CWD Guidance. 2010):

- Larger pieces of CWD provide ecological functions that differ from smaller pieces. Large logs (length and diameter) last longer, hold more moisture, contribute more organic material to the soil, and provide habitat for a greater number of species.
- Recruitment of CWD during the mid to later stages of a rotation is important to maintain continuous levels of CWD. Mid to later stage CWD can be managed with retention patches (island and matrix remnants) and other constrained or reserve areas. Individual standing live

and dead trees and/or stubs retained on cutblocks also represent important sources of CWD recruitment.

- Variability in the amount of CWD is important at both the site level and landscape level. Ecologically, it is advantageous to maintain the full range of decay and diameter classes of CWD on every site — different functions and ecosystem processes require CWD in different stages of decay
- Silviculture requirements, such as plantable spots, are considered along with CWD management
- HWP's intent is not to cut and leave merchantable stems as CWD – in general, logs left on site for CWD will come from the unmerchantable component of the stand.
- Coarse Woody Debris has additional value in riparian areas (where it is called Large Wood Debris or LWD), which are a valuable habitat resource for many species of wildlife. LWD entering or falling across a stream produces habitat for fish, invertebrates and vegetation. Most importantly, it contributes to stream geomorphology. Excessive amounts of fine woody debris can have negative effects on stream biology and will be avoided. The management of CWD in riparian areas (where it is called Large Woody Debris or LWD) is addressed in detail in HWP's Riparian Management Strategy (found in Appendix 2).
- Maintain variability in the levels of CWD at the landscape level. The natural distribution and amounts of CWD will vary according to natural subregions, stand types, and stand development history. Although the natural distributions of CWD cannot be mimicked exactly it is important that CWD management captures landscape variation and site-specific variations

3.361 Defining Coarse Woody Debris

Coarse Woody Debris (CWD) – CWD consists of fallen trees and other woody material on the forest floor. It is generally considered to be sound and rotting logs, stumps and branches greater than 10 cm in diameter, which provide, among other things, habitat for plants, animals and insects, and a source of nutrients for soil development. Maintaining CWD after harvesting is an important element of managing for biodiversity. In most cases, non-merchantable logs, breakages, short pieces, stumps, tops and branches left on the forest floor after harvesting provide the major source of CWD in managed stands. Ensuring that large pieces of CWD are recruited throughout the rotation is also a significant component of managing for CWD. (BC Ministry of Forest. March 2002).

3.362 Strategy

HWP's Coarse Woody Debris management strategy will consist of four major parts and is described below:

1. Manage existing CWD - In most cases, logs already lying on the forest floor are left after harvesting. This constitutes an obvious source of CWD. In addition, all other uneconomic wood resulting from harvesting (such as breakages, short pieces, tops, and dead and dry logs) also provides existing sources of CWD. The intent is to leave these behind after harvest as CWD.

2. Recruit CWD – HWP's focus will be on non-merchantable readily available sources of CWD recruitment. CWD recruitment will be addressed in a number of different ways, which include the following:

    - Leave stand structure retention in island and matrix remnants.

- Provide direction to HWP's harvesting contractors to either, leave standing, or fall and leave on site, trees (live or dead) that have obvious defects (e.g. multiple tops, forks, various scars, etc.). These types of trees are often referred to as cull trees and will usually produce low-grade lumber. Identifying cull trees during operations as sources of future CWD recruitment is a good example of improving CWD management.
- Stubbing - leaving high stumps, often several metres in height, to create standing dead wood.

3. Block inspections – HWP's Operations Supervisors conduct documented and undocumented logging inspections regularly. As part of these logging inspections, HWP supervisors will specifically check to see that CWD objectives are being met. At the time of the final documented logging inspection, CWD objectives will be deemed to have been met if three of the following four conditions are observed:

    - Island and matrix remnants identified in approved or amended FHP's are all retained.
    - There is evidence of cull trees (live or dead) being left standing or evidence they have been fallen and left in the block.
    - There is evidence of stubbing or additional stand structure retention patches left in or adjacent to the block that were not identified in the FHP.
    - Pieces larger than 11 centimeters in diameter on the butt and longer than 10 metres should make up less than 30% by volume of the cull piles based on an ocular estimation.

4. Silviculture Practices – Post harvest silviculture operations such as site preparation and stand tending will ensure CWD objectives for the block continue to be met. While CWD may be moved around on the block as a result of some silviculture practices, the goal will be to not remove any CWD from the block.

3.363 Target and Forecasts

HWP's target for CWD is to have 100% of harvested areas retain Coarse Woody Debris (CWD). Block inspections by HWP Operations Supervisors are carried out regularly – at least one final logging inspection per cutblock is carried out after harvesting is complete, and if harvesting of the block is likely to take more than one month, an interim documented inspection may also be made. HWP will monitor cutblocks with both documented and undocumented inspections to ensure CWD objectives are being met. For the purposes of reporting, each block will undergo a final harvesting inspection, at which time the Operations Supervisor will decide if the CWD objectives have or have not been met, based on the criteria outlined in HWP's CWD strategy (noted above).

The percentage of "haul-cleared" cutblocks that meet CWD objectives will be reported annually in HWP's Stewardship Report and summarized and reported every five years in the DFMP Stewardship Report. There is no forecast for this indicator.

3.37 Unsalvaged Natural Disturbance

3.371 Defining Natural Disturbance

A natural disturbance is an agent that causes trees and other vegetation to die. On the Hinton FMA natural disturbance agents include fire, wind (stem breakage and blowdown), flood, landslide, avalanche, insects, and disease. HWP defines a natural disturbance that kills ≥ 50% of the trees in an area ≥ one hectare in size as a stand-replacing disturbance. A natural disturbance event is a single episode of disturbance that occurs over a relatively short period of time.

3.372 Defining Timber Salvage

Timber salvage is the harvest and utilization of merchantable timber that was killed or injured by stand-replacing fire, insects, disease, blowdown, or other natural disturbance agents. HWP defines damaged timber as an area ≥ one hectare in size where ≥ 50% of the trees are dead or dying. Damaged timber does not include areas less than one hectare in size or individual trees that die in forest stands as a result of natural processes (endemic losses). Timber that has been damaged but not salvaged is called endangered timber because it must be salvaged before decay makes it unsuitable for forest products. The economic window to salvage dead trees that meet lumber quality specifications is usually ≤ three years from tree death to tree salvage. The economic salvage window for other wood products (e.g. chips, pellets, biomass fuel) may be longer than three years.

3.373 Defining Unsalvaged Natural Disturbances

Natural disturbances are a key component of the ecological processes that support healthy and dynamic forest ecosystems and long term ecological integrity. In managed forests, the basic strategy is to reduce the rate and amount of natural disturbances such as forest fires and use harvesting to maintain overall levels of disturbance similar to what would occur naturally. This strategy recognizes that it would not be possible or desirable to eliminate natural disturbances or to salvage harvest all trees killed or damaged by natural disturbances.

The Annual Allowable Cut is calculated by assuming that all merchantable timber from contributing lands will be harvested, except for timber retained for ecological values. When timber that is scheduled to be harvested is killed or damaged but not salvaged, the assumption is not met. This affects the amount of timber available for human use and it also affects the amount allocated to maintain ecological function and resilience. Significant disturbances such as a large forest fire or severe pine mortality caused by mountain pine beetle would trigger a new annual allowable cut determination and reassessment of ecological objectives. Timber salvage therefore supports the assumptions and analysis that determines the annual allowable cut. Salvage reduces risk of additional insect, disease, and fire occurrence, and it recovers timber value that would otherwise be lost. However, it is recognized that some dead trees must be left unsalvaged in the forest to maintain ecological function.

In practice, HWP, in cooperation with the government of Alberta, attempts to prevent and suppress all forest fires and epidemic disease and insect outbreaks that could lead to large scale disturbances, and also to reduce the potential for damage caused by other natural disturbances such as wind and floods. This approach will inevitably not be completely successful, and natural disturbances will continue to occur on the FMA. This provides an “insurance policy” to support the main strategy of replacing most large scale natural disturbance with harvesting.

Unsalvaged natural stand replacing disturbances refers to the area affected by natural disturbances that is not salvage harvested to ensure that some naturally disturbed and regenerated areas are maintained on the FMA through time.

3.374 Targets and Forecasts

Target #1

There are considerable ecological differences between salvaged and unsalvaged forest ecosystems, and the differences are most pronounced in the first few years following the disturbance. For this and other reasons (e.g. Lindenmayer et al. 2004, Lindenmayer and Noss 2006, Schmiegelow et al. 2006, Noss et al. 2006) HWP will not salvage harvest at least 25% of the area affected by stand-replacing natural disturbance. Therefore, HWP's first target to ensure areas of unsalvaged natural disturbances remain on the Hinton FMA is as follows:

1. The cumulative total area of unsalvaged natural stand replacing disturbances will be at least 25% of area disturbed based on a 20 year rolling average.

The above noted target is based on a rolling 20 year average to approximate the natural variability in disturbance events, meaning some disturbances may have less than 25% retention and others may have much more (up to 100%) of the area affected by the natural disturbance. A salvage plan will be developed for each new natural stand replacing disturbance event targeting for salvage of the timber that is least damaged and most accessible (in terms of sensitive ground, steep slopes, habitat issues, etc.). The unsalvaged area will be added to the rolling ledger, with the target of having at least 25% of natural disturbances remaining un-salvaged. The target will be calculated based on the gross FMA area because natural disturbances occur on the gross landbase.

HWP tracks occurrences of natural disturbances on the FMA through several processes. Area burned is tracked in the Annual Fire Statistic Summary Report prepared by the government and summary information is included in HWP's annual Stewardship Report. At present insects, disease, blowdown and other disturbances are monitored and reported on an informal basis. There have been no significant timber losses to insects and disease on the FMA since records started in 1954.

Endangered timber is identified by source through on-going inventory and survey programs. Significant occurrences are mapped and incorporated into the inventory program, and salvage is planned and approved through the planning and approval process. Harvested (salvaged) areas are reforested and tracked through the history and silviculture records system. The status of the FMA landbase is inventoried every 10 years. There is no historical data to calculate a 20 year rolling average for the first target, so the rolling average was commenced starting in 1997. The cumulative percentage of unsalvaged natural disturbances as of December 31, 2012 is 86.9% (Table 16).

Table 16 – *Cumulative total area of unsalvaged natural stand replacing disturbances on the Hinton Wood Products Forest Management Area, 1997-2012.*

Event	Year	Area disturbed (ha)	Area unsalvaged (ha)	Cumulative % unsalvaged
Fire 37	1997	1,603	1,310	81.7
1997 blowdown (multiple events)[1]	1997	400	200	75.4
Fire 61	2003	459	13	61.9
2005 blowdown (multiple events)[1]	2005	150	125	63.1
Fire EWF-059-2006	2006	163	148	64.7
Fire EWF-080-2006	2006	95	95	65.9
Fire EWF-138-2006	2006	240	240	68.5
McLeod 25 blowdown	2008	11.7	1.7	68.3
McLeod 12 blowdown	2009	54	1.5	67.2
2009 blowdown (multiple events)[1]	2009	181.6	181.6	69.0
2009 hail damage (multiple events)[1]	2009	1,714	1286.1	71.0
2011 hail damage (multiple events)	2011	5,450.4	5,450.4	86.0

Event	Year	Area disturbed (ha)	Area unsalvaged (ha)	Cumulative % unsalvaged
2011 Blowdown[2]	2011	669.9	669.9	86.9
No major events	2012	0.0	0.0	0.0
Total		11,191.6	9,722.2	86.9%

[1] The blowdown and hail damage areas reported here are approximate and include the entire extent of known events. Within the events there were portion that were not stand-replacing. The total areas associated with these events may be revised after more detailed analysis is completed and as we become aware of other disturbed areas associated with the 2009 wind and hail events.

[2] The blowdown areas reported here are approximate and include the entire extent of known events. Within the events there were portion that were not stand-replacing. The total areas associated with these events may be revised after more detailed analysis is completed and as we become aware of other disturbed areas associated with the 2011 wind and hail events. Some salvage has occurred of these events in 2011; however, a final accounting of these areas was not available at the time of this report.

The above noted Table will be updated annually in HWP's Stewardship Report.

Target #2

HWP will also develop an Operational Procedure that will be followed to plan salvage harvesting and retention following a natural disturbance. This will ensure that planning addresses aspects of the HWP response to the disturbance event.

HWP second target with respect to unsalvaged natural disturbances is as follows:

2. Apply operational procedures to address unsalvaged trees and patches at salvage planning stage.

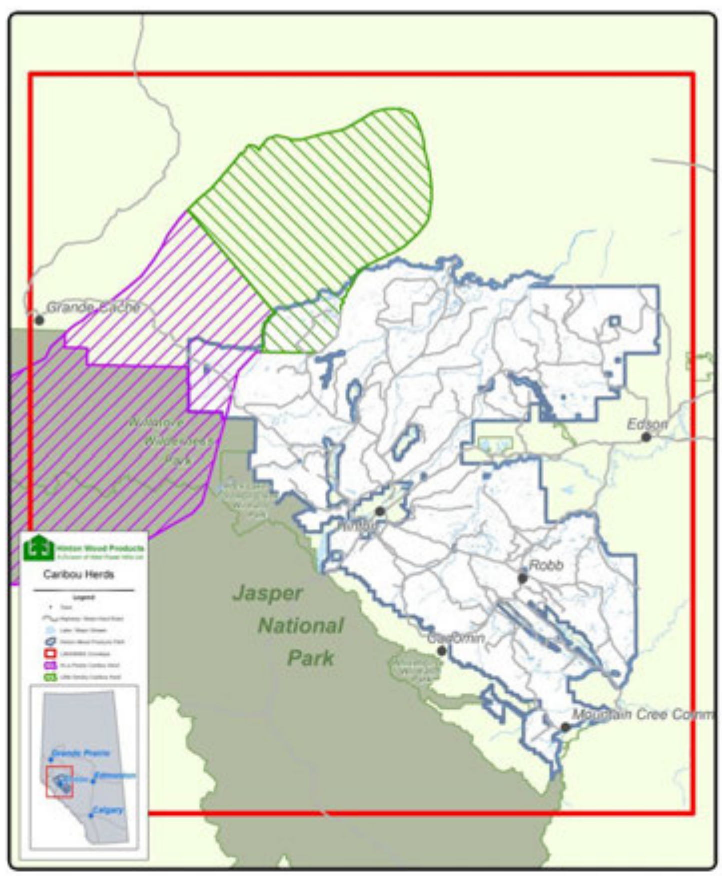
The operational procedures will ensure that retention within the overall disturbance event is planned to approximate natural disturbances, combining green (undisturbed) retention with partially disturbed and completely disturbed retention. A copy of these operational procedures can be found in Appendix 3.

4.0 Special Issues

Although the goal of this Natural Disturbance Strategy is to manage for all of the biodiversity on the landscape by managing the patterns on the FMA to approximate natural disturbance patterns, there still are situations where a different, more fine-filtered approach, to managing for biodiversity, as well as other values, may need to be considered. The following sections briefly describe some special issues that HWP has had to consider when developing this Natural Disturbance Strategy:

4.1 Caribou Range

Woodland Caribou in Alberta are designated as "threatened" under both the Alberta Wildlife Act and the Canada Species at Risk Act. Recovery strategies are required by the federal government. There are two caribou herds with portions of their range overlapping the Hinton FMA. The northwest corner of the FMA along the Berland River contains about 8% of the winter range of the A la Peche caribou herd and an area



occasionally used by the Little Smoky caribou herd (see Figure 34).

The A la Peche caribou herd is a migratory mountain ecotype caribou herd with summer range in the Rocky Mountains and winter range in the Foothills. The summer range is within Jasper National Park and Willmore Wilderness Park and adjacent areas in British Columbia. The winter range overlaps portions of Willmore Wilderness Park, Forest Management Unit E8 (Foothills Forest Products), and the Alberta Newsprint, Canfor, and Hinton Wood Products FMAs. In the last 15 years, it appears the A La Peche caribou are primarily using their winter range all year (i.e. they are not migrating onto their traditional summer range).

The Little Smoky caribou herd is a non-migratory boreal ecotype caribou herd with year round range to the east of the A la Peche herd on portions of Forest Management Unit E8 (Foothills Forest Products) and the Alberta Newsprint and Canfor FMAs. Little Smoky caribou occasionally cross the Berland River onto the Hinton Wood Products FMA for brief periods. Although the A la Peche and Little Smoky herd ranges share a common boundary, the two herds are believed to be genetically as well as behaviorally distinct.

Currently it is thought that predators, especially wolves, are the most limiting factor in terms of the survival of these and other Alberta caribou herds. The reasons for this are complex and not fully understood. Human activities such as timber harvesting and oil and gas extraction create young forest and linear corridors through caribou range. Young forest is good for moose, elk, and deer, and the corridors make it easier for wolves to move around. However, caribou are also not doing well in adjacent large protected areas such as Jasper and Banff National Parks; so industrial footprint doesn't appear to be the only issue. Milder winters, with less snow aren't good for caribou either, because caribou do well in deep snow, which force other ungulates like moose, elk, and deer to move elsewhere, taking the wolves with them. .

Figure 34 – *Little Smoky and A La Peche caribou herd ranges*

Natural events also influence caribou habitat and relationships with their predators. Forest fires have much the same effect as timber harvest – the young forest that regenerates following the disturbance isn't good caribou habitat. And now a new threat has arrived recently arrived in Alberta – the mountain pine beetle; left unchecked massive numbers of this tiny insect could kill most of the pine trees in Alberta (as they did in BC) and dramatically alter caribou habitat.

The Alberta Caribou Action and Range Planning Project is a government led project that will develop range plans for Alberta's caribou ranges and one action plan to meet the requirements of the Government of Canada's Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal population in Canada. In Alberta, caribou conservation and recovery are also guided by the Alberta Woodland Caribou Recovery Plan (2005) and A Woodland Caribou Policy for Alberta (2011).

As part of this Range Planning Project, Advisory Groups were formed to advise the government in the development of these Range Plans. The Little Smoky and A La Peche Multi-Stakeholder Advisory Group (Advisory Group) is one of four Advisory Groups supporting the Alberta's Caribou Action and Range Planning Project. The Alberta Forest Products Association has a representative on this Advisory Group representing the forest industry.

The Government of Alberta holds responsibility for writing the action and range plans. The Advisory Group, operating within the scope and purpose of the Alberta Caribou Action and Range Planning Project Charter provides advice for the Alberta's consideration in writing the plans. At this time, the Range Plan for the Little Smoky and A La Peche caribou herds is not completed. Once the plan is completed, there may, or may not, be access density targets, old forest retention targets, protected areas, or other constraints, all of which HWP will have to follow.

With respect to HWP's efforts to address caribou issues at a more fine-filter approach, we have undertaken the following:

1. NRV Analysis

HWP will carry out a natural disturbance analysis for the gross and contributing landbase for both the A Le Peche and Little Smoky caribou ranges. This analysis will include the following:

- The NRV will be calculated for each of the five seral stages (see Table 7) for each of the five forested cover types (see Table 7) in the range of the A Le Peche and Little Smoky caribou herds.
- NRV will be calculated for patch size and patch numbers for both caribou herds.
- The federal government has different seral stage brackets for examining caribou habitat. HWP will calculate NRV information for two age classes: less than 40 years and greater than 40 years, based on the five forested cover types, for the A Le Peche and Little Smoky caribou herd ranges.
- The Alberta government has different seral stage brackets for examining caribou habitat. They are as follows:

Age Strata	Young	Pole	Mature	Old
Pine	0-40	40-80	80-120	120+
Spruce	0-40	40-80	80-120	120+
Wetland Spruce	0-40	40-80	80-120	120+
Mixed	0-40	40-80	80-120	120+
Deciduous	0-40	40-80	80-120	120+

HWP will calculate NRV for each of the above noted seral stage and forested cover types in the range of the A Le Peche and Little Smoky caribou herd.

2. <u>Species Conservation Strategies</u>

HWP will develop and submit as part of the DFMP a comprehensive Species Conservation Strategy for the two caribou herds on the FMA. This strategy will contain:

- The latest information on the population status of the Little Smoky and A Le Peche caribou herds.
- A summary of the age classes and cover types within the home range of the caribou herds on the Hinton FMA.
- A road access strategy for the caribou area
- Operations timing strategy
- Best Management Practises

3. <u>Foothills Landscape Management Forum (FLMF)</u>

West Fraser is a founding partner of the Foothills Landscape Management Forum (FLMF). The FLMF provides a progressive forum for companies from the energy and forestry sectors who have recognized the importance of ILM and are committed to practicing environmental stewardship. It is unique in its governance structure, commitment to annual reporting, and the level to which plans are developed.

The FLMF was initiated in 2005 to manage risk through advancing integrated landscape management (ILM). FLMF members include five forestry companies, 10 energy companies, and one Aboriginal organization. There are a number of different initiatives the FLMF had initiated and implemented (or is still implementing), including:

- Developing an Integrated Industrial Access plan (2006)
- Caribou calf survival maternity ward project (2006)
- West Central Planning team (2006-2008)
- Seismic line inventory (2010) - 11,277 kilometres of lineal features collected seismic, pipelines, and well sites
- FLMF/ESRD partnership to complete a Regional Access Development Plan (2009-2012)
- Reclamation plan 2012 (current project) - Remove access no longer needed or redundant
- Foothills Land Stewardship Project – A newly proposed project. This project would be a formal public-private partnership between FLMF and Alberta. The project would support the

Land Use Framework, with the FLMF being the lead with respect to habitat (vegetation) and footprint and the GOA being the lead with respect to wildlife populations and people. The FLMF believes the working together we can achieve more than either can do alone, and that there can be a reallocation of resources to be more effective and efficient thereby reducing risk

4.2 Grizzly bear

In June 2010, the Government of Alberta officially declared grizzly bears a threatened species under Alberta's Wildlife Act. The management of grizzly bears is currently guided by the Alberta Grizzly Bear Recovery Plan. Grizzly bears are found throughout the FMA, with highest densities in the Upper Foothills and Subalpine Natural Subregions.

Timber harvesting on the Hinton FMA, which will maintain seral stages and cover types within their NRV, is not expected to have negative impacts on grizzly bear food resources, because grizzly bears are habitat generalists and bear foods tend to increase in recently disturbed habitats. Current research suggests that the highest correlation between human activities and grizzly bear mortality is access – when there are a lot of well-used roads in good grizzly bear habitat, people are more likely to come into contact with grizzly bears, and subsequently, grizzly bears are more likely to be killed. Under some conditions, grizzly bears may also avoid areas of high human activity, reducing the value of otherwise suitable habitat. Roads and other centers of human activity may also disrupt local and landscape-level grizzly bear movements.

No special natural disturbance related VOITs or natural disturbance data will be collected with respect to grizzly bear habitat. The primary mechanisms that HWP will employ to manage for grizzly bear will be through the implementation of our Natural Disturbance Strategy and through access management.

HWP will have a number of different access management related VOITs in the DFMP, which will include the following targets:

1. In core grizzly bear habitat units (see Figure 35) the target will be to have less 0.6 km/km2 of open all-weather forestry road.
2. In secondary grizzly bear habitat units (see Figure 35) the target will be to have less than 1.2 km/km2 of open all-weather forestry roads.
3. Annually, there will be less than 250 km of open temporary road for the FMA.
4. Develop Long Term Access Plans for the entire FMA.

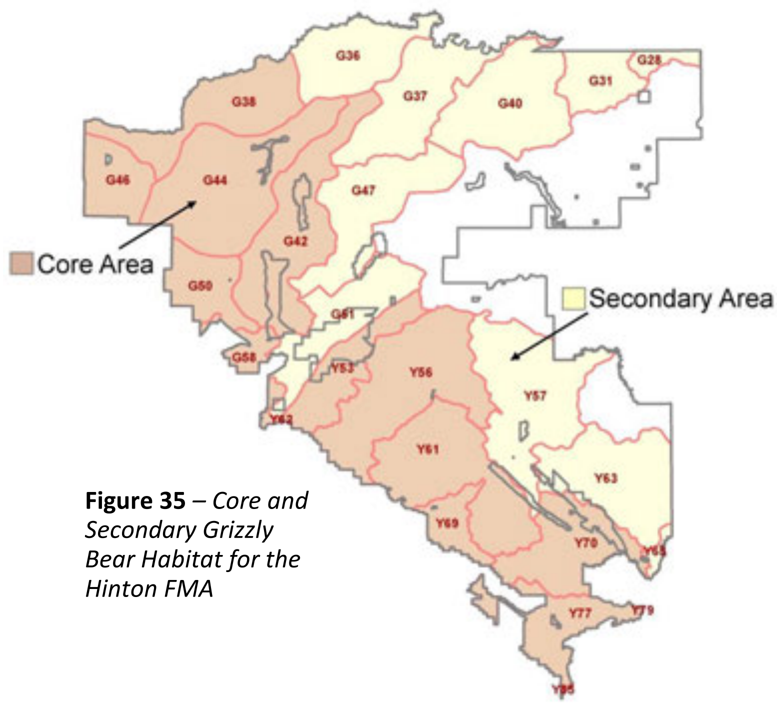


Figure 35 – *Core and Secondary Grizzly Bear Habitat for the Hinton FMA*

HWP will also develop a Species Conservation Strategy for grizzly bears, which will contain:

- The latest information on the conservation and population status of the grizzly bear population.
- Initiatives HWP is participating in with respect to grizzly bear conservation.
- An access management strategy

4.3 Olive-Sided Flycatcher

The Canada population of the olive-sided flycatcher was designated in the Species at Risk Act Schedule 1 as "threatened" in 2010. The most recent Alberta general status evaluation for the olive-sided flycatcher was "may be at risk" (ESRD 2010). The olive-sided flycatcher has not been evaluated by the Alberta Endangered Species Conservation Committee and is not designated under the Alberta Wildlife Act.

Olive-sided flycatchers are associated with open habitats during the breeding season. The species is widespread but uncommon on the FMA. Observations occurred in burned forest, along water body margins, and in early seral cutblocks.

Recent cutblocks with structure retention are potential breeding habitat. Retention of some naturally burned forest and structure retention when salvage harvesting burned forest should benefit the species. The application of HWP's Natural Disturbance Strategy should provide breeding opportunities and habitat for olive-sided flycatchers.

HWP's Natural Disturbance Strategy includes the following considerations for olive-sided flycatcher habitat:

1. Apply the natural pattern approximation approach (as outlined in this document) to develop the Spatial Harvest Sequence.
2. Implement stand structure targets as described in section 3.34.
3. As described in section 3.37, the cumulative total area of unsalvaged natural stand replacing disturbances will be at least 25% of area disturbed based on a 20 year rolling average.

HWP will also develop a Species Conservation Strategy for olive-sided flycatcher, which will contain information on:

- Conservation and population status
- FMA observations
- Limiting factors
- Habitat conservation strategy
- Monitoring
- Research and continual improvement

4.4 Athabasca Rainbow Trout and Bull trout

The Athabasca rainbow trout are native to Alberta waters and are confined to the upper Athabasca River and its tributaries, including on Hinton's FMA, the McLeod, Berland, and Wildhay Rivers. The Alberta Endangered Species Conservation Committee (ESCC) submitted a recommendation to ESRD in June 2009 to list the Athabasca rainbow trout as "threatened". This recommendation was based on the ESCC's assessment that there is a small population of Athabasca rainbow trout in a small area of occupancy, there are declines in the number of mature individuals, and habitat loss and degradation is occurring in their range. As of December 31, 2014, the legal designation was not finalized; however a recovery team was created with the task of developing a Recovery Plan for the trout. HWP's chief biologist Rick Bonar participated on the recovery team for this species. A recovery plan was released by Alberta in 2014 titled, "*Alberta Athabasca rainbow trout Recovery Plan 2014-2019*".

Bull trout are classified as "sensitive" in the current *General Status of Alberta Wild Species* report. Alberta's ESCC has identified the bull trout as a "species of special concern", which is species that without human intervention may soon become threatened with extinction. In December 2012, the Committee on the Status of Endangered Wildlife in Canada (COESWIC) assessed the bull trout and officially declared the populations "threatened" in the Saskatchewan and Nelson rivers due to habitat deterioration and reduced habitat connectivity. Bull trout occur throughout the Hinton FMA; however most of these fish occur in the Athabasca River drainage basin.

At this time, HWP does not believe there is anything in HWP's Natural Disturbance Strategy or its associated Riparian Management Strategy (section 3.35) that will be inconsistent with the Athabasca Rainbow Trout

Recovery Plan; nor do we believe there will be any negative impact on bull trout. One of the major tenants of HWP's Riparian Management Strategy is that removing all disturbances from riparian areas will have ecological consequences over time. However, as previously noted, Alberta has told HWP that at this time they will not approved any implementation of the Riparian Management Strategy near streams that are identified in the recovery plan as containing Athabasca rainbow trout or ecologically significant habitat for Athabasca rainbow trout.

HWP has also made additional commitments with the DFMP that will more specifically address considerations for Athabasca rainbow trout and bull trout, including the following:

1. HWP will continue to implement its Stream Crossing Inspection Program and maintain an inventory of all HWP watercourse crossings on the Hinton FMA.
2. HWP will remediate Company stream crossings (old and new) not meeting current standards on watercourses according to an annual action plan. The annual action plan will be updated throughout the course of the year to address unforeseen crossing issues.
3. New crossing designs will meet standards of the Code of Practice for Water Course Crossings.
4. HWP will continue to participate in the Foothills Stream Crossing Partnership, a group of companies and organizations with a mandate to inspect and repair old stream crossing in a geographic area centred around the Hinton FMA.
5. Portions of Mackenzie Creek and Little Berland River are Class A waterbodies and will have 100 metre buffers.
6. Portions the Tri-Creeks (Eunice, Wampus, and Deerlick Creeks) and portions of the upper Berland River and its tributaries Fox, Moon, Cabin, and Hendrickson Creeks are Class B waterbodies and will have 30-60 metre buffers depending on stream width.

HWP will also develop a Species Conservation Strategy for Athabasca rainbow trout and bull trout (and grayling), which will contain information on:

- Conservation and population status
- Limiting factors
- Habitat conservation strategy
- Monitoring
- Research and continual improvement

4.5 Aesthetics

The main principle around HWP's Natural Disturbance Strategy is that we want to approximate patterns created by natural disturbance – in the Foothills, this means patterns created by fire. The scale of fire events vary from the very small, which would occur often, to the very large (tens of thousands of hectares), which would occur less frequently. So to approximate fire, one needs to create a range of opening sizes, both large and small. Large openings can be creating either in a one, two, or three pass harvesting system, where the number of passes may increase as the other values such as aesthetics become more important. HWP's Natural Disturbance Strategy addresses opening/patch sizes (section 3.32), event sizes (section 3.34) and structure retention (3.34). However, none of these strategies directly address aesthetics; and there are areas on the FMA where aesthetics are more important, and where large events would not be as socially acceptable due to other values such as recreation, aesthetics, and ecotourism. In these situations, HWP has the flexibility to create smaller natural disturbance events, because not all events need to be large, and/or the flexibility to employ multiple-pass harvesting plans.

In order to identify which areas on the FMA were the most visually sensitive, HWP contracted Industrial Forestry Service to complete a Visual Landscape and Recreation Feature Inventory of the FMA in 1997. This inventory was conducted using the British Columbia Ministry of Forests standards and provided a description of the main visual landscape, recreation features, recreation sites and significant viewing locations on the FMA. The inventory covered areas visible from provincial highways and major river corridors. The inventory was further stratified into five visual quality classes, which defined the broad management intent with respect to aesthetics – a classification of "high" represented areas with the highest visual sensitivity from key locations by large numbers of people, and that were sensitive to disturbances that alter views.

Since 1997, visual assessments (computer generated images and metrics of planned harvesting) have been initiated or completed on all compartments identified as having high visual sensitivity in the visual landscape inventory. This will continue to be a strategy employed by HWP and will be part of a VOIT in the DFMP.

4.6 Habitat Supply

Implementing HWP's Natural Disturbance Strategy is the Company's overriding coarse filter approach to managing habitat supply for all species on the FMA. However, as previously noted, there are times when a more fine-filter approach may be required. One option is to run habitat supply modeling for various species to see that an appropriate supply of habitat is maintained over time. However, it has been HWP's experience to date that habitat modelling has limited value, as it proves to be very difficult to show any significant impact to the habitat of any species given that the FMA is so large.

For this DFMP, in order to address habitat needs of key indicator species, HWP has chosen the strategy of developing a Species Conservation Strategy VOIT, for species deemed to be threatened, at-risk, or of special concern. In the 2014 DFMP, HWP will develop Species Conservation Strategies for the following species:

- Arctic Grayling
- Athabasca Rainbow Trout
- Bull Trout
- Caribou
- Common Nighthawk
- Grizzly Bear
- Olive-sided Flycatcher
- Pinto Creek Mountain Goats
- Trumpeter Swan

HWP will report on the results of Species Conservation Strategies in HWP's Stewardship Report.

4.7 Sensitive Sites

The coarse-filter natural disturbance approach, by definition, does not necessarily address smaller sensitive sites and special features. However, these sites will not be ignored – when they are encountered in the field, we will tend to put in a retention patch or harvest carefully. The objective is to protect and maintain the integrity of rare ecological sites, sensitive sites, and special landscape features. Examples include tufa spring, glacial erratic, hoodoo formations and mineral licks. HWP has developed a specific VOIT for the DFMP to address sensitive sites.

5.0 Future Issues

5.1 Disturbance in the Passive Landbase

The guiding principle of HWP's Natural Disturbance Strategy is to remove natural disturbance from the landscape (to the extent possible) and replace this disturbance with timber harvesting in patterns similar to those caused by natural disturbance. However, timber harvesting cannot occur everywhere on the landbase – operational constraints such as: steep slopes, unmerchantable timber (e.g. black spruce/tamarack stands), wetland, and management buffers all mean that a significant portion of the landbase is unavailable for timber harvest. In the case of the Hinton FMA, this passive landbase accounts for approximately 35% of the total landbase. Over time, with no change in the current policy (which is to fight all fires on the FMA), this means that the passive landbase will become older than it would be in the absence of fire control. In other words, it will range outside of its NRV. Over long periods of time, this is likely to have ecological consequences, as some cover types (and the biodiversity associated with them), such as wetland black spruce, will have little to no young seral stages.

This issue is not something that has to be addressed right away; but as time passes, it may become an issue in the future. There are certainly available options to deal with the issue; the most apparent one being to carry out prescribed burns from time to time within the passive landbase. This obviously carries risk and would likely have to be something carried out by ESRD.

As technology and wood product demand change moving into the future, as they surely will, it is also possible that some of this passive landbase will become active again.

5.2 Distribution of Old Forest

Implementing HWP's current Natural Disturbance Strategy means that, over time, most old forest will be situated in the passive landbase. This is because as the current old forest in the active landbase is harvested, the resulting second growth will be harvested before it reaches an old forest stage; therefore, the old forest required to stay within NRV will by necessity migrate into the passive landbase. This will not become an issue immediately, but may over time, unless we change our standard procedure. There are also other options to address this issue, such as emulating old forest in mature forests through various harvesting techniques (e.g. group selection, shelterwood, etc.), or by implementing longer rotations on a portion of the landbase. Simply identifying an area as old forest and protecting it from harvest will not work in the long term, as these stands will eventually succumb to fire or die of old age.

5.3 Old Hardwood Forests

Old hardwood forests cannot be kept in an old seral stage indefinitely – these forests will eventually cycle to another cover type; probably white spruce or mixed wood. If hardwood stands are excluded due to economic or operational constraints, it may be difficult to maintain hardwood stands within their NRV on the FMA because these stands will eventually cycle to another cover type. This is not a short term issue, but may become an issue over time.

6.0 Conclusion

Managing landscapes based on natural disturbance (ND) principles is a concept that has gained wide acceptance and recognition across North America in the last decade and a half. In fact, most governments and independent forest certification schemes require some type of natural disturbance analysis and target setting. However, the differences between the current ND requirements/standards and what HWP is proposing in this Natural Disturbance Strategy are significant.

This Natural Disturbance Strategy tries to address all the aspects of current natural disturbance research and findings, not just the simpler ones (e.g. setting seral stage targets). For example, tracking and measuring stand structure retention based on new research, new terminology, and new models (e.g. LANDMINE and NEPTUNE) is something not being done anywhere else in Alberta. The common practise is to just leave a percentage (i.e. 1-5%) of merchantable trees in islands within cutblocks. While this is simple, it does not align with current science, which shows that all unburned (i.e. unlogged) and partially burned (i.e. partially logged) areas within a disturbance event are of equal importance. As explained in section 3.34, HWP is proposing to implement a new stand structure retention strategy that will track structure retention metrics; with the goal of being within the NRV for structure retention over time.

Another significant departure from status quo is HWP's proposed Riparian Management Strategy (Appendix 2). While it would simpler to ignore the fact (which is the common practise) that riparian areas experience and require disturbance, HWP has taken the unprecedented step of developing new methodologies to identify and classify riparian areas within the FMA, and are also proposing careful disturbance within these areas based on NRV targets developed specifically for riparian areas. Because we recognize the sensitivity of these riparian areas, HWP has also developed a rigorous monitoring and measuring program (Appendix 3, 4, and 5 in the RMS).

While HWP's Natural Disturbance Strategy is based on the principle that approximating the variability of natural forest patterns is the best way to ensure long term conservation of forest values, this strategy must also be balanced with societal values, economic constraints, changing expectations, and scientific knowledge. Through the implementation of this Natural Disturbance Strategy, HWP seeks to strike a balance that is scientifically sound, affordable, and acceptable to society.

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APPENDIX 1

Stand Structure Retention Sample Data

<u>Stand Structure Retention Sample Data</u>

This appendix presents some example data with the intent of showing how HWP would monitor and report on a number of key components of approximating natural disturbance; namely – event size (distribution and density), disturbance patch size (distribution and density), island remnants (percentage of an event distribution and density), and matrix remnants (percentage of an event distribution and density). Sample data and sample graphs are also shown.

The sample data found in Tables 1, 2, and 3 of this appendix describe natural disturbance metrics for three fictional events (two harvesting events and one fire event) a portion of which occurred in 2012 and three fictional planned events that would be part of HWP's 2014 Spatial Harvest Sequence. All sample graphs were also derived from this data.

To implement an event metrics tracking and reporting system, HWP would collect the following data for each event on the Hinton FMA in 2012, and for each proposed event in HWP's Spatial Harvest Sequence (up to various time points):

1. **<u>Event #</u>** – Each event will be identified as described in section 2.1 and given a unique number.
2. **<u># of Events</u>** – The total number of events (i.e. event density) will be tracked.
3. **<u>Status (O, C, or P)</u>** – The status of the event will be tracked. Events will either be: open (O), meaning all harvesting is not yet complete; closed (C), meaning all harvesting is completed; or, Planned (P) meaning the event is part of the Spatial Harvest Sequence and harvesting has yet to begin.
4. **<u>Natural Subregion</u>** – Each event will be in either: the Lower Foothills Subregion (LF), the Upper Foothills Subregion (UF), or the Subalpine Subregion (A). Events that fall into the Montane Subregion will be lumped into the Lower Foothills and events that fall into the Alpine Subregion will be lumped into the Subalpine Subregion.
5. **<u>Working Circle/Compartment</u>** – The working circle (Athabasca, McLeod, Embarrass, Marlboro, and Berland) and Compartment will be tracked for each event.
6. **<u>Year of original disturbance for the Event</u>** – For harvested events, the year of the original disturbance for the event will be determined based on the youngest age of a cutblock (based on the year the cutblock was skid cleared). For fires, the year of the original disturbance will be the year the fire took place.
7. **<u>Event Size (ha)</u>** – The total size of the event will be tracked, which is the sum of the area of disturbed patches, matrix remnants, and island remnants.
8. **<u>Harvest or ND</u>** – The event can either be a harvest event (i.e. caused by harvesting) or a natural disturbance event (i.e. caused by a natural disturbance such as fire, blowdown, or hail).
9. **<u>Disturbed Patches</u>** – The following information will be collected for each disturbed patch:

    a. *<u>Patch #</u>* – Each patch will be given its own unique identity number. The minimum size for a patch is 0.04 hectares.
    b. *<u># of Patches</u>* – The total number of patches (i.e. patch density) in each event will be tracked.
    c. *<u>Block #</u>* – The block number (i.e. working circle-compartment-block #) of each block making up a patch will identified.
    d. *<u>Block Area (ha)</u>* – The total net area of the block will be tracked (i.e. all islands in the block are netted out and counted separately as islands).
    e. *<u>Year Harvested</u>* – The year the block was finished harvesting (skid cleared).

10. **<u>Island Remnants</u>** – The following information will be collected for each island remnant:

    a. *<u>Island #</u>* – Each island patch will be given its own unique identity number.
    b. *<u># of Islands</u>* – The total number of islands (i.e. island density) in each event will be tracked.
    c. *<u>Island Type</u>* – Each island will be either identified as undisturbed (U), meaning there is burned area within the island, or disturbed (D), meaning there is burned area within the island. All islands created by harvesting will be categorized as undisturbed.
    d. *<u>Island Area (ha)</u>* – The area of each island will be tracked.
    e. *<u>In-block (Y/N)</u>* – Is the island within a harvested block? Yes, if the island is totally within a cutblock; No, if the island is created by the amalgamation of a number of cutblocks; "N/A" , if the island is a result of a natural disturbance. The intent of this column is to report on the percentage of islands left within HWP harvested cutblocks.

11. **Matrix Remnants** – The following information will be collected for each matrix remnant:

   a. Matrix # – Each matrix patch will be given its own unique identity number.
   b. # of Matrix – The total number of matrix remnants (i.e. matrix density) in each event will be tracked.
   c. Matrix Area (ha) – The area of each matrix remnant will be tracked.

TABLE 1 - SAMPLE DATA – EVENTS IN 2012 (YEAR 0) ON THE HINTON FMA

Event #	# of Events	Status* O, C, or P	Natural Subregion	Working Circle - Compartment	Year of original disturbance	Event Size (ha)	Harvest or ND	Disturbed Patches: Patch #	# of Patches	Blk. #	Area (ha)	Yr. harvested	Island Remnants: Island #	# of Islands	Island Type**	Area (ha)	In-block (Y/N)	Matrix Remnants: Matrix #	# of Matrix	Area (ha)
1	1	C	UF	1-4	2010	200.1	H	1-P1		1-4-0002	21.3	2010	1-I1	1	U	0.1	Y	1-M1	1	3
										1-4-0003	15.3	2010	1-I2	1	U	0.3	Y	1-M2	1	6.5
									1	subtotal	36.6							1-M3	1	13.2
								1-P2		1-4-0004	15.2	2012	1-I3	1	U	0.5	Y	1-M4	1	6.5
										1-4-0005	22.4	2012	1-I4	1	U	0.8	Y	1-M5	1	12.8
									1	subtotal	37.6							1-M6	1	15.2
								1-P3		1-4-0006	20.6	2012	1-I5	1	U	0.8	Y	1-M7	1	2.1
										1-4-0007	14.9	2012	1-I6	1	P	2.1	Y	1-M8	1	1.4
										1-4-0008	9.4	2012	1-I7	1	U	1.3	Y			
									1	subtotal	44.9		1-I8	1	U	0.2	Y			
													1-I9	1	U	5.3	N			
													1-I10	1	U	8.9	N			
								Grand totals Event #1	**3**		**119.1**			**10**		**20.3**	**6.1**		**8**	**60.7**
3	1	C	UF	2-4	2000	425.3	H	3-P1	1	2-4-0112	130.5	2005	3-I1	1	U	0.3	Y	3-M1	1	2.4
													3-I2	1	U	1.2	Y	3-M2	1	1.3
													3-I3	1	U	3.5	Y	3-M3	1	4.2
								3-P2	1	2-4-0113	110.3	2000	3-I4	1	P	4.5	Y	3-M4	1	36.1
													3-I5	1	U	0.4	Y	3-M5	1	19.7
													3-I6	1	U	3.2	Y	3-M6	1	2.1
								3-P3	1	2-4-0114	40.5	2012	3-I7	1	U	0.3	Y	3-M7	1	23.8
								3-P4	1	2-4-0115	15.1	2012	3-I8	1	U	2.3	Y	3-M8	1	1
													3-I9	1	U	10.4	N	3-M9	1	0.9
													3-I10	1	U	11.3	N			
								Grand totals Event #3	**4**		**296.4**			**10**		**37.4**	**15.7**		**9**	**91.5**
15	1	C	UF	4-3	2010	179.4	ND	15-P1	1	n/a	105.4	2010	5-I1	1		10.5	Y	15-M1	1	10.1
													5-I2	1		1.8	Y	15-M2	1	0.4
											subtotal							15-M3	1	2.1
								15-P2	1	n/a	10.2	2012	5-I3	1		0.4	Y	15-M4	1	0.6
												2012	5-I4	1		0.2	Y	15-M5	1	0.7
												2012	5-I5	1		0.4	Y	15-M6	1	2.1
											subtotal									
								15-P3	1	n/a	15	2011	5-I6	1		2.5	Y			
								15-P4	1	n/a	8	2011	5-I7	1		0.4	Y			
								15-P5	1	n/a	5	2011	5-I8	1		0.2	Y			
								15-P6	1	n/a	3	2011	5-I9	1		0.4	Y			
								Grand totals Event #15	**6**		**146.6**			**9**		**16.8**	**16.8**		**6**	**16**
				Total 1950-2012		**625.4**			**13**		**562.1**			**29**		**74.5**			**23**	**168.2**

TABLE 2 - SAMPLE DATA – EVENTS IN THE 2014 SPATIAL HARVEST SEQUENCE

		Status*						Disturbed Patches					Island Remnants					Matrix Remnants		
Event #	# of Events	O, C, or P	Natural Subregion	Working Circle - Compartment	Year of original disturbance	Event Size (ha)	Harvest or ND	Patch #	# of Patches	Blk. #	Area (ha)	Yr. harvested	Island #	# of Islands	Island Type**	Area (ha)	In-block (Y/N)	Matrix #	# of Matrix	Area (ha)
95	1	P	UF	5-12	2015	768.4	H	95-P1	1	5-12-0112	300.3	2015	95-I1	1	U	0.4	Y	95-M1	1	51.8
													95-I2	1	U	4.2	Y	95-M2	1	32.1
													95-I3	1	U	1.2	Y	95-M3	1	8.5
								95-P2	1	5-12-0113	162.8	2015	95-I4	1	U	1.7	Y	95-M4	1	3.2
													95-I5	1	U	1.8	Y	95-M5	1	1.8
								95-P3	1	5-12-0114	95.1	2015	95-I6	1	U	3.1	Y	95-M6	1	5.7
													95-I7	1	U	1.5	Y	95-M7	1	0.9
								95-P4	1	5-12-0115	30.4	2015	95-I8	1	U	9.5	Y	95-M8	1	1.2
													95-I9	1	U	2.1	Y	95-M9	1	6.8
								95-P5	1	5-12-0116	15.8	2016	95-I10	1	U	1.1	Y	95-M10	1	2.5
													95-I11	1	U	10.2	N	95-M11	1	3.1
													95-I12	1	U	8.4	N	95-M12	1	1.2
						Grand totals Event #95			**5**		**604.4**			**12**		**45.2**	**26.6**		**12**	**118.8**
99	1	P	UF	3-10	2016	1596.2	H	99-P1		3-10-0021	85.3	2016	99-I1	1	U	5.6	Y	99-M1	1	65.2
										3-10-0022	25.6	2024	99-I2	1	U	0.4	Y	99-M2	1	15.2
										3-10-0023	72.3	2016	99-I3	1	U	1.2	Y	99-M3	1	12.4
										3-10-0024	52.1	2024	99-I4	1	U	3.4	Y	99-M4	1	21.4
									1	subtotal	235.3		99-I5	1	U	0.4	Y	99-M5	1	10.2
													99-I6	1	P	2.6	Y	99-M6	1	1.2
													99-I7	1	U	17.5	Y	99-M7	1	0.5
																		99-M8	1	4.2
								99-P2		3-10-0025	36.9	2016	99-I8	1	P	8.1	Y	99-M9	1	0.4
										3-10-0026	75.1	2024	99-I9	1	U	2.1	Y	99-M10	1	0.8
										3-10-0027	26.3	2016	99-I10	1	U	1.2	Y	99-M11	1	1.2
									1	subtotal	138.3							99-M12	1	12.8
								99-P3		3-10-0028	320.25	2016	99-I11	1	U	0.4	Y	99-M13	1	1.2
										3-10-0029	180.2	2024	99-I12	1	U	2.5	Y	99-M14	1	1.5
										3-10-0030	146.1	2016	99-I13	1	U	21.6	Y	99-M15	1	0.9
										3-10-0031	95.6	2024	99-I14	1	P	9.5	Y	99-M16	1	0.5
													99-I15	1	U	42.1	Y	99-M17	1	0.4
									1	subtotal	742.15							99-M18	1	10.1
								99-P4		3-10-0032	32.1	2016	99-I16	1	U	1.2	Y	99-M19	1	1.1
										3-10-0033	15.2	2024	99-I17	1	U	1.2	Y	99-M20	1	0.3
										3-10-0034	8.9	2016	99-I18	1	U	2.3	Y			
										3-10-0035	15.2	2024	99-I19	1	U	1.8	Y			
									1	subtotal	71.4	2016	99-I20	1	U	5.2	Y			
								99-P5	1	3-10-0036	42.1	2024	99-I21	1	U	1.8	Y			
													99-I22	1	U	20.1	N			
													99-I23	1	U	21.1	N			
													99-I24	1	U	32.1	N			
						Grand totals Event #99			**5**		**1229.25**			**24**		**205.4**	**132.1**		**20**	**161.5**

Event #	# of Events	Status* O, C, or P	Natural Subregion	Working Circle - Compartment	Year of original disturbance	Event Size (ha)	Harvest or ND	Disturbed Patches: Patch #	# of Patches	Blk. #	Area (ha)	Yr. harvested	Island Remnants: Island #	# of Islands	Island Type**	Area (ha)	In-block (Y/N)	Matrix Remnants: Matrix #	# of Matrix	Area (ha)
111	1	P	UF	1-15	2017	214.4	H	111-P1	1	1-15-1011	92.2	2017	111-I1	1	U	15.2	Y	111-M1	1	12.1
													111-I2	1	U	3.3	Y	111-M2	1	5.2
													111-I3	1	U	1.9	Y	111-M3	1	1.2
								111-P2	1	1-15-1012	43.1	2017	111-I4	1	U	5.2	Y	111-M4	1	2.1
													111-I5	1	U	0.5	Y	111-M5	1	0.8
													111-I6	1	U	0.3	Y	111-M6	1	0.4
													111-I7	1	U	0.8	Y	111-M7	1	0.2
													111-I8	1	U	0.5	Y	111-M8	1	2.5
								111-P3	1	1-15-1013	10.2	2017	111-I9	1	U	4.5	Y	111-M9	1	0.3
													111-I10	1	U	0.4	Y	111-M10	1	0.5
													111-I11	1	U	0.5	Y			
													111-I12	1	U	10.5	N			
						Grand totals Event #111			**3**		**145.5**			**12**		**43.6**	**33.1**		**10**	**25.3**

TABLE 3 – SAMPLE DATA – EVENTS FROM YEAR 0 PLUS EVENTS IN THE 2014 SPATIAL HARVEST SEQUENCE (to Year 5)

Event #	# of Events	Status* O, C, or P	Natural Subregion	Working Circle - Compartment	Year of original disturbance	Event Size (ha)	Harvest or ND	Disturbed Patches: Patch #	# of Patches	Blk. #	Area (ha)	Yr. harvested	Island Remnants: Island #	# of Islands	Island Type**	ha.	In-block (Y/N)	Matrix Remnants: Matrix #	# of Matrix	ha
	6				**1950-2012 plus SHS - TOTALS**				**26**		**2541.3**			**77**		**368.7**	**230.4**		**65**	**473.8**
															% in-block retention		**9.1%**			

SAMPLE GRAPHS

The following graphs are examples (using the data in Tables 1, 2, and 3) of the type of natural disturbance metrics that HWP might track and report on. The information from these graphs would help direct the size and numbers of events (at the DFMP level) and the number and types of island and matrix remnants (at the DFMP and Forest Harvest Plan level).

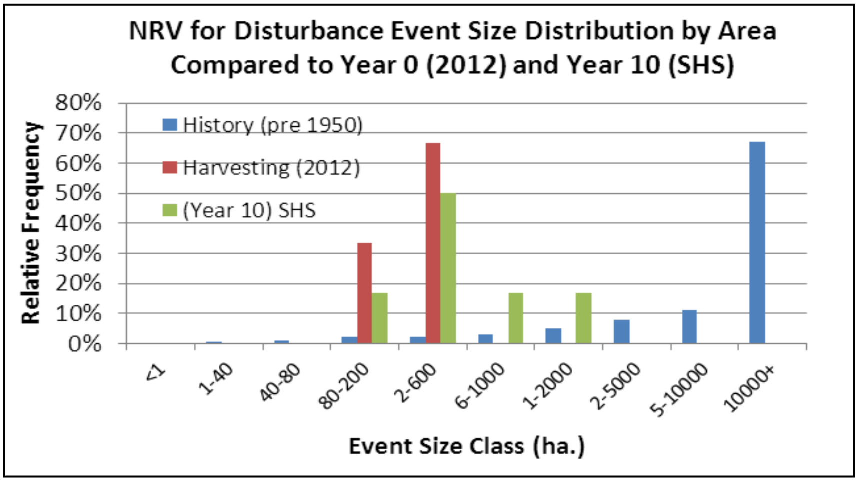

Figure #1 – *The NRV for event sizes in the Alberta Foothills compared with the Year 0 (2012) and forecasted based on Year 10 of the Spatial Harvest Sequence (SHS). The graph shows a strategy of moving into larger event class sizes over time. This graph is generated from sample data used in Tables 1, 2, and 3.*

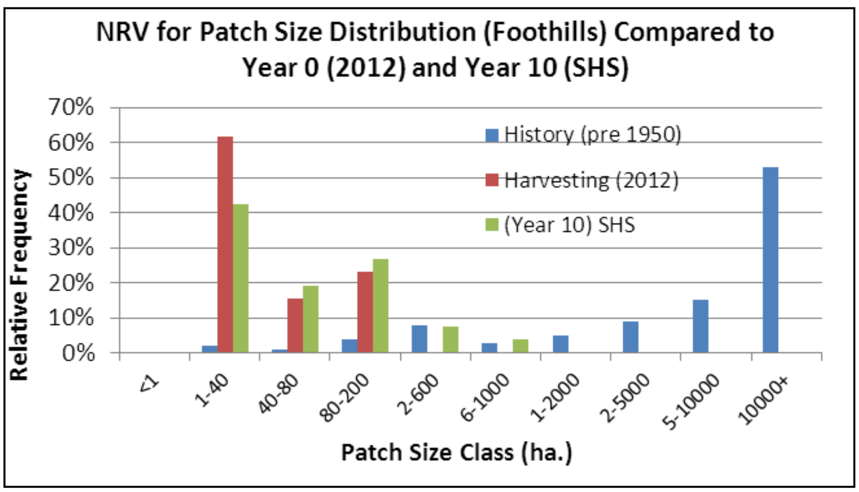

Figure #2 – *The NRV for patch sizes in the Alberta Foothills compared with the Year 0 (2012) and forecasted based on Year 10 of the Spatial Harvest Sequence (SHS). The graph shows a strategy of moving into larger patch class sizes over time. This graph is generated from sample data used in Tables 1, 2, and 3.*

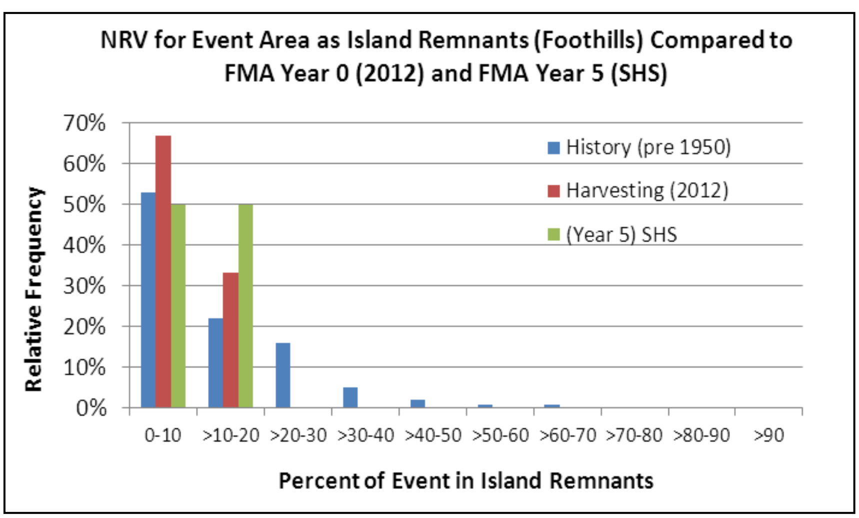

Figure #3 – *The NRV for island remnants in Alberta Foothills compared with the Year 0 (2012) and forecasted based on Year 5 of the Spatial Harvest Sequence (SHS). The graph shows a strategy of moving into a better balanced island retention strategy over time. This graph is generated from sample data used in Tables 1, 2, and 3.*

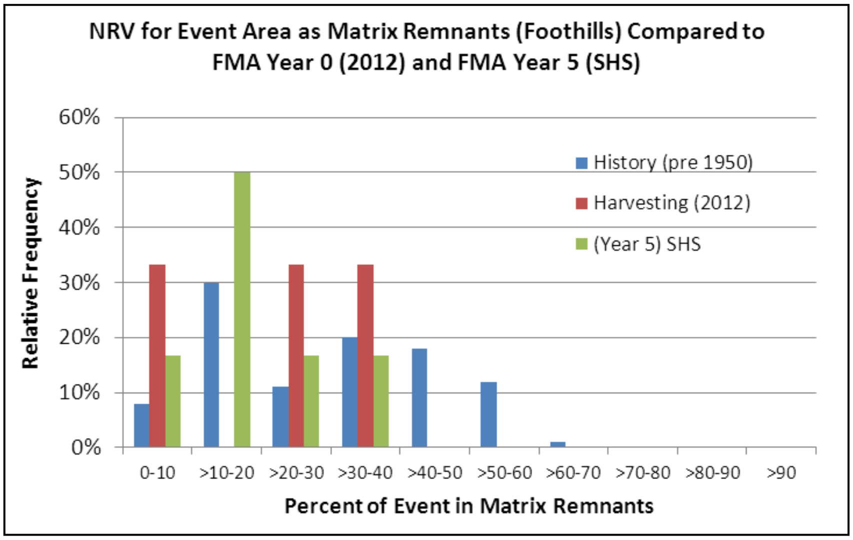

Figure #4 – *The NRV for matrix remnants in Alberta Foothills compared with the Year 0 (2012) and forecasted based on Year 5 of the Spatial Harvest Sequence (SHS). The graph shows a strategy of moving into a better balanced matrix retention strategy over time. This graph is generated from sample data used in Tables 1, 2, and 3.*

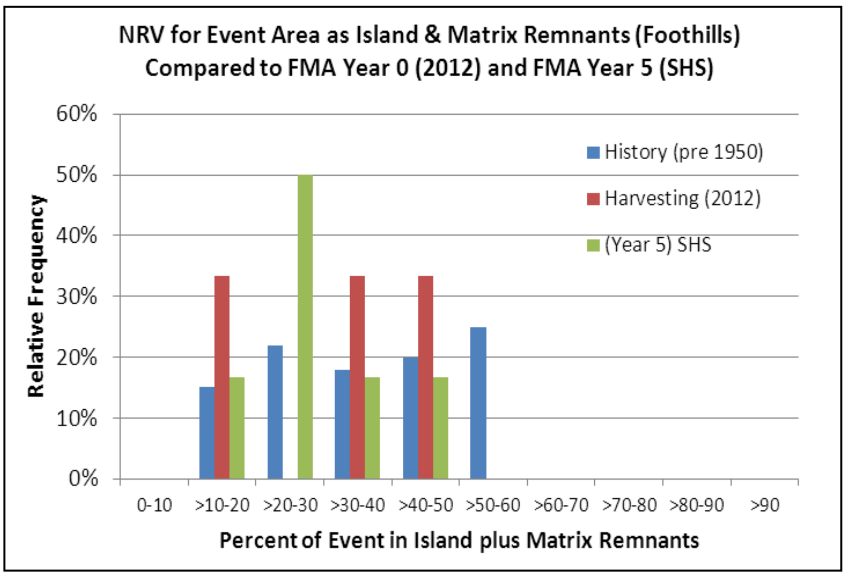

Figure #5 – *The NRV for island and matrix remnants in Alberta Foothills compared with the Year 0 (2012) and forecasted based on Year 5 of the Spatial Harvest Sequence (SHS). The graph shows a strategy of moving into a better balanced island and matrix retention strategy over time. This graph is generated from sample data used in Tables 1, 2, and 3.*

APPENDIX 2

HWP’s Riparian Management Strategy

Hinton Wood Products
A division of West Fraser Mills Ltd.

AN ECOSYSTEM-BASED RIPARIAN MANAGEMENT STRATEGY

Prepared by: Aaron Jones, RPF
Hinton Wood Products

December 2013

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9.1 Develop Stand-Level Riparian Disturbance Treatment Options

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1.0 Example of a Silviculture Treatment Options for Riparian Areas on the FMA used for the DFMP

1.0 Introduction

The Government of Alberta (GOA) completed a *Review of Riparian Management Policy in Alberta's Forests* (Alberta Sustainable Resource Development 2005). The review recommended maintaining fixed-width buffers in current policy. It also recommended that Alberta "retain variance provisions but provide clear direction and criteria when harvesting in buffers can be considered." Hinton Wood Products (HWP) has a long history of applying variable-width buffers through ESRD-approved variances to the Operating Ground Rules (OGR). ESRD staff have indicated that they will no longer approve OGR variances for watercourse buffers. Rather, ESRD requested that HWP develop a riparian management strategy for ESRD approval. Hinton Wood Products' response to this direction was to develop and incorporate a new riparian management approach for the Forest Management Area (FMA) into the 2014 Detailed Forest Management Plan and Operating Ground Rules. This document outlines HWP's proposed Riparian Management Strategy.

In the following sections, this Riparian Management Strategy will describe the management approach that will be applied to manage and conserve FMA riparian areas as part of HWP's overall Natural Disturbance Strategy. The guiding principle of a natural disturbance approach is to maintain natural forest patterns and ages across the landscape. That means all decisions – protected sites, roads, harvesting, and all other aspects of forest stewardship – are based on maintaining forests similar in condition and function to those produced by nature.

HWP is able to maintain forest patterns and ages across the landscape by understanding and approximating natural disturbances, such as fires, insects, disease, wind, and flowing water, that have shaped the forest landscape over time, so that new forests develop characteristics that are similar to natural forests.

2.0 Natural Disturbance – What It Means To Us

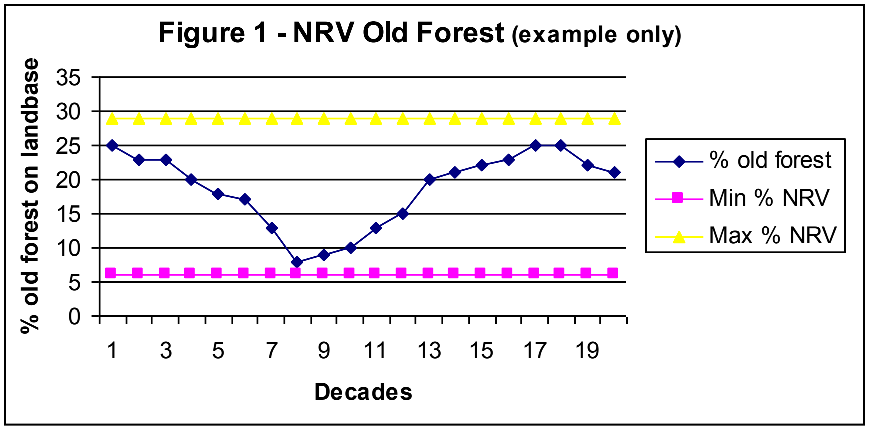
Approximating natural disturbance may mean different things to different people. In federal or provincial parks, for example, maintaining natural disturbance might mean aggressively fighting some fires while letting others burn; or it may mean purposely lighting fires in a more controlled way (i.e. prescribed burning). For HWP, maintaining natural disturbance patterns on the landbase is primarily accomplished through the planning and implementation of various patterns, sizes, shapes, and types of harvest openings.

HWP's understanding of natural disturbance, and the subsequent incorporation of natural disturbance principles into both our operational and long term harvesting plans, have been guided and shaped by the Natural Disturbance Program at the Foothills Research Institute (FRI). The Natural Disturbance Program at FRI began in 1996, and over the ensuing years has completed studies of natural disturbance patterns at very broad scales (like fire disturbance cycles and sizes) and has also explored questions at intermediate scales (like residual patterns after fires) and fine scales (like disturbance edge architecture). The Natural Disturbance Program was renamed the Healthy Landscapes Program in 2012, but its mandate remains the same.

The main assumption driving this research program is this – in the absence of information on alternatives, using natural disturbance patterns to guide management is the best approach to achieving ecological sustainability. This natural disturbance approach is designed to safeguard the values of healthy forests including biodiversity conservation.

Implementing a natural disturbance strategy depends on a key concept called the Natural Range of Variation (NRV). Forests are highly dynamic, and the measurable amount of any aspect of a forest (e.g. the amount of old forest) varies over time depending on the variable rate of disturbances and the time since disturbances. The range of this measurable variation is called the NRV. Remaining within the NRV and providing variation over time is thought to be a good way to increase the chance that managed forests will function ecologically the way natural forests do. In some situations, the landscape may already be out of the NRV – in these cases, HWP would want to manage the landscape over time to move back it into the NRV. Figure 1 illustrates the concept of NRV – the NRV is the area in the graph between the minimum percentage of the landbase that would be in old forest (the pink line) and the maximum percentage of the forest that would be old forest (the yellow line). This is an example only.

Natural disturbance events (such as fire) appear to affect the landscape more or less equally – that is, they don't consistently burn certain stands or landforms and leave others untouched. This is an important point when considering areas such as riparian zones.



In general, the word riparian refers to land adjacent to a stream, river, lake or wetland where water presence results in vegetation that is distinctly different from the vegetation of adjacent upland[1] areas.

The current practice in much of North America is to put no-harvest buffers around riparian areas – these buffers vary in width depending on the size of the watercourse being buffered. However, research by FRI (and others) has shown that fire burns through riparian zones roughly equal to how it burns in upland areas. FRI research also found evidence to suggest that fire in riparian zones is at least partially responsible for the unique habitat characteristics of riparian zones. The removal or prevention of disturbances from these habitats would presumably have significant ecological consequences (Andison and McCleary, 2002).

In summary, natural disturbance does mean different things to different stakeholders depending on your point of view and interests; however, for Hinton Wood Products, and our nearly one million hectare Forest Management Area, approximating natural disturbance patterns is our core guiding principle to sustainably managing forests. It drives decisions at the highest planning level, such as the Spatial Harvest Sequence in our Detailed Forest Management Plan (DFMP), to decisions made on-the-ground in operational plans like the Forest Harvest Plan (FHP). To summarize, for HWP, managing the landscape based on natural disturbance principles means the following:

- Harvest patterns, block sizes, stand structure retention and seral stage targets are all managed based on natural disturbance research, with the primarily goal being maintaining these attributes within their Natural Range of Variability.
- Both upland and riparian areas need to be managed based on natural disturbance principles – excluding riparian areas (the current practise) may have undesirable long term ecological consequences.
- Riparian and upland areas need to be identified based on their ecological and morphological characteristics.
- Approximating the variability of natural forest patterns is critical, but this strategy must be balanced with societal values, economic constraints, changing expectations, and scientific knowledge. HWP seeks to strike a balance that is scientifically sound, affordable, and acceptable to society.

3.0 Defining Riparian Areas and Riparian Values

Defining the riparian area isn't always as easy as it might sound; as the delineation between riparian and upland is often subtle and not easily quantified, especially when trying to make these decisions remotely (e.g. air photos, LiDAR, etc.). For the purposes of this document, riparian areas will be defined using the Alberta Water Council's working definition of riparian land, which is:

"*Riparian lands are transitional areas between upland and aquatic ecosystems. They have variable width and extent above and below ground. These lands are influenced by and exert an influence on associated waterbodies[2], including alluvial aquifers[3] and floodplains. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and hydrological processes.*"

[1] For the purpose of this definition, "upland" is considered to be the land that is at a higher elevation than the "lowland" alluvial plains, terraces or similar areas next to still waterbodies.
[2] A waterbody is any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood, and includes but is not limited to wetlands and aquifers (generally excludes irrigation works). Source: Alberta Water Act.
[3] For the purpose of this definition, alluvial aquifers are defined as groundwater under the direct influence of surface water (GUDI).

This definition extends the concept of riparian beyond distinct vegetation to include adjacency, hydrological processes, and landforms as important aspects of riparian function.

Riparian areas are a small part of the total landbase area but they contain and support many of the highest value or unique resources and ecological functions. Direct interaction between terrestrial and aquatic environments occurs in riparian zones (Oliver and Hinckley 1987). This relates to high diversity of landforms, ecosystems, and disturbance processes in riparian areas. Riparian ecosystems reflect disturbance processes related to water movement and biological (e.g. beaver) processes as well as processes that affect upland ecosystems (e.g. fire, wind, and other biotic factors). Because of this, riparian ecosystems can be described as mobile habitat mosaics characterized by variability and unpredictability (Hughes et al. 2005). The combination of landform diversity, ecosystem diversity, and disturbance diversity produces high biodiversity in riparian areas.

Values on these lands for human use are very high (recreation, aesthetics, timber, water, gravel, agriculture, wildlife, fish, etc). Riparian areas also provide other ecological services that contribute to watershed and biological integrity and maintenance of ecological functions. They support exchange of biological material and energy flows between terrestrial and aquatic ecosystems. They serve as ecological corridors, facilitating movements of species through landscapes and they provide habitat to support the requirements of many species.

Given their importance for multiple values and the different combinations of natural disturbance regimes that operate within riparian areas, HWP has protected or carefully harvested riparian areas since operations began in 1956.

This document, which describes HWP's new Riparian Management Strategy, will propose a different way to classify watercourse channels and still water, and their associated riparian areas, and will also propose new practises that will introduce limited disturbance into some of these areas, while still maintaining riparian values and ecological function.

4.0 Historic and Current Riparian Management

Riparian areas are permanently intertwined with human culture. Most of the known prehistoric cultural sites on the FMA and the highest probability areas for locating new sites are associated with riparian areas (Reeves and Bourges 2002). Aboriginal peoples obtained many of their food, water, shelter, transportation, and cultural needs from riparian areas and early European explorers, traders, and settlers followed in their footsteps. The new arrivals introduced commercial exploitation of riparian areas for the fur trade, fish and game animals, and eventually agriculture and timber. For many decades before the FMA was created, timber resources in riparian areas along larger rivers were extensively logged to provide lumber, railway ties, and mine timbers.

In the last half of the 20th century there was a widespread shift from exploitation of riparian areas to the view that they should be protected to conserve water quality, fish and wildlife habitat, aesthetics, recreation, and other values.

Fish habitat protection provisions under the federal Fisheries Act came into effect in 1977. The GOA traditionally administered fish habitat conservation, including riparian area management, mandated under the federal Fisheries Act until 2001 when Fisheries and Oceans Canada took over administration of most aspects of the Fisheries Act in Alberta. The GOA continues to administer their interests in water and fish conservation and the two levels of government are working together on their joint interests including riparian management.

The Alberta legislative and administration framework related to riparian areas is more complex because it tends to manage resources and not specific categories of land. The major Acts governing riparian management are the Forests Act, Water Act, and Public Lands Act.

Protected areas (buffers) beside FMA streams were first introduced in the 1958 Operating Ground Rules (OGR). Buffers were a set distance on either side of a channel or surrounding a waterbody from the ordinary high water mark (the non-vegetated channel border) based on stream size and water flow. A buffer of residual timber was retained for 1 chain (20.1 m) from the high water mark on either side of intermittent streams and secondary watercourses, 5 chains (100.6 m) on main watercourses and resort lakes[4], and 2 chains (40.2 m) on other lakes. HWP could ask for Forest Officer approval to harvest within these areas where it was possible to do so without harming water quality and other resource values, and the approval was routinely granted.

In 1973, the OGR buffer was reduced to 3 chains (60.3 m) on main watercourses and increased to 1.5 chains (30.2 m) on secondary watercourses. Intermittent watercourse buffer requirements were removed, but HWP still had to retain non-merchantable timber and other vegetation beside intermittent watercourses and protect the channel. A provision was added to keep roads, landings, and other bared areas at least 5 chains (100.6 m) away from most watercourses, except at crossings or with other approval. These basic OGR provisions were converted to metric measurements in 1988 and continued relatively unchanged until 1996. In 1996 variance requests were changed to require AOP approval instead of Forest Officer approval.

The ephemeral category was first introduced to the OGR in 1988. Ephemerals do not have a defined channel and are managed to maintain water flow linkages and minimize soil disturbance. In 2009 the definition of an ephemeral was updated to distinguish between dry and wet drainages (swales). Ephemerals are now considered to be drainages with sufficient water saturation of soils to support development of hydrophytic plants.

In 1996 the OGR were revised to introduce the concept of a Riparian Management Area. This area included "the watercourse, floodplain/riparian areas, steep slopes dropping directly into watercourses or floodplains, and adjacent areas that have a direct relationship to the watercourse". Within the Riparian Management Area, a Reserve Zone (buffer) was established on both sides of permanent streams and waterbodies, and remaining areas were assigned to a Management Zone. The Reserve Zone width was 30 m on small permanent streams, 60 m on large permanent streams (channel width >5 m), and 100 m on lakes (>2 m deep and >1 ha in area). Timber management was not permitted within Reserve Zones and timber management in Management Zones was designed to conserve other values, especially water quality. Reserve Zones could be converted to Management Zones with AOP approval. HWP variance requests continued to be routinely approved.

The 2002 OGR revision renamed the Riparian Management Area to Riparian Special Management Area.

The 2009 OGR revision revised the definitions of waterbodies, watercourses, wetlands, and related landforms. New categories were transitional (channel width 40-70 cm), watersource area, open wetland, treed wetland, and oxbow lake. Previously, intermittent channels were defined by whether or not flow dried up periodically (intermittent) during the year or not. Intermittent channels were redefined as channels <40 cm wide, irrespective of perennial versus intermittent flow. New buffer width requirements were established as 10 m on transitional channels and 20 m on watersource areas and oxbow lakes. Figure 2 provides an overview of the current riparian area classification and buffer system.

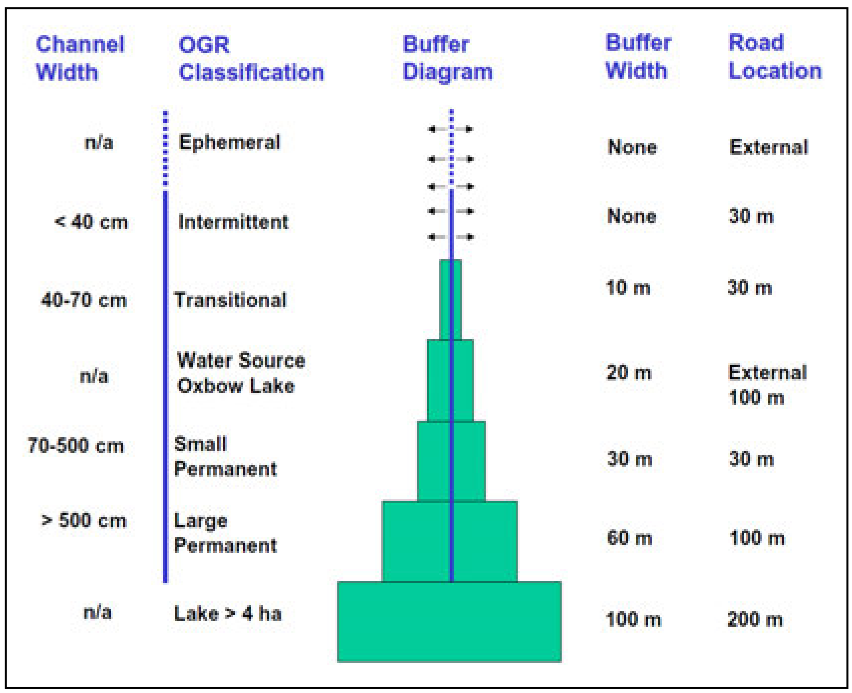


Figure 2 *– Current HWP OGR's riparian definitions and buffers*

Buffers were originally developed mainly to protect water quality and fish habitat (Richardson et al. 2012), and the simple definition and application made them relatively easy to administer. Although the OGR riparian buffer system has been in place for more than half a century it has not been rigorously evaluated to see if it conserves the riparian values and functions that it was developed to protect. The lack of evaluation is widespread (Lee and

[4] The 1958 Ground Rules did not define "resort lake".

Smyth 2003, Richardson et al. 2012). Additionally, the list of values and their relative emphasis has changed over time, and scientific understanding of riparian function has also increased.

5.0 Natural Disturbance in Riparian Areas

Riparian areas are unique because they experience disturbances that occur in uplands (fire, wind, insects, disease, etc), and also disturbances related to water processes (saturated soils, standing water, moving water, ice, etc). The unique ecological alterations caused by beavers are also important in riparian areas. The interaction between ubiquitous disturbances such as fires and unique riparian disturbances such as floods and beavers adds additional variability to the disturbance regime in riparian areas, and these can have major effects. For example, a flood event could be magnified if it occurs soon after extensive fire in a watershed, and this in turn could lead to progressive downstream failure of beaver dams that further increase the effects of the flood.

Riparian areas represent a unique challenge to the natural disturbance model of forest management. On one hand, the current reluctance to harvest in riparian zones in foothills and boreal forests is understandable. Harvesting and skidding trees within riparian areas can create mechanical disturbances such as rutting, compaction, and erosion that have no natural equivalent. Even the most severe fire will not alter the physical properties of either the soil or streambeds. Furthermore, the removal of biomass (dead or alive) from riparian zones represents another significant departure from the "natural" model of managing forests (Andison and McCleary, 2002).

Yet historically riparian areas in the foothills are clearly disturbed naturally on some level. This observation led to research in FRI's Natural Disturbance Program about natural disturbance within riparian areas. The goal of this research was to provide insight into exactly what degree, how, where, and why, riparian areas were being influenced by natural disturbances.

The FRI research found that fire burning rates and patterns in FMA riparian areas were not markedly different from those of upland areas. While there were some minor differences between fire in the upland and in the riparian, in all cases, the relationships were weak, and highly variable. FRI data demonstrates that fire burnt through the vast majority of the riparian areas studied, and the majority of islands of unburned or partially burned trees occurred nowhere near riparian areas. Furthermore, the high variation in the results suggests that the most likely source of variation in fire behaviour was local fire weather (Andison and McCleary, 2002).

The research also demonstrated that riparian areas experience steady ingress of trees for many decades after a fire, which presumably alters riparian forest characteristics until another fire occurs. Although there was evidence to suggest that riparian areas may burn somewhat differently than upland parts of the landscape, the fact that fire is an integral part of riparian ecosystems is inescapable. The removal or prevention of disturbances (fire or harvest) from these habitats would presumably have significant ecological consequences (Andison and McCleary, 2002).

Research suggests that protecting riparian zones is a very "unnatural" management strategy. Fires kill a large proportion of riparian trees and control ingress. The potential ecological implications of fire and harvest exclusion are numerous, including;

- Altering NRV seral stage patterns and variation (e.g. more mature and old and less young and pole – moving some seral stages outside of NRV).
- Increasing rate and influence of other disturbances (e.g. windthrow and age-related transitions).
- Shrinking or eliminating disturbance-maintained meadow and shrub riparian ecosystems.
- Changing the dynamics of coarse-woody biomass accumulation in streams.
- Creating "ribbon" patterns that are not linked and integrated into overall landscape patterns (e.g. reduced interior old forest overlapping riparian areas).

The natural disturbance approach assumes that continual disturbance and recovery from disturbance in riparian areas is necessary to conserve the variability that maintains ecological function over the long term. Regulatory frameworks and social acceptance do not allow unrestricted fires or unconstrained emulation of fire (i.e. harvesting) in riparian areas, and a balanced approach must be employed to maintain variability and function within acceptable social limits. In particular, disturbance must be managed to maintain variability without compromising aquatic ecosystem values and functions, which still have primary importance. One way to do this is to "*identify crucial processes and habitats at the stand and landscape scale and find ways to maintain these at sufficient levels*" (Granstrom 2001). The management challenge is to plan and implement changes to the current riparian management approach to more closely approximate natural disturbances and patterns, while maintaining the current focus on conservation of both timber and non-timber values.

So does that mean careful harvesting in riparian areas is the solution? HWP thinks it is part of the solution; however, concerns about harvesting within riparian management areas are also legitimate and must be addressed.

6.0 Current Fixed-Width Buffer Riparian Management

The conventional riparian management approach was designed primarily to protect the aquatic environment, biodiversity, and ecological functions in riparian areas from potential short term impacts related to forest management. The approach is based on a fixed-width buffer system where buffer width is linked to the width of the watercourse channel or the type and size of the waterbody.

It is important to note that under the current Operating Ground Rules, the fixed-width buffer system defines the "riparian area". In theory, everything within the fixed-width buffer is considered riparian, and everything outside (in the operable landbase) can be harvested using traditional harvesting methods. In reality, some area within the fixed-width buffer may not be riparian (using an ecological definition), and areas outside the fixed-width buffer can also be riparian and are, in fact, often excluded from harvest due to operational reasons such steep slopes and wet ground.

To apply the fixed-width buffer approach for the 2010 DFMP amendment, as part of the landbase netdown procedure, HWP developed an algorithm to classify digital hydrography into the OGR watercourse classifications. Next a GIS "buffer" tool was used to map buffers for the classified hydrography layer. Riparian areas within the buffer were removed from the net landbase as part of the netdown procedure. A Spatial Harvest Sequence (SHS) was then developed which excluded all riparian buffer areas.

To apply the approach at the Forest Harvest Plan (FHP) level, planners confirmed the classification of the watercourse or waterbody according to the OGRs and then selected the related buffer width, plus additional areas if applicable to address operability. If there were discrepancies between the DFMP and the FHP, the FHP decision overrode the DFMP designation. This created a variance to the SHS, which was reported in each FHP submission.

6.1 Pre-2009 Fixed-Width Buffer Riparian Management

Before the 2009 OGR revision, the buffer distances specified in the OGR were routinely modified in field application. The top of the fluvial hillslope closest to the channel was usually used as the cutblock boundary. When this was within the nominal OGR buffer distance, ESRD usually approved the relocation of the buffer boundary. Buffers were reduced in flat or gently sloping terrain, where blowdown risk was high. Buffers were also increased through a HWP initiative or ESRD request. This occurred when the distance to the top of the hillslope was greater than the OGR buffer distance or other site and environmental factors such as wetlands and steep slopes were present.

Traditional HWP two-pass harvest plans used watercourses and waterbodies and associated variable-width buffers as cutblock boundaries. At a watershed scale this resulted in alternating blocks on either side of a watercourse and the final buffer shape only became evident after both harvest passes were completed over a period of 10-25 years.

Through the years, the net effect of field modifications was to create variable-width buffers that reflected site conditions and increased the total area protected by buffers compared to the nominal OGR specifications (Figure 3). Operational practices converted fixed-width buffers to variable-width buffers. Standard practices would have meant no harvest within the buffers and clearcut harvest adjacent to buffers.

Figure 3 – *Variable-width buffers along lower Teepee Creek and tributaries (McLeod 7 compartment). Cutblocks are highlighted with light green shading with green outline.*

Following the 2009 OGR revision, ESRD stopped approving HWP buffer reduction variance requests and asked HWP to develop and submit with the 2014 DFMP a Riparian Management Strategy that provided rationale, methodology, and monitoring and measuring protocols. This document is addressing that ESRD request.

6.2 Traditional Fixed-Width Buffer Riparian Management Evaluation

In the Foothills, there has been no research into the effectiveness of the traditional fixed-width buffer (see Figure 4) in conserving and protecting riparian values. In other areas in North America, research has been done into what types of riparian buffers (fixed width versus variable width) are most effective (Polyakov, Fares, and Ryder. 2005) and what widths are most effective (Hawes and Smith. 2005), but most of this research starts with the premise that riparian buffers are required and no disturbance within these buffers is the primary goal.

Governments created fixed-width riparian buffers to protect and conserve values associated with riparian areas from the effects of forest harvesting and these buffers have since become normal practice across North America for the protection of riparian ecosystems. However, requirements for fixed-width buffers usually originated for administratively simple but scientifically untested reasons. Reliance on fixed-width buffers suffers from a scarcity of actual tests and evaluations of the effectiveness of current guidelines (Richardson et al. 2012).

Figure 4 – *A 30 metre fixed width buffer in the Alberta foothills*

The results of most assessments of effectiveness of riparian buffers suggest that typically mandated widths are insufficient to prevent some alterations of stream and riparian function; however, the effectiveness depends on the objectives, which are often vaguely stated, if at all (Richardson et al. 2012). Most assessments compare pre-harvest to post-harvest conditions. Under the NFM approach, assessments should compare conditions that are roughly equivalent. For example, comparison of similar sites 5 years after wildfire or harvest would be appropriate.

If the buffer width is intended to maintain natural patterns of long-term channel dynamics and contributions of large wood, some rivers would need very large buffers, and fire suppression would need to be forgone to allow natural processes to play out. Fires and floods constitute large-scale disturbances that help structure aquatic and riparian ecosystems (Pettit and Naiman 2007a, b). Both types of disturbances result in short-term habitat degradation by raising water temperatures and adding fine sediment to streams, but they confer long-term habitat benefits in terms of channel complexity by recruiting large wood and boulders. The width of a naturally disturbed riparian zone needed to provide these key habitat elements varies according to the morphology of the watershed and may (or may not) exceed the width of any fixed-width prescribed buffer (Richardson et al. 2012). This approach is appropriate to apply in riparian areas within protected areas but is generally not suitable for a managed forest.

Landscape-level considerations usually have been absent from riparian management guidelines used throughout North America. In areas where there is allowance for management discretion when developing harvesting plans (i.e. fixed-width buffers can be modified), many managers default to the fixed-width buffers anyway because of the implementation simplicity and the uncertainty of the consequences of varying from the prescribed norm. Natural disturbance processes at the landscape level are not well integrated into riparian management guidelines or rules (Richardson et al. 2012).

This lack of integration can have impacts - over long periods reduced or excluded disturbance rates (both from fire and harvesting) would likely lead to riparian areas with characteristics outside their Natural Range of Variability. This presumably would have an effect on ecological function of riparian areas and the values they conserve, and it runs contrary to the disturbance approach.

The effectiveness of traditional fixed-width buffers is not well-known, especially at the landscape level; however, variations from the fixed-width buffer methodology must be done in a measured and systematic way. Strategies to maintain ecologically functional aquatic and riparian ecosystems, like those being proposed in this document, must be carefully thought out and combined with research and evaluation.

7.0 Watercourse Classification in Alberta

To this point we have been talking about riparian areas – their importance, values, and uses, as well as the difficulties and issues encountered when using fixed-width buffers for defining and managing riparian areas. However, a large part of any riparian management system is classifying the watercourse/waterbody associated with the riparian area. Many jurisdictions in North America, including Alberta, use classification systems based on flow permanence and/or channel width; however, both these parameters have significant issues.

The Operating Ground Rules in Alberta provide definitions for various types of watercourses and waterbodies, and then outline the buffers and/or allowable practises associated with each definition. Table 1 below provides a brief overview of the current (2009) OGR watercourse classification system (also see Figure 2).

Table 1 – *OGR Channel Classification*

Channel Type	Channel Description	Operating restrictions
Class A Waterbody	n/a – designated through legislation	100 m buffer from the high water mark
Class B Waterbody	n/a – designated through legislation	30-60 meter buffer depending on large or small perm designation
Large Permanent	Non-vegetated channel width exceeds 5 metres	60 metre buffer
Small Permanent	Banks and channel well-defined. Channel width from ≥ 0.7 m to 5 m	30 metre buffer
Transitional	Transitional streams – channel widths are between 0.4 and 0.7 m	10 m buffer or to slope break, whichever is further.
Intermittent	Distinct channel development; channel usually has no	Buffer of trees or brush to be left

Channel Type	Channel Description	Operating restrictions
	terrestrial vegetation; channel width less than 0.4 m. Usually some bank development.	undisturbed along the channel.
Ephemeral	Little or no channel development; Flow area is usually vegetated.	Undisturbed vegetation
Lakes	Shorelines defined by absence of permanent terrestrial vegetation.	100 meter buffer (on lakes less than 4 ha. a 30 metre buffer).
Watersource Area	No channel development, but may be pronounced vegetation changes.	20 metre buffer
Open Wetland (no tree cover)	Usually marsh, open fen, or shallow water. Areas with saturated organic or mineral soils.	No buffers
Treed Wetland (tree cover)	Usually bogs, fens, or swamps.	No buffers
Oxbow Lake	Large water collection area formed when oxbow cut off from main river channel – often vegetated	20 metre beyond the high water mark of the oxbow lake.

7.1 OGR Watercourse/Waterbody Classification – Issues

The OGR waterbody and wetland classification system is generally based on permanence of flowing or still water and width of channel or size of waterbody. Classified waterbodies A and B (Water Act) are based on other values such as important fish spawning areas – HWP's Riparian Management Strategy is not proposing any alternative strategies for classified waterbodies. There are only a small number of classified waterbodies on the FMA and HWP will follow all applicable legislation, policy, and rules when operating near these waterbodies.

The following sections outline issues with the current OGR methodology of classifying watercourses and waterbodies on the Hinton FMA:

7.11 Permanence

Many waterbodies fluctuate over time in relation to water inputs and outputs. Changes are most pronounced where waterbodies completely dry up during periods of drought or have flow or surface water only during periods of high precipitation or runoff. Ground water discharge moderates fluctuations but locations and volumes of ground water discharge are not well known. Small FMA streams frequently have springs as their main source of flow. Classification based on permanence using inventory data is also problematic because inventory and predictability are poor. Field classification is problematic because there is typically only one visit to a site and permanence recorded at the time of visit may not reflect the dominant regime at the site.

7.12 Channel Width

All channels vary in structure including width; and channel width variation is not uniform between channel types and sizes. Classification based on width using inventory data is problematic, especially for small channels because inventory and predictability are poor. Field classification of width is usually estimated by taking a series of width measurements and calculating an average width. The procedure appears to be quantitative but it is difficult to produce consistent estimates of average width. There is no single combination of interval between width measurements, number of measurements, and length of channel reach over which measurements should be taken that would be appropriate for all channels. The choice of a starting point for width measurements is also subjective and can significantly influence the estimate.

7.13 Watercourse Classification and Buffer Width

Fixed buffer-width based riparian management is currently linked to the classification of the watercourse/waterbody the buffer is to be applied to. Generally buffer width increases with permanence and larger flows or waterbody size. This approach assumes that riparian values and functions increase with permanence and size and require additional buffer width to protect.

There are several significant issues with the current approach:

- Lack of, or low, resolution inventory makes it difficult to classify watercourses (based on stream width) at the DFMP level. HWP experience shows that the landbase netdown process over the years has consistently underestimated the actual extent of FMA watercourses and this in turn affected (overestimated) the net operable landbase that is used for the AAC determination. This also increases the variance between the Spatial Harvest Sequence and FHP.
- Even at the field level, it is difficult to make a consistent classification due to natural variability and measurement subjectivity. As the buffer width is linked to the classification, this leads to potential disagreement between HWP and ESRD about whether or not the correct classification was made, particularly near transitions between OGR categories (e.g. intermittent to transitional). Variation along channel reaches is also an issue, as channels sometimes switch back and forth between categories over fairly short distances.
- The current OGR approach does not adequately address or respond to variability encountered in the field. The long-standing practice of converting fixed-width to variable-width buffers partially addressed variability. It provided a process to adjust buffer location to more appropriately recognize and address values and functions at the site.
- Disturbance, especially windthrow, continues in riparian buffers after they are created, altering them significantly. Windthrow along block boundaries that are newly exposed to wind after harvesting is an active process on the FMA. Where blocks border riparian buffers windthrow into the riparian area can be significant and may be higher in rate and impact than natural windthrow events that are not involved with a block boundary and wind exposure. The process alters riparian values and functions.
- The buffer approach is linked to values and functions by assumptions that have not been well tested and evaluated. For example, science that links function to channel width or channel width to buffer width is not well developed. As managers are ultimately interested in ecological function there is a need to better identify and manage the functions.

8.0 Riparian Area Values and Goals

People value riparian areas for multiple reasons. It is generally accepted that a main goal of riparian area management should be to conserve the ecological values and functions associated with riparian areas. These include clean water, habitat for aquatic and terrestrial species, and the many ecological processes that maintain them such as nutrient and energy exchanges. Riparian areas also provide products for human use, including wood, water, fish, wildlife, and livestock forage. They provide high-value recreation opportunities and they often have historical significance. So another major goal of riparian area management is to conserve their social and economic values. The overall management goal is to manage riparian areas in a balanced way to conserve ecological, social, and economic values. This goal recognizes that ecological values have primary importance and social and economic values must also be conserved to maintain ecological function over the long term.

8.1 HWP's Riparian Management Assumptions

As previously discussed, this document contains a new proposed Riparian Management Strategy (section 9.0) that is ecosystem-based and incorporates landscape level natural disturbance principles. In the development of this Riparian Management Strategy, HWP has made the following assumptions:

1. Disturbances and recovery from disturbances within the Natural Range of Variation of riparian areas is necessary over the long term to conserve the variability that maintains ecological function and supports social and economic values.
2. The current management approach excludes fire and harvesting from significant proportions of riparian areas and research and forecasting predicts this will reduce the disturbance rate over the long term to below the NRV.
3. Carefully managed disturbance including harvesting can be used to increase riparian disturbance rates while conserving riparian values and functions.
4. Increased managed disturbance rates and ecological condition variability will act to reduce ecological function risks.
5. Increased managed disturbance rates will provide some timber production from riparian areas without compromising ecological function and other non-timber values.

6. Integrating riparian and upland management within watersheds is the best approach to conserve ecological function over the long term.

Considering these assumptions, a logical conclusion is that managed disturbance in riparian areas is the best management option to balance between ecological, social, and economic values and goals. In the following sections HWP's Riparian Management Strategy will be discussed and explained in detail.

9.0 HWP's Ecosystem-Based Riparian Management Strategy

HWP's overall riparian strategy is to maintain ecological function over the long term by increasing ecological condition similarity between natural and managed riparian areas. The proportion of riparian area that experiences some form of disturbance will be increased with the objective of generating seral stage amounts and other indicators at amounts and patterns within NRV. Targets for structure and composition variability within NRV will be adjusted to conserve the important values recognized in the traditional riparian conservation management approach.

The number and importance of ecological functions of riparian areas decreases with the distance from the channel and the probability that there will be direct interaction between the aquatic and terrestrial ecosystems. Therefore a more conservative approach will be applied to areas close to channels, and where there are special non-timber values (e.g. bull trout spawning streams). Working within a structured framework as described in the following sections, professional judgment will be used to determine appropriate management prescriptions for each site in the field.

HWP will introduce disturbance into areas previously contained within fixed-width buffers. Concurrently HWP will ensure that disturbance within ecologically-defined riparian areas that are outside what was the fixed-width buffer is designed to maintain ecological function overall. For example, floodplains dominated by white spruce will be mainly managed with alternative silviculture systems, regardless of their distance from a channel.

Harvesting will be substituted for natural disturbance processes where harvesting can be applied safely and economically without causing environmental damage or impairing long term ecological function. This will increase riparian area that experiences disturbance but it is expected that many areas will still not be suitable for harvest treatments. If necessary in the future, other treatments (prescribed fire, mechanical brushing, etc) will be considered in partnership with ESRD to ensure that riparian areas remain within the NRV over the long term.

Planned riparian area disturbance will be integrated with plans for adjacent uplands as part of the DFMP's Spatial Harvest Sequence and related Forest Harvest Plans.

HWP's Riparian Management Strategy will consist of the following 9 main steps:

1. Identify the type of watercourse/waterbody (at the DFMP level using remote sensing technology). This will be done using a new watercourse classification system developed at the Foothills Research Institute and HWP's Ecological Land Classification (ELC) layer,
2. Identify and map the riparian area based on ecological and morphological features (at the DFMP level using remote sensing technology)
3. Review each riparian area and classify the area into landform/vegetation classes and operability classes (e.g. operable or non-operable)
4. Use natural disturbance modelling (LANDMINE) to determine NRV for both upland and riparian areas.
5. Use timber modelling (Woodstock and Stanley) to create a Spatial Harvest Sequence (SHS). The SHS is for a 20 year period and is recalculated every 10 years as part of the DFMP. The SHS will set targets (hectares) for disturbance (based on LANDMINE modelling for NRV) within the ecologically defined riparian areas.
6. As part of the Forest Harvest Plan (FHP) development, each riparian area and stream classification will be field verified and adjusted as required. The total hectares of riparian disturbance as compared to the target will be reported in each FHP.
7. Develop stand-level riparian disturbance treatment options – silvicultural prescriptions will be developed for each riparian area where disturbance is prescribed.

8. Disturbance will take place primarily through careful harvesting.
9. The process of implementing the Riparian Management Strategy will be monitored, measured, and reported on.

The following sections outline and describe the 9 main steps of HWP's proposed Riparian Management Strategy for ecological defined riparian areas within the Hinton FMA.

9.1 Step 1 – Identify the Type of Watercourse/Waterbody

First HWP must remotely (i.e. air photos, inventories, etc.) identify the type and location of each watercourse and waterbody on the FMA. As described in section 7.0, the Alberta OGR channel classification system is based on flow permanence and channel width, both of which create significant problems. The issues, and associated solutions, have been documented and researched over the last five years at the Foothills Research Institute (FRI) as part of FRI's Fish and Watershed Program. Dr. Rich McCleary, who has been the lead researcher in this program, has been working on developing a field-classification manual that provides riparian-area classification guidelines relevant to the foothills of Alberta. What follows is a description and discussion around the erosion-based channel classification taken from McCleary's most recent version of his "Field Manual for Erosion-Based Channel Classification" (McCleary, Haslett and Christie. 2012). This is the new erosion-based channel classification system that HWP is proposing to adopt as a main feature of our new Riparian Management Strategy.

9.11 Overview of the New Erosion-Based Channel Classification

A width-based channel classification is consistent with the general premise that as stream size progressively increases down the length of any watercourse, greater levels of protection are required to preserve important functions and values; however, this approach presents both operational and theoretical challenges. From an operational perspective, HWP foresters have encountered problems when applying a width-based classification in close proximity to source areas. Due to their low volume, these headwater channels lack sufficient power to regularly erode material from their banks; hence, channel width is highly variable and strongly influenced by the type of vegetation immediately adjacent to the stream. Even with repeated measurements, it can be difficult to get consistent width measures by different people or on successive visits. Channels with such characteristics are commonly encountered within or adjacent to cutblocks in the Foothills. Many such streams are not shown on available maps. For those streams that are mapped, there is no objective way to determine their width so they can be classified. Without such maps, it is difficult to align strategic and operational forest harvest plans. For example, given the quantity of timber that may fall within riparian buffers, without accurate maps of channel-width class with buffers assigned, it is difficult to estimate wood supply across a region.

From an ecological perspective, it is important to consider features other than channel width for determining the sensitivity of a stream and its riparian area to forestry-related impacts. Channel dimensions, specifically width and depth, are related to bankfull discharge; however, the width:depth ratio, floodplain extent and sensitivity of a channel to disturbance are also dependent upon other factors including the percentage of fine material (silt-clay) in the channel boundary (Schumm 1985). The greater the amount of fine material, the lower the width:depth ratio, the greater floodplain development, and the higher sensitivity to disturbance.

Data on the stream network in Alberta was limited by the effective resolution of available air-photographs – many of the smaller watercourses simply couldn't be detected beneath the shrubs and trees. In addition, foresters found that the width-based classification system assigned to the Alberta stream network was inconsistent, difficult to interpret, didn't align well with actual field data, and didn't link with the width-based ground rules classification.

Thus, a new regional stream mapping project was initiated at FRI with a goal to develop a classification system that would be ecologically based and more easily repeatable in the field and that would provide better information on the locations of headwaters streams.

9.12 Erosion-Based Channel Classification

Researchers from the international community have developed various methods to remotely classify stream channel segments across entire landscapes in mountainous terrain for the purposes of management and assessment. The most widely used reach-scale classification system recognizes that the watersheds can be divided into four regions:

1. **Uplands** – regions that lack any evidence of channelized flows;
2. **Swales** – depressional features created by extreme events during previous climatic regimes that are completely vegetated and lack an open channel;
3. **Seepage-fed channels** – open channels that lack sufficient flows to transport all of the sediment and organic material that accumulates within them during the average year but are subject to rapid evacuation of this material during major runoff events; and
4. **Fluvial channels** – open channels that have sufficient flow to transport most of the material that they receive at average annual runoff levels.

This system was successfully applied in the Foothills near region near Hinton (McCleary personal communication 2012).

The new classification system being proposed in this Riparian Management Strategy is based on surface erosion processes. Using this system, five erosion process categories were defined, resulting in four types of channels (Table 2 and Figure 5). Because this system is based on stream functions, it aligns well with the overall goal for management of riparian areas in forested regions of Alberta "to maintain or enhance the structural and functional integrity of riparian areas and associated aquatic ecosystems" (Borutski et al. 2005).

Table 2 – *Erosion Channel Classes and Definitions*

Class	Best corresponding class in OGR classification	Description of erosion processes
Upland	Upland	Drainage features are absent. Surface erosion is driven by overland flow and tree root throw. On LiDAR-generated stream network maps, false channels may appear on uplands. These features can be removed from the map as required.
Swale	Ephemeral or water source areas	Historically, channels extended into these areas to remove material and create an obvious depression. Soil is sufficiently wet to support hydrophytic vegetation. These areas are susceptible to compaction and subsequent erosion.
Discontinuous channel	Intermittent	This drainage feature includes alternating sections of channel and vegetated ground. The channel may be stable or alternately be migrating upstream through headward extension or in the recovery process with vegetation encroaching into the old channel (Leopold et al. 1964). Erosion typically initiates at a headcut at the upstream end of the channel section with sediment transported a short distance downstream.
Seepage-fed channel	Intermittent, transitional, or small permanent.	A channel with a continuous bed but insufficient stream power to transport larger streambed material including gravel and cobbles; hence, these channels typically lack bed features (e.g., regular sequences of pools and riffles) that Foothills fishes are adapted to. Sediment is transported as suspended load and bedload; however, only the smaller streambed material is mobile on an annual basis with larger clasts (e.g., cobbles and boulders) remaining stationary for long periods of time. In high relief areas, gravity transports upland sediment directly into these channels. In such areas, "colluvial channel" is a more appropriate name.
Fluvial channel	Small permanent or large permanent	A channel with a continuous bed and sufficient power to transport most of the material that it flows through. Sediment transport includes suspended and bed load. Bedload transport is not limited to fine material, and includes larger size materials such as gravel.

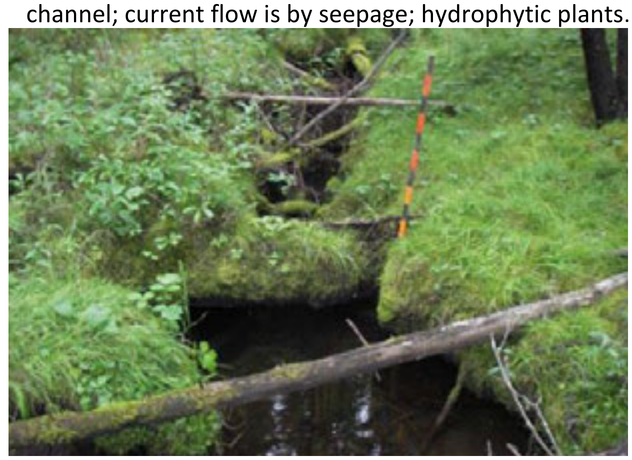
Initial use of this system has been encouraging – because this erosion-based classification system does not rely on stream width or flow performance, it has been much easier for multiple people over multiple time periods to arrive at the same classification. In addition, this new classification system tends to align better with riparian values and functions. For example, there is a much closer correlation between fish presence and fluvial channels than there is with width as per the OGR system. Figure 5 below provides examples of the five different erosion-based classes:

Figure 5 – *Examples of erosion based channel classification*

Upland – Carved by water in the past; no current water flow; no hydrophytic plants.

Swale – Carved by water in the past or depression; no channel; current flow is by seepage; hydrophytic plants.

Discontinuous Channel – Water at surface; no continuous channel; flow by seepage; water does not shape channel.



Seepage-fed Channel – Continuous channel highly variable width; organic bridges and undercut banks; bed is soft unconsolidated and in-situ material; water does not move bed material or shape channel.

Fluvial Channel – Continuous channel and flow; bed is fluvial materials; water shapes channel; typical pool/riffle structure.

9.13 Remote Channel Classification

In order for this channel classification system to be useful for forest management purposes, it would have to be able to be applied at a landscape level (i.e. the Hinton FMA) using remote inventories (e.g. air photos, LiDAR, etc.).

McCleary developed a methodology using LiDAR data to classify channels into the four different watersheds regions – upland, swale, seepage-fed, and fluvial) (McCleary personal communication 2012). During the first stage of this research, criteria to delineate the four watershed regions were captured in a field procedure that was extensively field tested by a diverse group that included forest technologists, fisheries biologists, and senior forest managers. A testing region near Hinton was established. Once the advisory group to the Project was satisfied that the procedure could be consistently and rapidly applied by people from various backgrounds, the second stage, a field study to develop a statistical model for the region, was launched.

A new GIS stream layer was produced that contained detailed information on stream slope and upstream drainage area for each segment in the network. The network contained 2,350,000 reaches with an average reach length of 36 metres. A stratified random sampling system was applied and more than 700 sites were visited and classified. A variety of statistical models were tested, all of which indicated that drainage area was the most important factor for delineating the four landscape regions. As a result, the Hinton FMA was sub-divided into drainage basins of low, medium, or high relief.

Next, drainage area thresholds for the upland-swale, swale-seepage-fed channel, and seepage-fed channel-fluvial channel transitions were established for each of the three basin types using statistical models. The models were accurate about two-thirds of the time, and when the classification prediction was incorrect, it was only off by one class (e.g. swale instead of seepage-fed) almost all of the time. These drainage area thresholds can be applied to any channel network that includes information on upstream drainage area for individual channel segments, including two LiDAR-derived networks – the Wet Areas Mapping predicted streams and NetMap reach layers. In comparison to unglaciated mountainous regions with highly organized drainage networks that have been the subject of similar modelling exercises, the glaciated Foothills and Boreal Plain regions of Alberta have unorganized landscapes and complex drainage patterns. Hence, this extensively ground-truthed model has provided HWP with a much improved picture of watershed networks from which to base planning from (McCleary personal communication 2012).

9.14 Field Classification

All classifications that are made remotely as part of a DFMP process, and are part of the Spatial Harvest Sequence, will be checked in the field during layout as part of the Forest Harvest Plan. In order to standardize the methodology for classifying channels using this erosion-based system, field guide has been developed. A copy of this field guide can be found in Appendix A.

9.15 Lakes, Wetlands and Springs

Lakes, wetlands, and springs also have associated riparian areas, although the riparian areas are either associated with the entire feature (like swamps, bogs, and fens) and therefore defined by the ecosite, or as in the case of springs and some lakes, made up of the standing (or very slowly moving) water and the ecosite from the water's edge to the upland (which also may include wetlands). Figure 6 illustrates these concepts.

In the case of lakes, wetlands, and springs, as is the case with streams, natural disturbance research shows that these riparian areas burn at the same frequency as upland areas (Andison and McCleary, 2002). Lakes, wetlands, and springs are significantly different in how they are able to be treated on the ground (i.e. introducing disturbance), so each will be dealt with separately in the following sections:

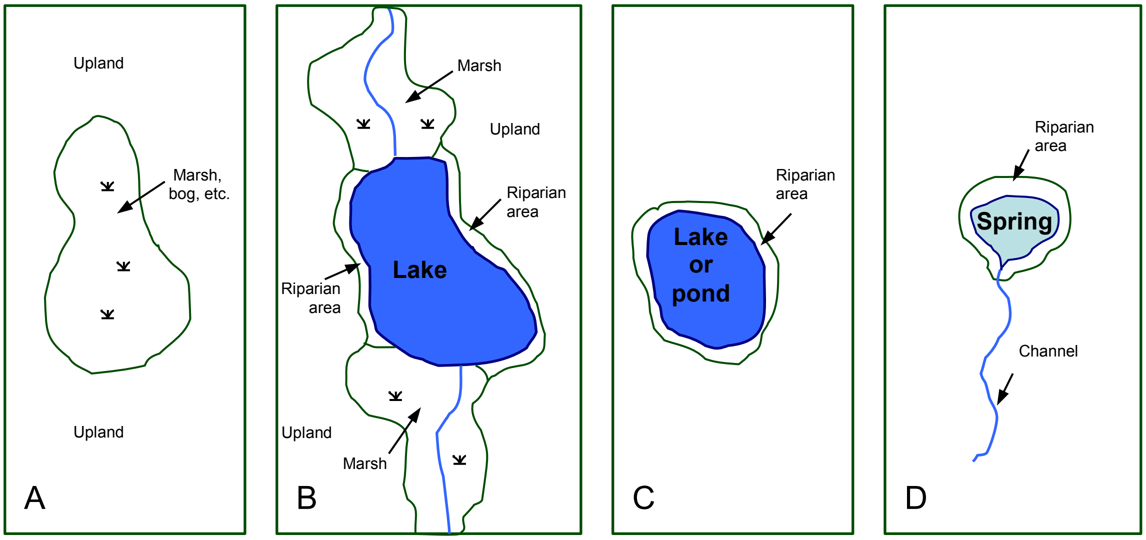


Figure 6 – *These illustrations describe the three main types of lake/wetland systems found on the Hinton FMA. Figure 6A shows a wetland found in a depression and defined by its ecosite. Figure 6B shows a lake as part of a wetland system consisting of the lake; it's associated lakeside riparian areas, and an associated wetland marsh. Figure 6C shows a lake/pond in a depression within its associated (typically very small) riparian area. Figure 6D shows a spring (also called a watersource area) and its typically very small riparian area.*

A. <u>Lakes</u>

The 2009 Operating Ground Rules (OGR) classify two types of lakes – a lake that is a permanent waterbody and greater than two metres in depth and one hectare in size, and an oxbow lake; a large water collection area formed when an oxbow is cut off from a main river channel. In the OGR there are different buffer requirements for these types of lakes, which vary in width depending on the size of the lake.

Under HWP's proposed Riparian Management Strategy there are two types of still water – ponds and lakes; each distinguished by its size and depth of water. A lake is a body of water greater or equal to one hectare area and usually over two metres in depth surrounded by land. Lakes have permanent standing water with at least some surface area free of rooted emergent vegetation. A pond is a body of water less than one hectare in size and usually less than two metres maximum depth. A permanent pond has permanent standing water with at least some surface area free of rooted emergent vegetation. A seasonal pond is an area of shallow open water that annually or periodically dries up. A beaver pond is a pond formed by a beaver dam of flowing water.

Disturbance will be introduced in the riparian area of lakes; however, the opportunity to include disturbance will be relatively small, as the riparian areas of lakes and ponds normally either consist of wetlands (marsh, bogs, etc.), where there is little or no opportunity for harvest disturbance, or are very small (i.e. the area between the water edge and the upland). In this latter case, for the small riparian areas between a lake or pond's edge and the upland, HWP would maintain a 10-metre function zone, where trees leaning into the lake or interacting with the lake would not be cut – all remaining trees could be removed. The only exception to this rule will be for lakes that currently support an active sport fishery or have active recreational use, in which case a 100 metre buffer (no harvest) will be established.

Table 3 summaries the 2009 OGR buffer requires and contrasts those requirements with HWP's proposed Riparian Management Strategy.

Table 3 – *2009 OGR lake buffer requirements compared to HWP's Riparian Management Strategy*

Classification System	Watercourse Classification	Allowable Disturbance	
		Roads, Decking & Bared Areas	**Watercourse Protection Areas**
2009 OGRs	Lakes – Permanent waterbody >2 m depth and >1 ha size.	➢ No disturbances shall be permitted within 200 m of the high water mark unless specifically approved in the AOP.	➢ On lakes, no disturbance or removal of timber within 100 m of the high-water mark unless specifically approved in the AOP. Alberta in the FHP may require additional protection. ➢ On lakes less than 4 ha, removal of timber prohibited within 30 m of the high-water mark and any removal within 100 m requires Alberta's approval.
	Oxbow Lakes – Large water collection area formed when oxbow cut off from main river channel.	➢ Construction not permitted within 100 m of oxbow lake unless specifically approved in the FHP.	➢ The buffer shall encompass the area from the high water mark of the main watercourse to 20 m beyond the high water mark of the oxbow lake. Oxbow lakes outside the buffer of the main watercourse shall be treated as watersource areas.
HWP's Riparian Management Strategy	Recreation Lakes – Lakes that support an active sport fishery or have active recreational use. On the Hinton FMA, this includes the following lakes: ➢ Petite Lake ➢ Dunn Lake ➢ Rainbow Lakes ➢ Peppers Lake ➢ Mayan Lake ➢ Flapjack Lake	➢ No disturbances shall be permitted within 200 m of the high water mark unless specifically approved in the AOP.	➢ No disturbance or removal of timber within 100 m of the high-water mark unless specifically approved in the AOP. Alberta in the FHP may require additional protection.
	Lakes – Permanent waterbody >1 ha size and usually >2 m maximum depth.	➢ No disturbances shall be permitted within 100 m of the high water mark unless specifically approved in the AOP.	➢ A 10-metre function zone – trees leaning into the lake or interacting with the lake will not be cut – all remaining trees can be removed
	Ponds – Less than 1 ha area and usually < 2 m maximum depth, and includes permanent, seasonal, and beaver ponds.	➢ No restrictions	➢ A 10-metre function zone – trees leaning into the pond or interacting with the lake will not be cut – all remaining trees can be removed

B. Wetlands

The 2009 Operating Ground Rules classification of treed wetlands include bogs, fens, and swamps with saturated organic (bogs and fens) or mineral (swamps) soils.

Under HWP's Riparian Management Strategy, a wetland is an area that is regularly saturated by surface water or groundwater and is characterized by vegetation that is adapted for life in saturated soil conditions. As per the "Field Guide to Ecosites of West-central Alberta" (Beckingham et al. 1996) HWP Riparian Management Strategy subdivides wetlands into the following seven categories:

1. Bog – A peatland with weakly to moderately decomposed Sphagnum and forest peat material formed in oligotrophic (nutrient-poor status) environments. The bog surface is acidic and low in mineral nutrients due to slightly raised peat surfaces dissociating it from underlying and surrounding mineral-rich soil waters.
2. Poor Fen – An ecosite that is transitional between the fen and bog. A poor fen is intermediate in nutrient regime and is similar floristically to the fen and bog. Sedges and peat moss, golden and brown mosses compose the majority of the organic matter content.
3. Rich Fen – A peatland with moderate to well-decomposed sedge, grass, and reed peat material formed in eutrophic environments. Mineral-rich waters are at or are just above the fen surface. Sphagnum is usually absent or subordinate to other mosses.

4. Wet Meadow – A wet meadow is a nutrient-rich treeless area where flooding or high water tables increase soil water content and replenish nutrients. A shrub meadow is dominated by deciduous shrubs, usually willows and dwarf birch. A forb meadow is dominated by forbs such as purple avens, tall larkspur, veiny meadow rue, cow parsnip, etc.
5. Marsh – A mineral wetland or organic peatland that is periodically inundated up to a depth of 2 m by sanding or slowly moving nutrient-rich water. Marshes are typically dominated by emergent rushes, reeds, grasses, and sedges with generally little organic matter accumulation.
6. Swamp – A swamp is a wooded mineral wetland or a peatland with standing water or water gently flowing through pools or channels that persist for long periods.
7. Shallow waters – Shallow waters are one of the wetland types of the Canadian Wetland Classification system. This wetland type is covered by the lake and pond classification (see above).

Introducing disturbance into wetlands is problematic from a timber harvesting point of view, as wetlands generally do not include merchantable timber in economic amounts. Wetlands are primarily netted out of the landbase (except along the edges of swamps where some merchantable timber can sometimes be reached); therefore, most future disturbances in these riparian features would have to occur through natural or prescribed fire.

Table 4 below summaries the 2009 OGR buffer requires for "treed wetlands" and contrasts those requirements with HWP's proposed Riparian Management Strategy.

Table 4 – *2009 OGR wetland buffer requirements compared to HWP's Riparian Management Strategy*

Classification System	Watercourse Classification	Allowable Disturbance	
		Roads, Decking & Bared Areas	Watercourse Protection Areas
2009 OGRs	Usually bogs, fens, or swamps. Areas with saturated organic or mineral soils. Water present at or near surface all year	➢ Construction only during frozen conditions.	➢ None
HWP's Riparian Management Strategy	bogs, fens (rich & poor), wet meadow, marsh, swamps	➢ Construction only during frozen conditions.	➢ None

C. Springs

The 2009 Operating Ground Rules identifies watersource areas as areas with saturated soils, surface flow or seepages contributing directly to stream flow. They are normally identified during layout.

Under HWP's Riparian Management Strategy, a watersource area is synonymous with a spring. A spring is a location where groundwater flows naturally to the land surface or into a surface waterbody. If water discharge is sufficient to form a channel, a spring immediately becomes a stream. An area of water saturated soils associated with sub-surface groundwater flow is called a seep or watersource area. The riparian areas associated with these springs or watersource areas are normally very small – a wet ecosite that quickly turns into upland. Table 5 below summaries the 2009 OGR buffer requires for "watersource areas" and contrasts those requirements with HWP's proposed Riparian Management Strategy.

Table 5 – *2009 OGR watersource-area buffer requirements compared to HWP's Riparian Management Strategy*

Classification System	Watercourse Classification	Allowable Disturbance	
		Roads, Decking & Bared Areas	Watercourse Protection Areas
2009 OGRs	Areas with saturated soils, surface flow or seepages contributing directly to stream flow.	➢ Construction not permitted unless approved in the AOP; No log decks permitted; ➢ The number of crossings must be minimized; ➢ No disturbance of organic duff	➢ Treed riparian management zone of at least 20 m on all watersource areas; No harvest of merchantable trees or disturbances of lesser vegetation unless specifically approved in the AOP;

Classification System	Watercourse Classification	Allowable Disturbance	
		Roads, Decking & Bared Areas	Watercourse Protection Areas
		layers or removal of lesser vegetation.	
HWP's Riparian Management Strategy	A spring or area of water with saturated soils associated with sub-surface groundwater flow.	➢ Same as above	➢ There will normally be no harvest within the riparian area associated with the watersource area or spring. Potential harvest within the area and in the surrounding area would be determined at the time of layout.

9.2 Step 2 - Riparian Area Definition and Mapping

The ability to define and map riparian areas is important for development of the overall Riparian Management Strategy in the DFMP, especially the landbase net-down and the SHS. A clear riparian area definition is also needed to support field identification and management prescriptions.

Managers must choose a boundary for the riparian area corridor that has a significant influence on a stream or is significantly influenced by a stream (Hunter 1990). Available criteria include various combinations of distance from water, geomorphology (landforms), wetlands, vegetation, soil characteristics, position related to aesthetic or recreation values, and functional linkages between aquatic, riparian and upland ecosystems. For convenience, it is useful to include in riparian areas waterbodies and any associated wetlands, riparian lands (areas directly beside or influenced by waterbodies), and parts of adjacent upland areas that have a strong functional linkage to waterbodies or wetlands (after Ilhardt et al 2000).

To define and map riparian areas for the 2014 DFMP, HWP will use an approach based on a combination of landscape geomorphology and vegetation attributes. This encompasses the inherent natural variability of riparian areas at multiple scales and provides classification flexibility.

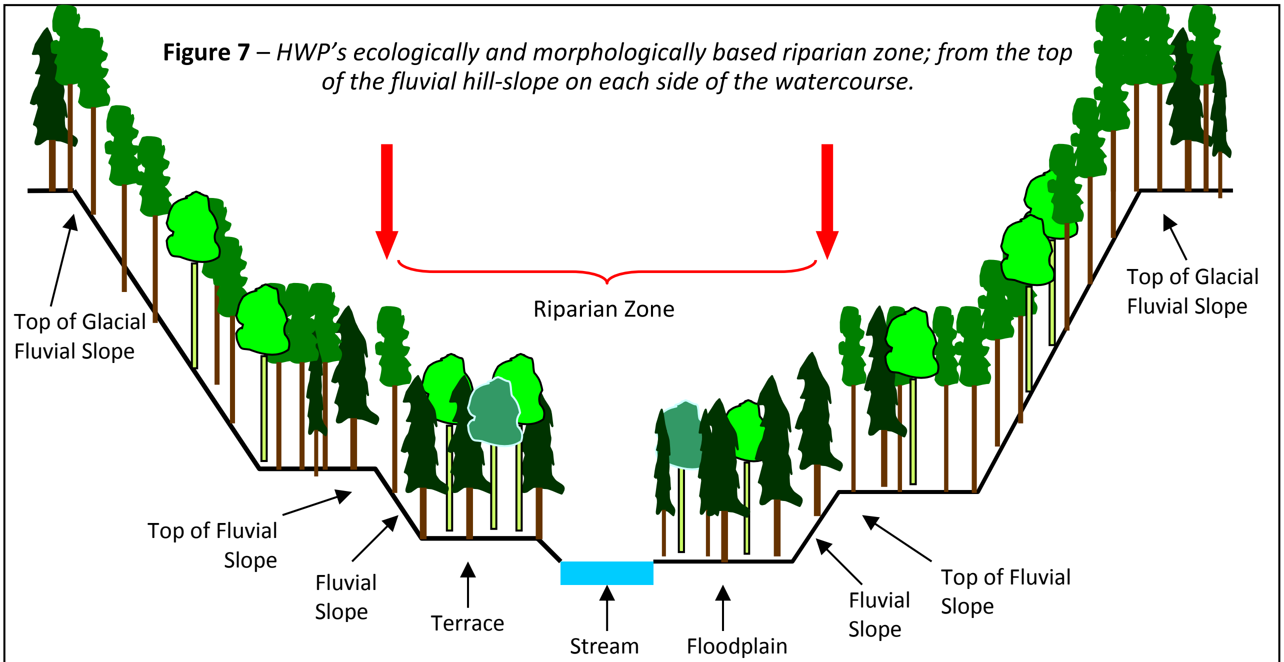
9.21 HWP Riparian Area/Zone Definition

Because landscape geomorphology controls the location and extent of riparian areas it is the most logical first step basis for defining riparian area boundaries. The geomorphology of today's FMA landscapes was strongly influenced by glacio-fluvial processes associated with melting of glacial ice at the end of the last ice age circa 12,000 years ago. However, along the larger watersheds, hill-slopes and terraces formed by glacio-fluvial processes have probably not been significantly influenced by fluvial processes for thousands of years. For this reason HWP decided to exclude erosion-based glacio-fluvial landforms in riparian area mapping, but include more contemporary fluvial based slopes as the top of the riparian area.

The border of HWP's ecological-based riparian zone is defined generally as the top (location of significant slope break) of the outermost contemporary fluvial hillslope that borders most streams (flowing water) and waterbodies (still water) on the FMA (see Figure 7). HWP chose the top of the contemporary fluvial slope as the first measure of the riparian area boundary for the following reasons:

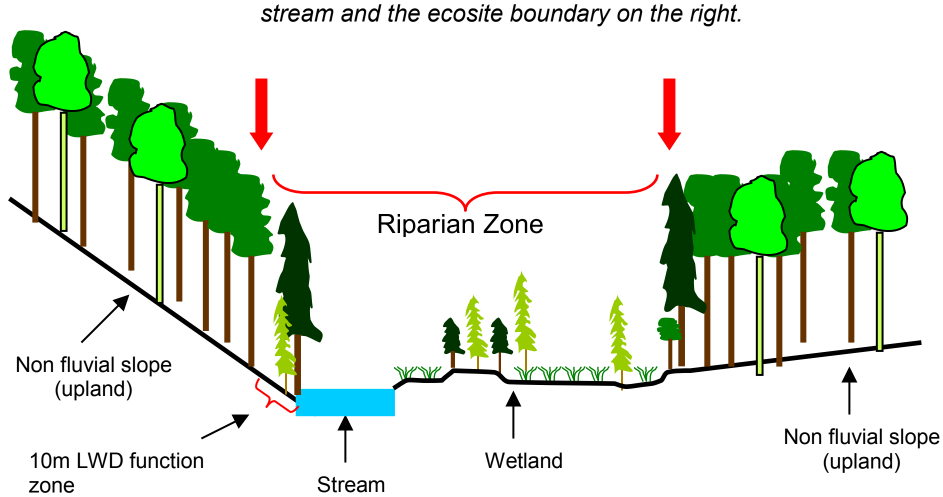
1. The areas (up to the top of the contemporary fluvial slope) were carved by water.
2. The top of the contemporary fluvial hill slope is the location that we can most consistently map across the entire FMA.
3. The top of the contemporary fluvial hill slope is the location that we can most consistently locate and agree to in the field.
4. The top of the contemporary fluvial hill slope also identifies where we have more operational constraints to consider (e.g. length of slope, degree of slope, working area at the bottom of the slope, groundwater discharge on slopes, ecosite or water at the bottom of the slope, etc).
5. In some cases, the top of the contemporary fluvial hill slope will coincide with the boundary of the contributing landbase and in those situations we will not propose operating within the riparian area. The FMP landbase classification will provide a good preliminary assessment of this. For example, in some areas of the FMA fluvial channels are closely associated with steep slopes. In those cases we will not operate in those locations.

Figure 7 – *HWP's ecologically and morphologically based riparian zone; from the top of the fluvial hill-slope on each side of the watercourse.*



Fluvial hill-slopes are sometimes absent in low relief terrain. In most of these cases the ecosite boundary between upland and wet or riparian ecosites will be the riparian zone boundary; however, on streams where there are no fluvial hill-slopes, riparian landforms, riparian ecosites, or legal requirements adjacent to a waterbody, the riparian area boundary will be placed a minimum of 10 m from surface water (see Figure 8) as part of a Large Woody Debris (LWD) function zone. See section 9.43 for a more detailed discussion on the 10-metre function zone.

Figure 8 – *Riparian zone definition in the absence of fluvial hill slopes. Note the 10 meter Large Woody Debris Function Zone on the left side of the fluvial stream and the ecosite boundary on the right.*



In some special cases riparian zones on the FMA are defined by legislation or policy. Under the Watercourse Crossing Code of Practice (Water Act) portions of Mackenzie Creek and Little Berland River are Class A waterbodies. Portions of these streams, the Tri-Creeks (Eunice, Wampus, and Deerlick Creeks), and a portion the upper Berland River and tributaries Fox, Moon, Cabin, and Hendrickson Creeks are Class B waterbodies. In these situations, the riparian zones default to the fixed-width buffers for Class A and B waterbodies found in the OGRs.

HWP's riparian zone boundary designation criteria summary in order of application is as follows:

1. A regulatory boundary (Class "A" and "B" waterbodies).
2. The top of the innermost fluvial hillslope separating upland from riparian ecosites.
3. The ecosite boundary between a riparian ecosite or landform and upland ecosites.
4. At least 10 metres from the vegetated bank of surface water.

It is important to note that defining the riparian area or zone as described above is not analogous to a fixed-width buffer. Riparian zones as defined by HWP are simply those areas on the FMA that meet the definition of riparian areas, as previously described:

Riparian lands are transitional areas between upland and aquatic ecosystems. They have variable width and extent above and below ground. These lands are influenced by and exert an influence on associated waterbodies, including alluvial aquifers and floodplains. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and hydrological processes.

9.22 Delineating the Riparian Zone

Now that we have an ecologically based definition of a riparian zone, the next step is to map those riparian areas/zones at the FMA level. This information will be used for the development of the 2014 DFMP and its associated Spatial Harvest Sequence.

Table 6 describes the inventories and data sources to delineate riparian zones (as described in section 9.21).

Table 6 – *Digital Inventory Layers used for Riparian Delineation*

Data Type	Inventory
Hydrography	Alberta base map – best inventory of still water for the FMA
	NetMap – LiDAR derived stream network, classified to predict channel width and fluvial processes.
	Wet Areas Mapping – LiDAR derived stream network, similar to NetMap
Landforms	2011 colour air photos (with the ability to look at photos in 3D)
	Timberline inventory – air photo derived digitized hillslope breaks
	Bare-earth hillshade – LiDAR derived depiction of landform surface
	DEM – LiDAR derived slope
Ecosites and Vegetation	ELC – Ecological Land Classification
	AVI – Alberta Vegetation Inventory
	Wet Areas Mapping – depth to water table
	Wetlands Mapping – ESRD layer
	LiDAR Vegetation – tree height, density, volume, understory, etc
	2011 colour air photos (with the ability to look at photos in 3D)

Due to the complexity of identifying channel riparian areas based on all the factors described in section 9.21, riparian areas associated with channels have to be identified and digitized manually. This was carried out by experienced interpreters working for GreenLink Forestry Inc., who consulted and referred to all the inventories outlined in Table 6.

The methodology currently being used is to refer to the following two primary inventories:

1. DEM LiDAR derived slope and bare earth – This is used first to identify the fluvial slope break; however, fluvial slope breaks are not always there or may not be readily apparent.
2. 2011 colour photo in 3D – If the fluvial slope break cannot be found (or needs to be confirmed), then the next step is to look (in 3D) at 2010 colour photos to pick up vegetation changes and small slope breaks.

The other inventories referenced in Table 6 are primarily used as required to confirm or refine decisions made. It should be noted that this is only a brief summary of the methodology that HWP will use to define the riparian zone. It's actually considerably more complex and HWP will eventually provide a report to ESRD that describes the procedure in detail with field confirmations of predicted boundaries to determine accuracy.

Figure 9 below shows how the riparian zone was delineated using bare earth LiDAR, while Figure 10 shows the riparian zone using air photo interpretation.

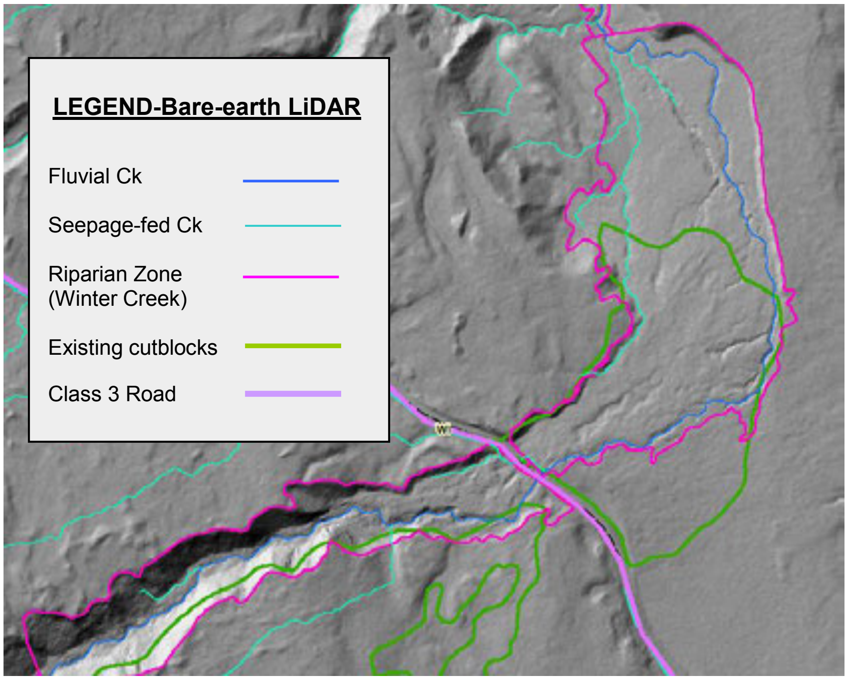


Figure 9 – *Bare earth LiDAR showing the digitized location of Winter Creek (dark blue line) and its riparian zone (pink line).*

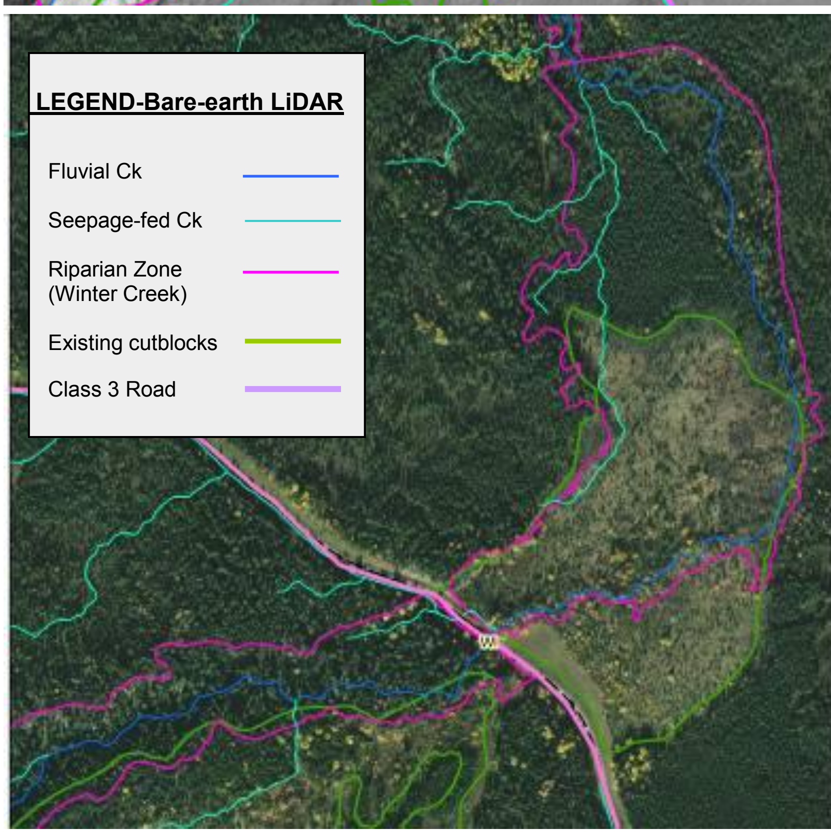


Figure 10 – *2010 colour air photo showing the digitized location of Winter Creek (dark blue line) and its riparian zone (pink line).*

Appendix B contains a full detailed description of the work carried out by GreenLink to classify and digitize all of the riparian areas on the Hinton FMA based on McCleary's channel classification system. After the GreenLink project was completed, there were four different types of riparian areas classified:

1. Fluvial Riparian – Fluvial riparian areas were defined as the area immediately adjacent to an EBCC-defined fluvial channel. This designation also includes riparian areas surrounding standing bodies of water such as lakes or ponds that have a fluvial channel flowing in or out of them. The top of the contemporary fluvial slope was the main driver in the fluvial boundary; however, ecosite (i.e. ELC) was referenced regularly to ensure consistency and accuracy.

2. Seepage-fed Riparian – Seepage-fed riparian areas were defined as the area immediately adjacent to an EBCC-defined seepage-fed channel. They were often closely associated with discontinuous channels and water source areas in poorly drained areas with minimal erosion potential. Ecosite boundaries, as well as the top of the associated contemporary slope, were used to determine the location and extent of the boundary.

3. Isolated Wetland – Isolated wetland areas were defined as wet areas completely surrounded by upland features. The main difference between seepage-fed and isolated wetland features is that seepage zones eventually flow horizontally into fluvial features, whereas isolated wetlands do not visibly drain over the surface of the landscape. Ecosite boundaries were usually used to determine the location and extent of the boundary.

4. Complex – Complex areas were defined as riparian areas that could not be accurately represented by any other category due to the large upland component mixed in with riparian features, resulting in areas that could not be accurately digitized. The complex classification was only used in a 295 hectare area located in the middle of the Upper Wildhay River drainage basin. The area contained very gentle and hummocky slopes consisting of upland vegetation interspersed with immediately adjacent riparian areas. These areas require additional field investigation to map riparian versus upland and determine any future management objectives. The entirety of the "complex" category is within the Switzer Park boundary and therefore will likely not pose management issues.

All other areas not classified into one of the above noted categories, was classified as "upland". Table 7 summarizes the results from the GreenLink riparian area classification project.

Table 7 – *Summary of the 13 watersheds into the area (hectares) occupied by each riparian spatial category*

Watershed	Fluvial	Seepage	Isolated Wetland	Upland	Complex	Grand Total
Brazeau/Pembina River	7,783	13,352	214	52,532		**73,882**
Edson/Windfall	5,295	10,591	464	48,365		**64,714**
Erith River	14,391	40,072	488	84,003		**138,954**
Lower Athabasca River	6,757	10,968	343	49,319		**67,387**
Lower Berland River	7,679	17,048	600	34,380		**59,708**
Lower McLeod River	7,571	15,537	410	29,167		**52,685**
Lower Wildhay River	13,786	25,693	950	72,210		**112,638**
Mid Athabasca River	15,146	29,995	816	65,429		**111,386**
Mid Berland River	4,788	12,593	335	31,270		**48,986**
Upper Athabasca River	9,036	12,838	519	54,307		**76,700**
Upper Berland River	3,962	3,523	9	19,415		**26,910**
Upper McLeod River	18,589	21,032	769	95,117		**135,507**
Upper Wildhay River	8,388	13,968	587	41,317	295	**64,554**
Grand Total (ha.)	123,170	227,210	6,503	676,831	295	**1,034,010**
Grand Total (%)	11.9%	22.0%	0.6%	65.5%	0.03%	100%

9.23 10-Meter Channel Function Zone

Research in the Alberta foothills has shown that nearly 100% of all large woody debris that interacts with a stream channel originates within 10.2 metres of the channel (McCleary. 2005). Therefore, all riparian zones for fluvial and seepage-fed channels will have a 10 metre function zone applied to both sides of the channel. On fluvial channels HWP will leave sufficient trees to maintain fully the Large Woody Debris (LWD) function along the channel. This means we will only remove trees that are unlikely to fall toward the channel. HWP may take up to a limit of 50% of the remaining stems. HWP is concerned about LWD and channel function on all seepage-fed and fluvial channels; however, more so on fluvial channels as we want to maintain full LWD function as a first priority. HWP will not harvest anything within that zone unless we feel we are maintaining LWD function.

For seepage-fed channels, trees that are leaning into the channel or interacting with the channel will be protected from harvest. Brush and immature trees interacting with the channel will also be protected. All remaining trees can be harvested.

9.3 <u>Step 3 – Classify Riparian Areas – Vegetation and Operability Classes</u>

Once the channel has been classified and the riparian zone of that channel defined (as outlined in section 9.2 and 9.3 and illustrated in Figure 11), the next step is to determine for all of the riparian zones what land is designated as passive (i.e. no timber harvest) and what land is designated as active (i.e. some form of timber harvest may be proposed at some time in the future). See Figure 12.

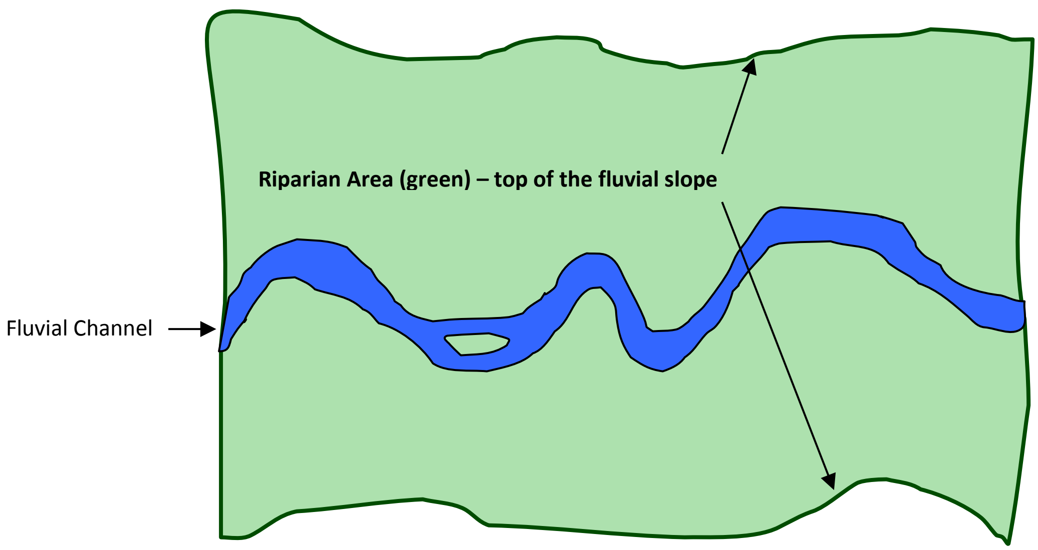


Figure 11 – *This illustration demonstrates the first step in the process of preparing a management strategy for a riparian zone; identify the channel classification and the riparian area. In this case the channel is fluvial and the riparian zone is identified by the top of the fluvial slope.*

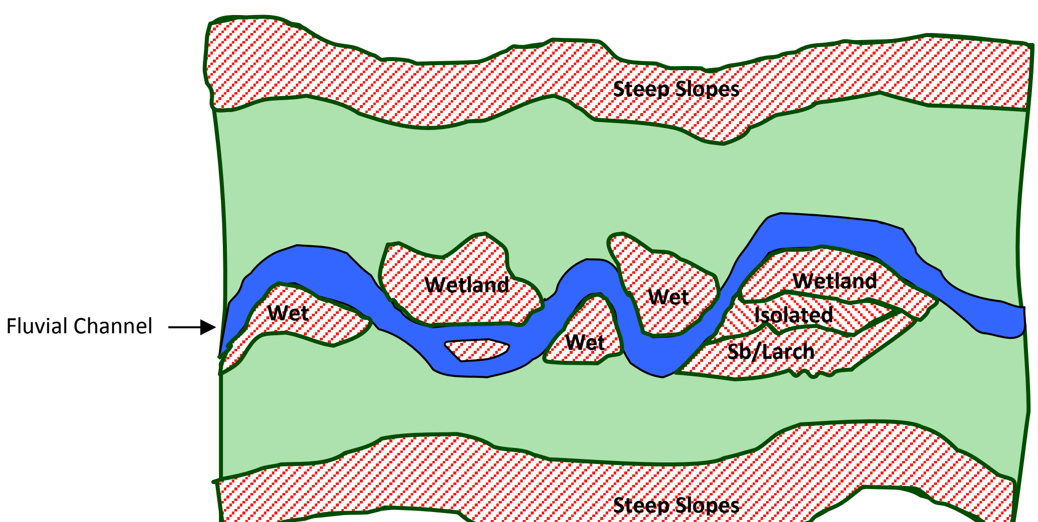


Figure 12 – *This illustration demonstrates the second step in the process of preparing a management strategy for a riparian zone; identify the area within the riparian zone that is unavailable for harvesting disturbance; for example, wet ecotypes, wetlands, black spruce/larch types, isolated areas, and steep slopes.*

After the area that is unavailable for harvesting disturbance has been identified and netted out of the riparian area, the next step is to identify the vegetation classes (and age) of the remaining area available for disturbance. Figure 13 illustrates this concept.

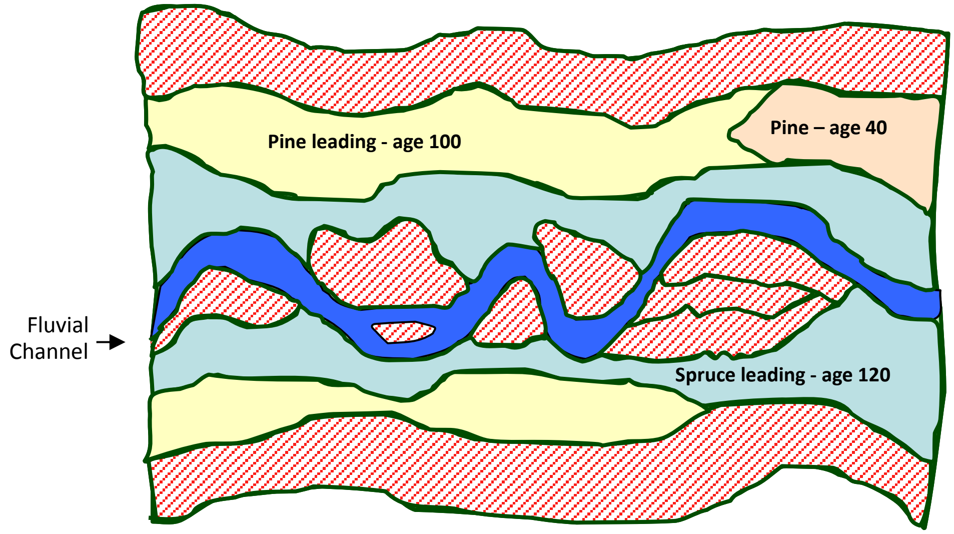


Figure 13 – *This illustration demonstrates the third step in the process of preparing a management strategy for a riparian zone; identify vegetation classes by age; for example, pine leading (100yrs old) is shown in yellow; spruce leading (120yrs old) is shown in blue and pine (40yrs old) is shown in orange.*

9.4 Step 4 – Natural Disturbance Modelling – Creating NRV Targets for Riparian Areas

Hinton Wood Products has engaged the services of Dr. David Andison (Bandaloop Landscape-Ecosystem Services) to assist in quantifying the natural range of variation (NRV) of seral stages across the FMA. NRV ranges will also be determined for upland and riparian portions of the FMA. This analysis will be completed using LANDMINE. LANDMINE is a spatially explicit landscape disturbance simulation model that was developed by Dr. Andison. This tool will aid in defining historical (i.e. natural) landscape conditions based on a series of modeled disturbance (fire) events. Values such as area by seral stage and cover type are summarized for each model scenario, which represents one possible landscape condition. When the results of multiple scenarios are compared, a range of the selected values can be calculated. These ranges are reported as the natural range of variation.

9.5 Step 5 – Develop Stand-Level Riparian Disturbance Treatment Options

Silviculture prescriptions will be developed by HWP silviculturalists that will provide a range of acceptable treatments that will depend on the vegetation type, the ecological classification of the area (nutrient and moisture class) and the morphological characteristics (e.g. flood plain, terrace, etc.) of the riparian, as well as other factors, such as the extent of the any required partial cutting. Prescriptions may vary from clear-cut (with reserve individual trees or patches) to partial cut systems like shelterwood (on floodplains) or selection with varying percentages of removal within the 10-metre channel-function zones.

Riparian disturbance may be treated as the part of the harvest opening (i.e. one treatment unit) or may be treated as a separate opening (i.e. two treatment units). Currently there are no administrative processes in place in Alberta to deal partial cutting systems such as shelterwoods and selection systems. HWP would work with Alberta to ensure such administrative details are agreed too ahead of implementing this Riparian Management Strategy. Section 7.3.12 (Riparian Management Strategy Reforestation) in the DFMP and Table 85 describe HWP's approach to reforestation within riparian areas..

Table 8 below provides an example of how the silviculture options may look for the riparian areas on the Hinton FMA.

Table 8 – *Example of Silviculture Treatment Options for Riparian Areas on the FMA used for the DFMP*

Vegetation Class	Ecosite		Landform	Harvesting Season	Silvicultural System
	moisture	nutrient			
White spruce leading	subxeric to mesic	very poor to medium	terrace	any	clear-cut with reserves
Pine leading	subxeric to mesic	very poor to medium	terrace	any	clear-cut with reserves
Pine leading	mesic to subhydric	rich to very rich	terrace	winter	clear-cut with reserves
Mixed wood with understorey	subxeric to mesic	very poor to medium	terrace	any	clear-cut with reserves
White spruce leading	hygric	rich	floodplain	winter	partial cut

9.6 Step 6 – Timber modelling – Creating the Spatial Harvest Sequence (SHS)

The natural range of variation (NRV) in seral stage targets produced from the LANDMINE model will be used as targets for the FMA timber supply model scenarios. One objective of the timber supply model will be to generate a forest condition that generally falls within the seral stage NRV. It is possible that some values will initially be outside of the natural range due to historical management practices (fire suppression, two-pass harvesting, etc.). As a result, it may take several decades or longer for the landscape to resemble a natural condition. It is also possible that some values will fall outside of the natural range due to limitations on management activities (e.g. lack of disturbance within areas that are not included in the productive forest landbase). The timber supply model will be designed with a goal to achieve NRV of seral stages in both the upland and riparian areas. The disturbance method that will be modeled is forest harvesting. A Spatial Harvest Sequence (SHS) will be generated that provides a stand level map of stands to be harvested to generate the annual allowable cut, which is also designed to generate the desired future landscape condition. The SHS will sequence stands in upland and riparian areas to achieve the NRV targets. Harvest systems will be identified as noted above in Table 8. Figure 14 below provides an example of what the SHS might show in the riparian area of a larger sized river.

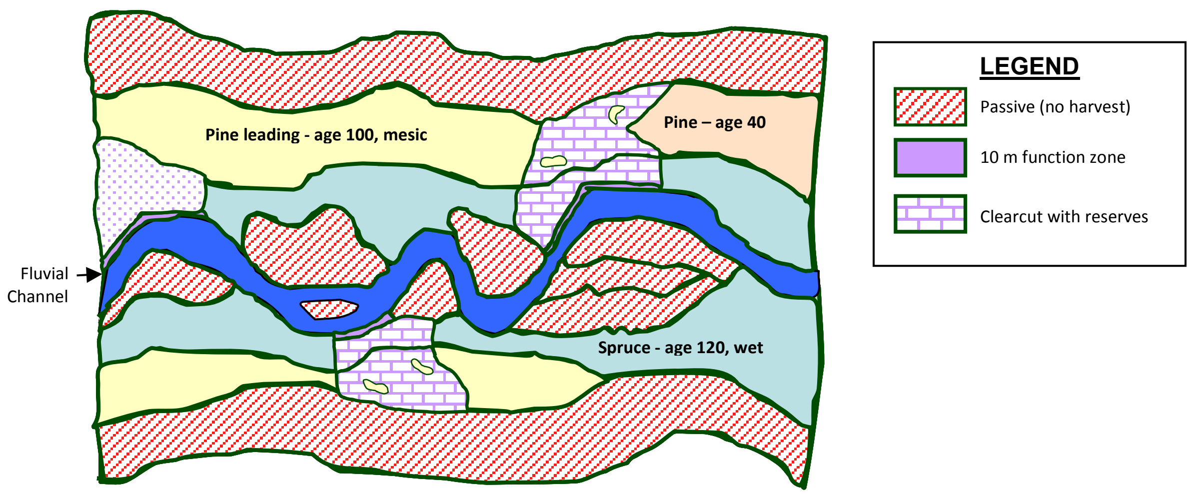


Figure 14 – *This illustration shows what a riparian zone along a major river might look like. Note the three proposed harvest openings, each with a 10-metre function zone along the river where all trees leaning into the river or interacting with the river would be retained. The portions of the blocks within the spruce leading stand types would be partial cut, while the portions of the blocks within the pine leading types are proposed to be clearcut (with reserves).*

For comparison, Figure 15 illustrates what harvesting roughly the same area might look like under HWP's 2009 Operating Ground Rules, where the riparian area is identified with a fixed-width buffer.

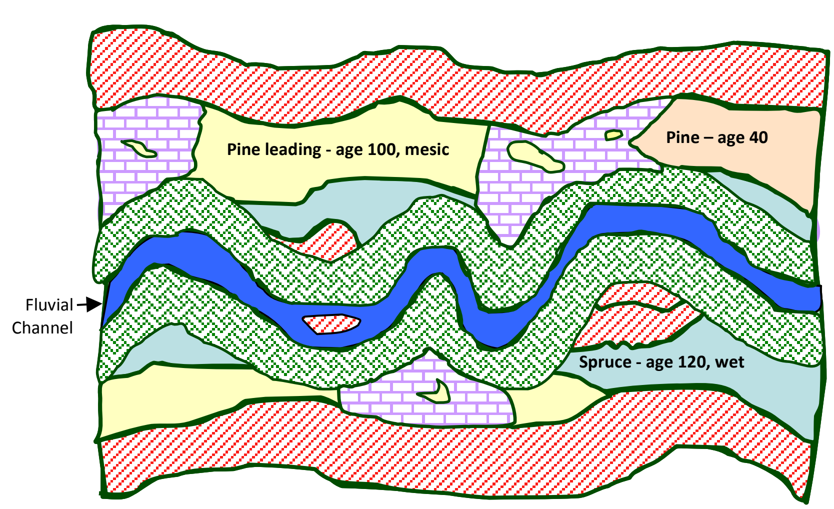


Figure 15 – *The illustration shows what the same ecological riparian zone might look like under 2009 HWP OGRs – with a fixed buffer. All other area within the ecological riparian area could be clearcut with the exception of the passive (i.e. non-operable) landbase.*

Figures 16 and 17 below show the differences in the harvesting pattern and disturbance levels using HWP's proposed Riparian Management Strategy (Figure 16) versus using the 2009 Operating Ground Rules' definition of the riparian zone (Figure 17). Both systems would harvest approximately the same area; however, the HWP's proposed strategy would result in some disturbance adjacent to the stream channel, while the OGR system does not.

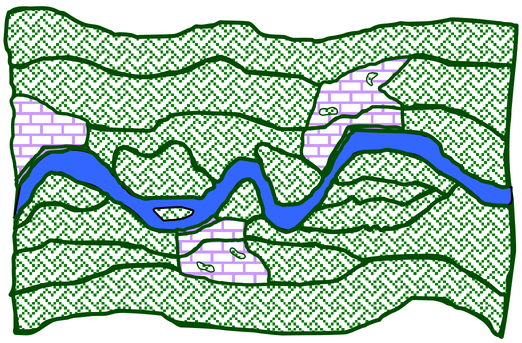


Figure 16 – *This figure illustrates what the disturbance would look like in the riparian zone after implementing HWP's Riparian Management Strategy (as in Figure 14).*

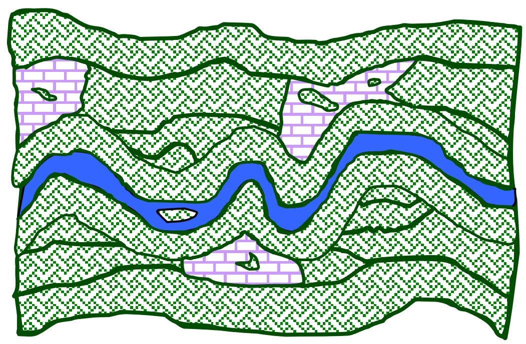
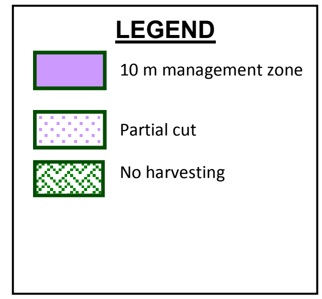


Figure 17 – *This figure illustrates what the disturbance would look like in the riparian zone after implementing the 2009 OGRs' riparian zone guidelines (as in Figure 15).*



9.7 Step 7 – Riparian Area, Stream Classification and Silviculture Strategy Verified

The Spatial Harvest Sequence (SHS) will identify the watercourse classification, the riparian area, and the silviculture strategy; however, these calls will be verified in the field during the development of the Forest Harvest Plan (FHP) and may be revised. It is at the FHP stage that specific stand-level riparian disturbance treatment options will be reviewed in the field and finalized. The first decision will be whether or not harvesting is acceptable based on a field confirmation of inventory used to produce the SHS. Section 9.71 below describes how stand-level treatments will be refined at the FHP stage.

9.71 Finalize Stand-Level Riparian Disturbance Treatment Options

When developing a FHP within a designated riparian area, a combination of recognizable riparian features will be used to guide decisions about stand-level treatment options needed to conserve riparian values and functions. HWP's intent is to develop field guidelines and train staff in how to use it. For example, potential disturbance treatments will be developed for various combinations of forest types and riparian features, as described in Table 9 below. This will help define acceptable treatments that may be applied. Treatments that would not conserve function and other values and/or would be high-risk or uneconomic will be considered unacceptable.

Table 9– *Potential disturbance treatments based on riparian features and dominant forest types – used for FHP*

Channel Type	Vegetation	Landform	Soils moisture/nutrients	10m function zone	Disturbance options	Season
fluvial	white spruce (other conifer, balsam poplar)	floodplain (periodic flooding and possible channel migration)	Subhydric - hygric; rich to very rich	Yes. Up to 50% of the merchantable stems will be retained for recruitment of large woody debris into the fluvial channel over time. Lesser vegetation and snags will also be retained.	no harvest; group selection; or shelterwood	winter
		terrace and/or fluvial slope	mesic to subhydric; rich to very rich		no harvest; group selection; shelterwood; or clearcut with reserves	winter
		terrace and/or fluvial slope	subxeric to mesic; very poor to medium		Clearcut with reserves	any
	pine leading (other conifer, aspen)	Floodplain (rare for pine to grow on floodplains)	Subhydric - hygric; rich to very rich		no harvest, or clearcut with reserves (more structure retention in these stands)	winter
		terrace and/or fluvial slope	mesic to subhydric; rich to very rich		no harvest; or clearcut with reserves	winter
		terrace and/or fluvial slope	subxeric to mesic; very poor to medium		clearcut with reserves	any

Channel Type	Vegetation	Landform	Soils moisture/nutrients	10m function zone	Disturbance options	Season
seepage-fed	white spruce (other conifer, balsam poplar)	floodplain (typically very small floodplains – related to occasional bank overflow)	mesic to subhydric; rich to very rich	Yes. Merchantable stems that are leaning over the channel or are directly interacting with the channel will be retained. Lesser vegetation and snags will also be retained..	no harvest, or clearcut with reserves	winter
		terrace and/or fluvial slope	mesic to subhydric; rich to very rich		no harvest, or clearcut with reserves	winter
		terrace and/or fluvial slope	subxeric to mesic; very poor to medium		clearcut with reserves	any
	pine leading (other conifer, aspen)	floodplain (typically very small floodplains – related to occasional bank overflow)	mesic to subhydric; rich to very rich		no harvest, or clearcut with reserves	winter
		terrace and/or fluvial slope	mesic to subhydric; rich to very rich		no harvest, or clearcut with reserves	winter
		terrace and/or fluvial slope	subxeric to mesic; very poor to medium		clearcut with reserves	any

Disturbance rate and scheduling decisions will be based on plans that approximate variable-size disturbance events and are within the NRV and following the FMP targets at the context and scale being measured. At small scales such as first and second order stream basins natural disturbances can affect the entire basin, including riparian areas. As area size increases the likelihood that a smaller proportion of a basin will be affected also increases. This suggests that disturbance extent in small basins should sometimes include large portions of the basin. Decisions about whether or not to disturb large portions of small basins will consider the values and sensitivity of the basin and associated riparian areas. For example, if a basin has an important bull trout spawning stream the disturbance proportion and rate could be deliberately reduced whereas another similar basin with no bull trout spawning could have a higher level of disturbance.

9.8 Step 8 – Careful Road Building and Harvesting

HWP will avoid building permanent gravelled roads within riparian zones wherever practical. Access and operations will take place during dry or frozen periods followed by deactivation/revegetation (if route will be needed again) or reclamation/reforestation (if route is not needed again).

Implementation of the FMA Road Corridor Plan and HWP's Long Term Access Plans will minimize the landbase "footprint" of human infrastructure in riparian areas. Access planning will ensure that all stream crossings meet standards, that redundant stream crossings are removed and reclaimed, and that new stream crossings are planned to minimize the number needed and placed in appropriate locations. The impacts of existing permanent roads in riparian areas will be reviewed and actions will be taken to mitigate, relocate, or reclaim roads to address identified issues. Current practices to locate new permanent high-standard roads outside riparian areas will be continued and low-standard roads and trails will be used to access riparian areas for management.

Harvesting within HWP-defined riparian zones will carried out in a careful manner with the main goal being to minimize soil disturbance and protect water quality. Fluvial, seepage-fed, and discontinuous channel crossings will be minimized and, where crossings are required, proper crossing structures will be put into place.

9.9 Step 9 – Monitoring and Reporting

9.91 Monitoring Program

A post-harvest systematic sampling protocol will be implemented that will monitor the impacts of harvesting on the properly function condition of adjacent streams and riparian areas.
This monitoring protocol, called "Evaluating the Condition of Streams and Riparian Areas in the West Central Foothills of Alberta" was adapted by Dr. Rich McCleary (McCleary Aquatic Systems Consulting)

for HWP in the fall of 2013 from a similar monitoring protocol used in British Columbia. This riparian monitoring protocol is based on the concept of a riparian area having a properly functioning condition (PFC). The PFC on a stream and its riparian area can be measured, and from this measuring information, a call can be made on whether or not the riparian area is in a PFC or not.

Riparian habitats can be said to be in a Properly Functioning Condition (PFC) if the impacts of development on the attributes of the riparian area are:

- on average, small or within the range of natural variability of the habitat; or
- large and beyond the range of natural variability in no more than a small portion of the habitat

The key underlying assumption of PFC is that if the range of impacts attributable to the management activity affecting the riparian habitat lies "within the range of natural variability over most of the habitat, it is likely that the natural ecological functions of the habitat will be maintained."

The primary goal of monitoring the PFC of stream channels and their adjacent riparian management areas is to determine whether standards and practices proposed within HWP's Riparian Management Strategy are achieving the desired result of maintaining ecological function (and other values), by properly maintaining channel and riparian functions.

The concept of assessing PFC as a way to gauge riparian health has a long history. It started in the United States in the mid-90s, when the US Bureau of Land Managers were challenged to provide status reports on the condition of streams and riparian areas across large areas, and subsequently found that each region had own style that prevented comparisons. They came up with the idea of carrying out a detailed riparian vegetation condition assessment coupled with a detailed channel assessment, and compiling and assessing these results using a series of PFC questions.

Alberta's Cows and Fish Program was also interested in ways of measuring riparian health. They started by bringing PFC experts from Montana (Paul Hansen and Bill Thompson) to advise them. The Cows and Fish Program adapted a similar PFC assessment framework as the US system, and Hansen and Thompson have continued to support rangeland management in Alberta since that time (e.g., regional riparian vegetation classifications, reference site establishment in Clearwater, Elbow, and Oldman 2009).

In 2003, BC formed a team to develop a procedure to evaluate the effectiveness of the new results-based Forest and Range Practices Act; specifically, its effectiveness in conserving riparian values. The team reviewed available options and also decided on PFC framework. The PFC assessment developed in BC was specifically designed to look at the effects of harvesting on streams and their accompanying riparian areas – in the BC assessment, significantly more information is collected and evaluated than in the US and Cows & Fish assessments.

It was this BC PFC assessment that McCleary adapted for use in the Alberta Foothills. It was adapted in collaboration and with full cooperation of the authors of the BC protocol (Tripp, D.B., Tschaplinski, P.J., Bird, S.A., and Hogan, D.L. 2009a). The US, Alberta and BC PFC assessments are all science-based and peer reviewed.

This protocol for "Evaluating the Condition of Streams and Riparian Areas in the West Central Foothills of Alberta" is essentially a detailed PFC assessment, based on the data collected to answer 15 PFC related questions. McCleary adapted the BC PFC assessment to the conditions and terminology specific in the Foothills of Alberta. The 15 questions that McCleary adapted for the Foothills PFC assessment are as follows:

1. Has the vegetation retained in the Riparian Management Area been sufficiently protected from windthrow?

2. Has the amount of bare ground or soil disturbance in the riparian area been minimized?
3. Has sufficient vegetation been retained to maintain an adequate root network or Large Woody Debris (LWD) supply?
4. Has sufficient vegetation been retained to provide shade and reduce bank microclimate change?
5. Is the riparian vegetation within 10m of the stream edge generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach?
6. Does the stream support a healthy diversity of aquatic invertebrates?
7. Is the riparian area free of noxious weeds and/or invasive plants?
8. Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?
9. Are the channel banks undisturbed?
10. Are channel LWD processes undisturbed?
11. Is the channel bed undisturbed?
12. Is the channel morphology undisturbed?
13. Does the stream support a good diversity of fish cover attributes?
14. Does the amount of moss present on the substrates indicate a stable and productive system?
15. Has the introduction of fine sediments been minimized?

The Foothills PFC assessment is carried out in two main parts – office activities and field activities, which are further broken down as follows:

A. Pre-field activities:

1. Block selection
2. Determine stream class (i.e. fluvial/seepage-fed) from maps
3. Use GIS to identify upstream activities (e.g. road crossing, logging, mining, etc.)

B. Field activities:

1. Collect stream/cutblock information
2. Identify channel and riparian area characteristics
3. Collect PFC field measurements
4. Fill out PFC checklist
5. Carry out the 15 question summary
6. Determine reasons for “No” answers
7. Determine additional riparian information and compliance evaluation
8. Make final comments

At the completion of the PFC assessment, it provides the following:

1. A rating based on whether or not each of the ecological functions is being performed.
2. Where functions are not being performed, the assessment will also determine why and what the recommended management response is.

The sampling methodology for the Foothills PFC Assessment is proposed as follows:

1. Randomly select the blocks using two strata:
   - Channel type (seepage-fed and fluvial)
   - Harvest type (partial and clearcut)
2. Samples would be taken at least two years since harvest
3. Target sample size is four plots per strata or 16 per year (in BC it is 15 plots per district)

ESRD has expressed concerns about some of the thresholds identified in the Program, as well as the fact that there was no data collection proposed for reference streams (i.e. streams with no riparian harvesting that could be used to compare to stream with riparian harvesting). HWP agreed for the need for some reference streams and that thresholds can be re-examined. As HWP moves forward with a measured roll out of its Riparian Management Strategy, the Monitoring and Measuring Program will also need to adapt and evolve. The issue of which reference streams, and how many need to be sampled, and the appropriateness of the thresholds will all issues that will be dealt with in the upcoming years (likely between the time this DFMP is submitted for approval and the time when it is approved). In a September 9, 2014 ESRD/HWP meeting in Edmonton, ESRD asked that HWP not submit its proposed Monitoring and Measuring Program as part of this DFMP submission, but rather submit it later under a separate cover after issues raised by ESRD are all addressed. Therefore, the Monitoring and Measuring Program developed for this Riparian Management Strategy will be submitted separately (i.e. not part of the 2014 DFMP submission).

Once the HWP Riparian Management Strategy is operationally implemented, and a Monitoring and Measuring Program has been approved, monitoring will also involve on-site supervision while harvesting is taking place, which will be more intensive when the Riparian Management Strategy is initially implemented. Training programs will also be implemented for both HWP supervisors and logging and site preparation contractors.

> **Note:**
> In December 2014, after the HWP had submitted the 2014 DFMP, Alberta sent HWP a letter (dated December 1, 2014) noting that they would not allow the implementation of HWP's Riparian Management Strategy in any stream identified in the Athabasca Rainbow Trout Recovery Plan as containing Athabasca rainbow trout or ecologically significant Athabasca rainbow trout habitat. In addition, Alberta asked that HWP establish a suite of reference streams in order to better set the thresholds associated with HWP's proposed monitoring program (as described above). Until HWP's Monitoring and Measuring Program was approved by Alberta, HWP would not be able to implement its Riparian Management Strategy. Alberta also outlined numerous other required changes in the monitoring program that HWP had to address.
>
> Over the course of the next 10 months, HWP began the development of a Reference Stream Program and other calibration work. The Monitoring and Measuring Program questions were also modified to address Alberta concerns. Two additional questions were also added to the protocol that dealt directly with stream temperature and spawning gravel sedimentation. This is a work still in progress and will likely continue into 2016.

9.92 Reporting

Reporting on the implementation of HWP's Riparian Management Strategy will be undertaken at a number of different levels:

- **Stand Level** – At the stand level, each Forest Harvest Plan will include a variance report that will describe the planned target riparian disturbance area based on the Spatial Harvest Sequence; and then will report on the differences between the planned riparian disturbance area and the actual riparian disturbed area.

- **Landscape Level** – At the landscape level, HWP will summarize and report on the amount of disturbance within the riparian area compared with the amount of disturbance planned in the SHS. This reporting will take place annually in HWP's Stewardship Report, which will include an annual summary and a cumulative summary of riparian disturbance as compared to the plan. HWP will also report on the results on its Monitoring Program annually in the Stewardship Report and every five years in the DFMP Performance Stewardship Report.

In the 2014 DFMP, HWP will have VOITs that specifically describe and report on HWP's Riparian Management Strategy and that have the specific objective of retaining ecological values and functions associated with riparian zones. The wording of these VOITs is outlined in Table 10 below:

Table 10 – *HWP's Riparian Management Strategy VOIT*

Value	Objective	Indicator	Target	Means to Identify Target	Legal & Policy Requirements	Means of achieving Objective and Target	Monitoring and Measurement	Reporting	Acceptable Variance	Response
Landscape scale biodiversity	Retain ecological values and functions associated with riparian zones	Compliance with the riparian-related sections of the Operating Ground Rules.	100% consistent and compliant with the DFMP's Riparian Management Strategy	Research into natural disturbance on the HWP FMA by the Foothills Research Institute. (http://foothillsresearchinstitute.ca/pages/Programs Natural_Disturbance/default.aspx)	Operating Ground Rules / Federal Fisheries Act / Water Act	Initiate and implement a program for introducing disturbance into riparian areas / Air photo interpretation / Field work / Field trips	The SHS will be implemented - riparian disturbance will be measured and compared to targeted NRV riparian disturbance in the SHS. - HWP will develop a government-approved Monitoring and Measuring Program to measure and monitor any negative environmental impacts from the implementation of the Riparian Management Strategy.	-Report variances with the targeted riparian disturbance (based on the approved SHS) with each FHP submission. -Annually and cumulatively summarize variances and report in HWP's annual Stewardship Report and every five years in the DFMP Stewardship Report.	0% positive variance in meeting the 5 year SHS target for riparian disturbance (up to 20%negative variance is acceptable)	Adjust strategies in subsequent DFMP

Value	Objective	Indicator	Target	Means to Identify Target	Legal & Policy Requirements	Means of achieving Objective and Target	Monitoring and Measurement	Reporting	Acceptable Variance	Response
Landscape scale biodiversity	Retain ecological values and functions associated with riparian zones	Compliance with the riparian-related sections of the Operating Ground Rules.	Zero non-compliance incidents on an annual basis.	All relevant legislation and regulations, including the OGRs, as enforced by government.	Forest Act / Timber Management Regulation / HWP Operating Ground Rules / and other forestry or landuse related provincial and federal acts and regulations	Regular training of contractors and staff, third-party audits (e.g. SFI, ISO, FOMP), HWP logging inspections, HWP SFI/ISO compliance audits, West Fraser internal SFI/ISO divisional audits.	Monitoring will occur through on-site inspections, internal and external auditing, and incident reporting. Environmental incidents and follow up action items are tracked on a database.	All incidents that are reportable to the government will be reported immediately and then summarized annually in HWP's annual Stewardship Report and every five years in the DFMP Stewardship Report.	No variance; apply operational procedures	Internal investigation, and if required, timely remedial actions

As noted above in Table 10, there will be no positive acceptable variance on the amount of hectares disturbed in riparian areas over a five year period for this VOIT. HWP can control the amount of hectares disturbed within the riparian zone (during layout), so can ensure the amount of area disturbed does not exceed the amount of area planned in the SHS. Negative variance (i.e. not meeting the amount of hectares planned) is acceptable.

10.0 Continual Improvement

HWP recognizes the importance of research and continual improvement to support implementation and evaluation of the riparian management strategy.

Previously established stand level research and operational trials include the lower Gregg River trials (winter 1990-1991), the McLeod River trials (winter 1998-1999), and three stand level trials on seepage-fed channels (2002-2003). Additional stand level and watershed and/or event scale trials will be investigated for implementation in future years. HWP will maintain a catalogue of trials and significant findings.

The riparian management strategy is founded on many years of research conducted through the Foothills Research Institute and by others. HWP will continue to support and participate in FRI research. In particular, the FRI Water Program and Healthy Landscapes Program will provide new scientific knowledge to support implementation and evaluation of the riparian management strategy.

HWP will review results of trials and research at least bi-annually and make regular improvements to the Riparian Management Strategy.

11.0 Risks and Benefits

There are environmental, social, and economic risks, and benefits with implementing HWP's Riparian Management Strategy. There are also the same types of risks and benefits with continuing to implement the watershed protection measures outlined in HWP's 2009 Operating Ground Rules. Table 11 and 12 below compares and contrasts the risks and benefits of each riparian management strategy.

Table 11 – *Risks and Benefits Associated with HWP's Proposed Riparian Management Strategy*

Type of Benefit/Risk	Risks/Issues	Benefits
Environmental	➢ Riparian areas typically contain wetter soils, which if harvested on, are more prone to compaction, rutting, and erosion, and the accompanying increased siltation to adjacent waterbodies. This risk can be mitigated by operating when soils are frozen and building (and removing) proper crossings. ➢ Riparian areas are typically more ecologically diverse than upland areas and also are important wildlife movement corridors (particularly with large, wide riparian areas). This risk can be mitigated by keeping harvest levels within NRV and not harvesting on both sides of major river valley bottoms in one pass. ➢ Forests and vegetation provide shade, filter sedimentation, and provide structure to watercourses within the riparian areas. For fluvial channels, this risk can be mitigated by implementing a 10-metre function zone, where trees interacting with the channel or leaning toward the channel are not harvested. For seepage-fed and discontinuous channels, streamside vegetation will be protected, the channel will only be crossed using proper crossing structures, and logging debris will not be allowed to enter the watercourse. ➢ The mechanical removal of biomass (dead or alive) from riparian zones represents a significant departure from the "natural" model of managing forests. However, research shows that 100% of all large wood debris that interacts with a stream channel originates within 10.2 metres of the channel. HWP's proposed 10-metre function will protect all trees interacting with the channel or leaning toward the channel.	➢ Riparian and upland areas are identified based on their ecological and morphological characteristics. ➢ HWP's new erosion-based classification system tends to align better with riparian value; for example there is a much closer correlation between game fish presence and fluvial channels, then there is in the width-based OGS system. ➢ The natural disturbance approach assumes that continual disturbance and recovery from disturbance in riparian areas is necessary to conserve the variability that maintains ecological function over the long term. Introducing careful disturbance in the ecologically-defined riparian zone through HWP's new Riparian Management Strategy accomplishes this.
Social	➢ Avoiding harvesting adjacent to channels and lakes, through fixed-width buffers, has been the standard practice throughout North America. Any movement away from this buffer system could be viewed as an eroding of environmental protection.	➢ Because this erosion based classification system does not rely on stream width or flow performance, it has been much easier for multiple people over multiple time periods to arrive at the same classification.
Economical	➢ It is unclear whether the time and effort that it will take to identify and map out ecological-based riparian zones, and the added cost and complexity of developing NRV for all riparian areas, will outweigh any benefit received in terms of additional timber available from areas previously protected by fixed-width buffers.	➢ Classifying channels remotely using tools such as LiDAR and NetMap allows a more accurate inventory of watercourse channels, making strategy planning (i.e. the SHS) and stand level planning (the FHP) more accurate and therefore efficient. ➢ Some timber (i.e. only that in the operable land base) previously looked up in permanent buffer withdrawals would now be available for harvest.

Table 12 – *Risks and Benefits Associated with the Riparian Management Strategy in HWP's current Ground Rules*

Type of Benefit/Risk	Risks	Benefits
Environmental	➢ Research has now shown that both upland and	➢ Administratively easy to implement – one size

Type of Benefit/Risk	Risks	Benefits
	riparian areas need to be managed based on natural disturbance principles – excluding riparian areas (the current OGR practise) would presumably have long term ecological consequences. ➢ Even at the field level, it is difficult to consistently classify channels due to natural variability and measurement subjectivity. Variation along channel reaches is also an issue, as channels sometimes switch back and forth between categories over fairly short distances. ➢ Disturbance, especially windthrow, continues in riparian buffers after they are created, altering them significantly. The process can alter riparian values and functions. ➢ The buffer approach is linked to values and functions by assumptions that have not been well tested and evaluated. For example, science that links function to channel width, or channel width to buffer width, is not well developed. In reality, the prescribed buffer width is rarely, if ever, the actual ecologically based riparian zone. ➢ Other potential ecological implications of fixed-width riparian protection during harvest are as including; • Shrinking or eliminating grassland or shrub riparian habitats, • Changing the dynamics of coarse-woody biomass accumulation in streams. • Increasing the risk of fire, insect and disease outbreak everywhere by leaving a network of older forest to decline. • Decreasing landscape productivity by ignoring and allowing that portion of the landscape covered by riparian zones to decline • Decreasing the proportion of interior old forest by forcing them into linear spatial elements.	fits all. ➢ All water above a certain channel width or waterbody type is protected from any disturbance associated from harvesting (e.g. siltation, logging debris, etc.).
Social	➢ As the buffer width is linked to the channel classification, this leads to potential disagreement between HWP and ESRD about whether or not the correct classification was made, particularly near transitions between OGR categories (e.g. intermittent to transitional).	➢ Easy to demonstrate that water (above a certain channel width or waterbody type) is being protected.
Economical	➢ Lack of, or low, resolution inventory makes it difficult to classify watercourses (based on stream width) at the DFMP level. Experience shows that the landbase netdown process over the years has consistently underestimated the actual extent of FMA watercourses and this in turn affected (overestimated) the net operable landbase that is used for the AAC determination, which also increases the variance between the SHS and the FHP. ➢ Operable and economical timber is continually isolated due to the arbitrary nature of the fixed-width buffer.	➢ Relatively inexpensive to implement both at the landscape and stand level.

HWP's proposed Riparian Management Strategy and the existing watershed protection measures outlined in HWP's 2009 Operating Ground Rules both have risks and benefits.

The main benefits associated with the water protection measures in the 2009 OGRs are the simplicity in administrating the rules, the relative ease in determining landbase withdrawals at the landscape level, and the social acceptance associated with fixed-width buffers on water channels and water bodies. However, the risks and issues associated with this system are numerous, including; the difficulties with channel classification repeatability; that the actual ecologically-based riparian area is not being identified; and, that there is a long-term ecological consequences from excluding all disturbance alongside and within streams and waterbodies.

HWP's proposed Riparian Management Strategy addresses a number of the shortcomings of the 2009 OGRs, including; a better "erosion-based" channel classification system that is more easily repeatable and more directly related to ecological functions; the actual riparian area will be ecologically defined; and, measured and careful disturbance will be introduced into the riparian areas, which is in line with recent science research and will help maintain ecological function. However, this system also comes with risks and issues, mainly centred on the social acceptability of harvesting in riparian areas that have previously been buffered. While there are risks inherent in operating adjacent to watercourses, these risks can largely be mitigated by careful harvesting in the appropriate conditions (e.g. frozen soils).

Certainly the easiest thing for both HWP and Alberta to do would be to continue on with the status quo – which would mean the continued implementation of the fixed-width buffer system. However, research in the last 10 years has clearly shown that excluding disturbance from riparian areas is not without ecological consequences. It is HWP's belief that we can begin to introduce careful disturbance into some riparian areas in areas where we are confident that it can be done without undue impacts to stream channels and waterbodies. This is not the easy way, but we believe it makes the most sense based on the Foothills Research Institute's research that we have been a part of for over 15 years.

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13.0 Glossary

Alluvial Fan: A fan-shaped deposit of water-transported material (alluvium) that forms at the base of topographic features where reduced slope gradient causes water to slow down and deposit alluvium. Consequently, alluvial fans tend to be coarse-grained, especially at their mouths. At their edges, however, they can be relatively fine-grained.

Buffer: A strip of vegetated land protected from harvest disturbance beside watercourses, mineral licks, and other important features.

Channel: A non-vegetated water drainage that has been scoured by water flowing between continual definable streambanks. The key to identifying a stream is a scoured channel with evidence of fluvial processes (sands, gravel, etc.) that have been deposited by moving water.

Creek: A small natural watercourse. (See also Stream, River, and Watercourse)

Ecosystem: an assemblage of organisms (plant, animal and other living organisms—also referred to as a biotic community – living together with their environment, functioning as a loose unit. That is, a dynamic and complex whole, interacting as an "ecological unit."

Ecosite: Ecological unuits that develop under simlar environmental influences (climate, moisture and nutrient regime). Source: Beckingham et al. 1996.

Ecotone: a transition area between two adjacent ecological communities (ecosystems). It may appear on the ground as a gradual blending of the two communities across a broad area, or it may manifest itself as a sharp boundary line.

Ephemeral: A water drainage that flows below the ground surface or on the surface only during snow-melt and rainfall run-off events. There is generally no water-scoured channel development and the drainage path is usually vegetated with hydrophytic plants that markedly differ from surrounding ecosites. A dry ephemeral drainage has vegetation that is similar to adjacent upland ecosites indicating occasional water flow. A wet ephemeral drainage has vegetation that is not similar to adjacent upland ecosites, indicating prevalence of water saturated soils and below surface flow. Plant species in wet ephemeral drainages are also found in wetland ecosites (e.g. willows, mountain alder).

Fish Stream: A stream known to support fish (eggs, juveniles, or adults) at any time of the year, or a stream that has a high probability of fish occurrence according to the Foothills Model Forest fish probability map. www.fmf.ab.ca.

Floodplain: The area beside a stream that experiences annual or periodic inundation by the stream during flood events.

Groundwater: Water flowing underground within aquifers through the pore spaces in unconsolidated sediments and the fractures of rocks, below the water table. Groundwater is recharged from surface sources, and may eventually flow to the surface at springs and seeps.

Hillslope:

Intermittent Stream: A stream with a continuous non-vegetated channel that has surface flowing water only during some periods of a year. Surface flow may cease during dry and/or frozen periods.

High-water Mark: The point on the bank or shore of flowing or still water where presence and action of water produces a distinct and easily recognized mark indicated by erosion or terrestrial vegetation.

Machine-free Zone: The area where tracks or wheels of forest management machinery is excluded. Machines may reach into machine-free zones to harvest timber or prepare planting sites.

Management Zone: The area within the Riparian Special Management Area (RSMA) where appropriate special management operations are permitted.

Reserve Zone: The area within the Riparian Special Management Area (RSMA) that is protected and operations are not permitted. (See also Buffer).

Riparian Area: An area of land adjacent to a stream, river, lake or wetland that contains vegetation that, due to the presence of water, is distinctly different from the vegetation of adjacent upland areas.

Riparian Special Management Area (RSMA): An area consisting of a watercourse or waterbody, the adjacent riparian area, and other related features where management practices are designed to conserve riparian values and functions.

River: A large natural watercourse. (See also Creek, Stream, and Watercourse).

Seep: A wetland that forms in areas where groundwater discharges to the land surface, often at the base of steep slopes, but where water volume is too small to create a stream or creek. These wetlands have a perpetually saturated soil but may have little or no standing water. (See also Spring, Groundwater, Wetland, and Water Source Area).

Spring: A location where groundwater flows naturally to the land surface or a surface waterbody. (See also Groundwater, Seep, and Water Source Area).

Stream: A body of flowing water, confined within a bed and banks and having a detectable current. Stream is the umbrella term used in the scientific community for all flowing natural waters. (See also Creek, River, and Watercourse.)

Terrace: An abandoned floodplain generally $\geq$ 3 m above the bankfull discharge level, or above maximum long-term flood levels (e.g. 1 in 100 year flood). Terraces were once part of floodplains and became terraces as the channel eroded deeper over time.

Watercourse: A channel with bed and banks within which water flows, either continuously or in season. A watercourse is continuous in the direction of flow and may extend laterally beyond the banks to include overflow channels contiguous to the ordinary channel. (See also Creek, Stream, and River)

Water Source Area: an area where the soils are water saturated and surface or subsurface flow is occurring. (See also Seep, Spring, Groundwater, and Wetland).

Wetland: An area that is regularly saturated by surface water or groundwater and is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions (e.g. swamps, bogs, fens, marshes, and estuaries).

Appendix A

FIELD MANUAL FOR
EROSION-BASED CHANNEL CLASSIFICATION

Field Manual for Erosion-Based Channel Classification

Version 7.0, November 2012

By:

Richard McCleary, Stephen Haslett and Kevin Christie
Fish and Watershed Program

foothills RESEARCH INSTITUTE
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Disclaimer

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1.0 Introduction

Land managers require a naming system for streams that can be consistently applied in planning and field applications. Applied researchers also need a classification to organize projects and facilitate knowledge transfer to a technical audience. Many jurisdictions, including Alberta, have used classification systems based on flow permanence and channel width; however, these two parameters are problematic. In the rest of this introduction, these two problems are reviewed. In this report we describe a classification system that uses a more robust set of parameters related to erosion processes. The five classes within the erosion-based system are defined in Section 2. Section 3 includes the field procedure to differentiate the classes. Finally, Section 4 includes considerations for applying this system in the boreal region and limitations for using any classification to describe complex drainage networks.

The first challenge relates to the consistent application of flow-related stream categories (e.g., ephemeral, intermittent, permanent). With seasonal and annual fluctuations, flow permanence may vary from one visit to another. Physical characteristics that reflect flow permanence have proven more practical than actual flow observations for determining flow permanence (Fritz et al. 2008) and they form the basis of the erosion-based classification.

The second challenge relates the use of a width-based classification for forest planning applications and for protecting riparian functions. A width-based classification for forest management applications is consistent with the general premise that as stream size progressively increases down the length of any watercourse, greater levels of protection are required to preserve important functions and values; however, this approach presents both operational and theoretical challenges. From an operational perspective, foresters have encountered problems when applying a width-based classification in close proximity to source areas. Due to their low volume, these headwater channels lack sufficient power to regularly erode material from their banks; hence, channel width is highly variable and strongly influenced by the type of vegetation immediately adjacent to the stream (Figure 1). Even with repeated measurements, it can be difficult to get consistent width measures by different people or on successive visits. Channels with such characteristics are commonly encountered within or adjacent to cutblocks in the Foothills. Many such streams are not shown on available maps. For those streams that are mapped, there is no objective way to determine their width, other than determining the drainage area – channel width relation and extrapolating this across the area of interest. Without such maps, it is difficult to align strategic and operational forest harvest plans. For example, given the quantity of timber that may fall within riparian buffers, without accurate maps of channel class with buffers assigned, it is difficult to estimate wood supply across a region.

Figure 1 – *Variable width in a headwater Foothills stream*

From a theoretical perspective, it is important to consider features other than channel width for determining the sensitivity of a stream and its riparian area to forestry-related impacts. Channel dimensions, specifically width and depth, are related to bankfull discharge; however, the width:depth ratio, floodplain extent and sensitivity of a channel to disturbance are also dependent upon other factors including the percentage of fine material (silt-clay) in the channel boundary (Schumm 1985). The greater the amount of fine material, the lower the width:depth ratio, the greater floodplain development, and the higher sensitivity to disturbance. For example, let's compare two channels with similar bankfull discharge volumes – one draining a basin in the Front Ranges of the Rocky Mountains, the other draining a Foothills watershed. The typical Front Ranges stream transports a mix of gravel, sand, and fine material with the streambanks made of a corresponding mix of material. The typical Foothills stream transports a greater percentage of fine material; hence the channel banks and floodplain surface are largely comprised of silt and sand. The Front Ranges stream will have a wider, shallower channel with less developed floodplain in comparison to the Foothills channel.

2.0 Erosion-Based Classification System

A system adapted from existing classifications (e.g., Montgomery and Foufoula-Georgiou 1993) was used for a regional stream mapping project in the Foothills region near Hinton. Important considerations of the overall project are described herein. The regional stream mapping project (McCleary 2011) was initiated for two main reasons. First, the complete representation of the headwaters portion of the Government of Alberta 1:20,000 scale stream network was limited by the effective resolution of available air-photographs – many of the smaller watercourses simply couldn't be detected beneath the shrubs and trees. Second, likely because ground truthing was very limited and mapping was done by a variety of photo interpreters, foresters have found that the classification system assigned to the Government of Alberta stream network was inconsistent from one map-sheet to the next, was difficult to interpret, didn't align well with actual field data, and didn't link with the width-based ground rules classification. Thus, the goals of the regional stream mapping project were to provide better information on the locations of headwaters streams and to assign a classification that could support management needs.

Five categories were defined based on the dominant surface erosion processes (Table 1 and Figure 2). Because this system is based on stream functions, it aligns well with the overall goal for management of riparian areas in forested regions of Alberta "to maintain or enhance the structural and functional integrity of riparian areas and associated aquatic ecosystems" (Borutski et al. 2005).

Table 1 – *Erosion classes and definitions*

Class	Best corresponding class(es) in Alberta OGR classification	Description of erosion processes
Upland (U) *(figure 2a)*	Upland	Drainage features are absent. Surface erosion is driven by overland flow and tree root throw. On LiDAR-generated stream network maps, false channels may appear on uplands. These features can be removed from the map as required.
Swale (S) *(figure 2b)*	Ephemeral or water source areas	Historically, channels extended into these areas to remove material and create an obvious depression. Soil is sufficiently wet to support hydrophytic vegetation. These areas are susceptible to compaction and subsequent erosion.
Discontinuous channel (DC) *(figure 2c)*	Intermittent	This drainage feature includes alternating sections of channel and vegetated ground. The channel may either be migrating upstream through headward extension or in the recovery process with vegetation encroaching into the old channel (Leopold et al. 1964). Erosion typically initiates at a headcut at the upstream end of the channel section with sediment transported a short distance downstream.
Seepage-fed channel (SFC) *(figure 2d)*	Intermittent, transitional, or small permanent.	A channel with a continuous bed but insufficient stream power to transport larger streambed material including gravel and cobbles; hence, these channels typically lack bed features (e.g., regular sequences of pools and riffles) that Foothills fishes are adapted to. Sediment is transported as suspended load and bedload; however, only the smaller streambed material is mobile on an annual basis with larger clasts (e.g., cobbles and boulders) remaining stationary for long periods of time. In high relief areas, gravity transports upland sediment directly into these channels. In such areas, "colluvial channel" is a more appropriate name.
Fluvial channel (FC) *(figure 2e)*	Small permanent or large permanent	A channel with a continuous bed and sufficient power to transport most of the material that it flows through. Sediment transport includes suspended and bed load. Bedload transport is not limited to fine material, and includes larger size materials such as gravel.

Figure 2– Example photos of erosion classes

(a) Upland

(b) Swale

(c) Discontinuous channel

(d) Seepage-fed channel

(e) Fluvial channel

For the regional initiative, a stream network was derived from LIDAR data (Figure 3a). The extent of the network was over-estimated to ensure all streams were captured. Removal of the false drainage features will effectively truncate the original digital stream network. Spatial models calibrated with field survey data can be used to map streams by channel class for an area of interest (Figure 3b).

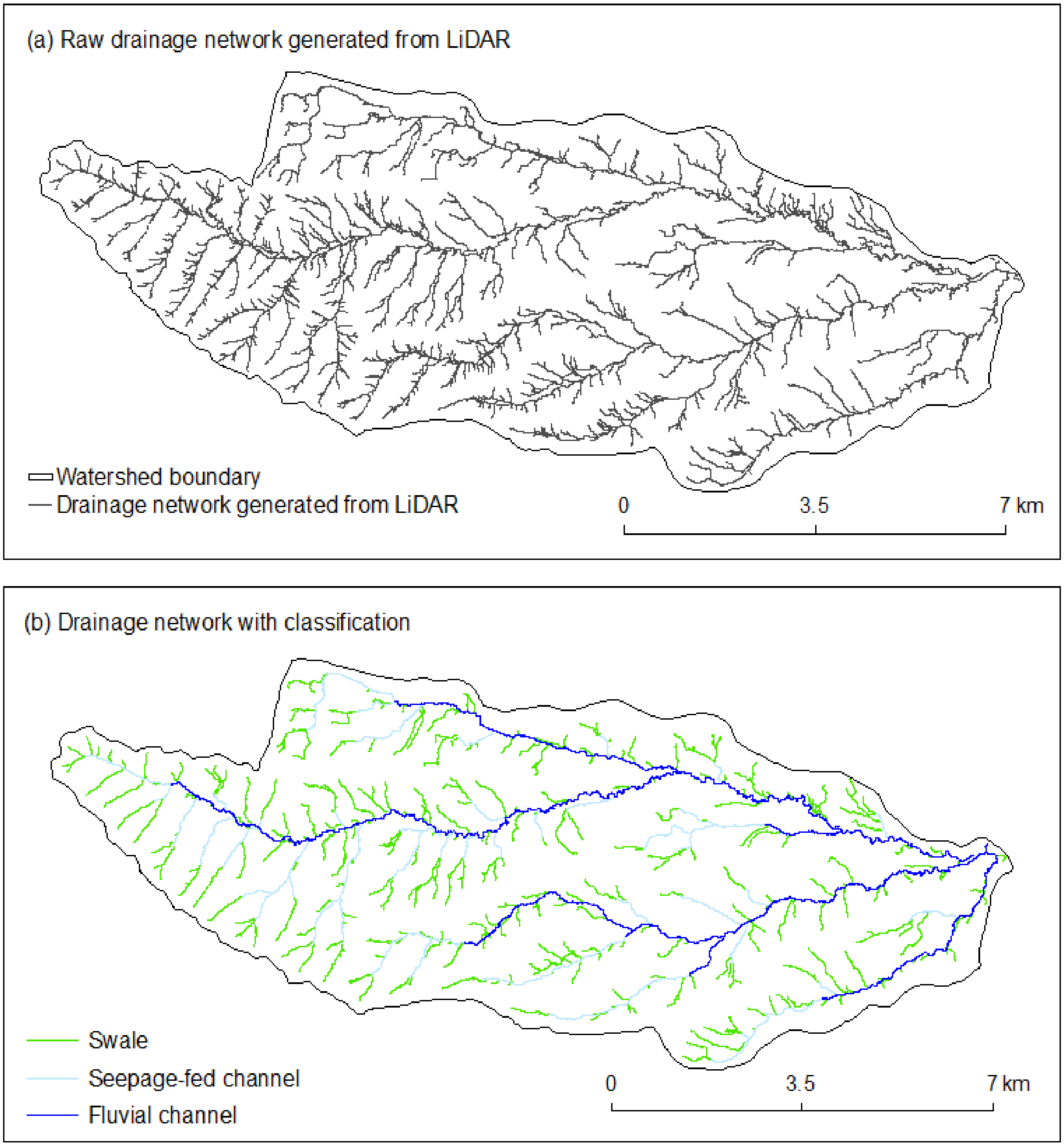


Figure 3 – Maps of a raw LIDAR-generated stream network (3a) and a stream network with channel classes assigned (3b). Note that for this modelling exercise, the discontinuous channels were grouped within the swale category.

3.0 Field Classification Procedure

A two part process is used to determine the erosion class. In Part I, a number of simple observations are made to distinguish between the first three classes (Figure 4). In Part II, a total of eight criteria are considered to determine if a continuous water course is a seepage-fed or fluvial channel (Table 2). The field sheet (Appendix 1) can be used to record the measurements and results from both parts of the exercise.

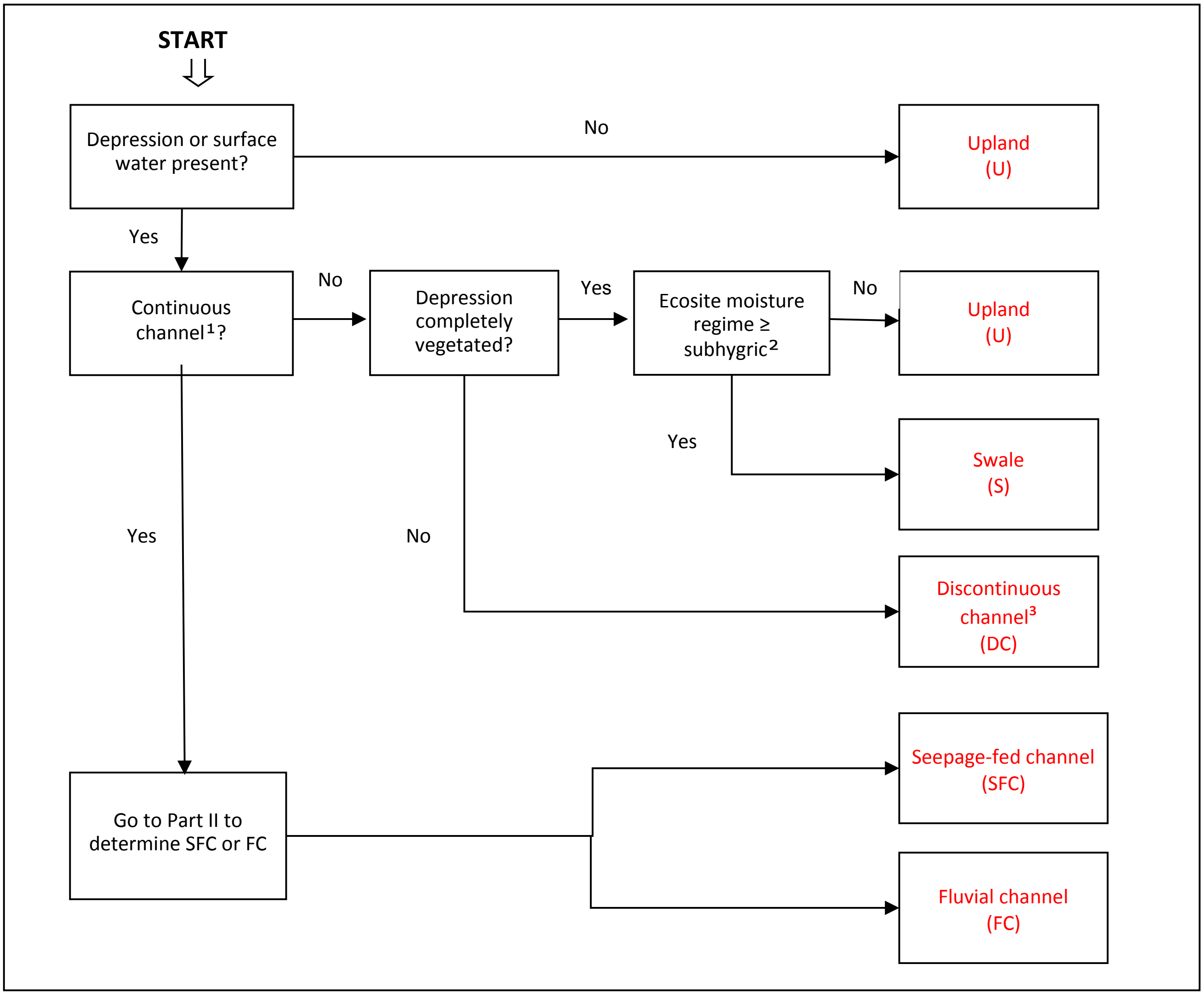


Figure 4 – *Key to erosion classes – Part I*

[1]Bed of channel is visible over extended lengths and if organic bridges are present, they are limited in length with an obvious connecting channel under the ground surface (see Figure 2c and 2d).

[2]Ecosite moisture regime is determined first by using the key to plant community types from the ecosite field guide (e.g., Beckingham et al. 1996) and then by referring to description of typical moisture regime for corresponding plant community type.

[3]Sections of channel are interspersed between vegetated areas that function to filter out sediment that is transported from upstream areas. If organic bridges are present, they are long and lack an obvious underground flowpath. For statistical modelling and subsequent mapping (see Figure 2c and 2d), discontinuous channels were grouped with swales due to lack of statistical evidence to support their use as a fifth category in the classification system.

Table 2 – Key to erosion classes – Part II.

Feature number	Seepage-fed channel features	Fluvial channel features
1	Fine bed material collected from deepest part of channel is mostly silt and organic matter. If required, use a hand texturing procedure to confirm.[a]	Fine bed material collected from deepest part of channel is mostly well-sorted sand. If required, use a hand texturing procedure to confirm.[a]
2	Unconsolidated bed along the deepest part of channel. Indicated if when standing on one foot, the surveyor's boot sinks to a depth > 10 cm.	Consolidated channel bed. Indicated if the surveyor's boot does not sink to a depth of > 10 cm.
3	No steps / riffles created by mobile gravel or cobbles[b].	Steps / riffles with regular spacing created by mobile gravel or cobbles[b].
4	No pools present[b].	Pools present with regular spacing[b].
5	Organic bridges present[b].	No organic bridges present[b].
6	Head cuts present[b and c].	No head cuts present[b and c].
7	Maximum bankfull width[d] >3x the minimum width.	Maximum bankfull width[d] <3x the minimum width.
8	Total undercut width[e] > bankfull width.	Total undercut width[e] < bankfull width.
Total	**See Section 3.1 for interpreting tally**	**See Section 3.1 for interpreting tally**

a. Grab a handful of material from the bottom of the deepest part of the channel. Squeeze it tightly and wring out as much water as possible. If possible, remove the larger pieces of organic matter including fibers, leaves, twigs, etc. Hand texturing procedures are developed for dry soils that are wetted just to the point where soil begins to adhere to fingers, so if possible, set the material aside to allow it to dry out. Given that clay should not be a major component of any stream bottom sample, focus the test to determine whether the material has > or < 50 % sand. Based on the procedures detailed in Beckingham et al. (1996), do the following:

   i. Start with a 2.5 cm mass. Roll into a ball. Throw the ball in the air to a height of 30 cm. If the ball falls apart easily, material is > 50 % sand.

   ii. Roll the ball into a cigarette shaped cylinder and then squeeze out between forefinger and thumb. If the ribbon is less than 3 cm long before breaking, the material is > 50 % sand; otherwise the material is < 50 % sand.

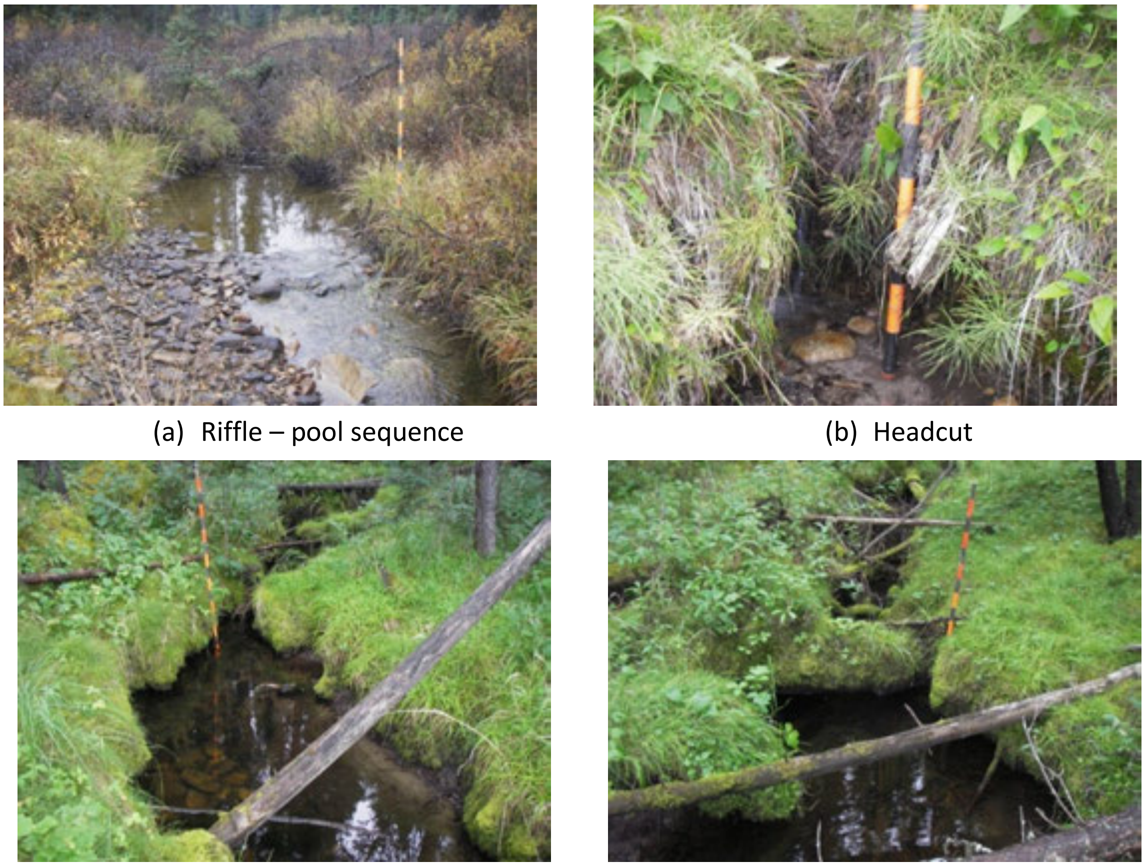
b. See reference photos (Figure 5).

c. Head cuts are an abrupt vertical drop in the bed of a stream. This active erosion feature appears as a small waterfall flowing over roots or the forest floor. This indicator of seepage-fed channels is a transient structure and can exhibit relatively rapid upstream movement during periods of high runoff. Groundwater seepage may also be present from the face or base of the head cut.

d. Bankfull width is measured from the base of rooted woody bank vegetation typically near the break in slope on one bank across to a corresponding feature on the opposite side (see photos in Appendix 2).

e. To measure undercut width, stand with one leg in a vertical position against the tip of the bank that has the undercut of interest (Figure 6). Take your ruler and extend it underneath and at right angles to the bank to its furthest point. Press the ruler back until it contacts solid material. This is the back of the undercut. Read the distance at the point where the ruler meets the outside of your leg. Depending on the water depth, your ruler may be under the water surface. Measure the undercuts on both banks and add the measurements together to get the total undercut width.

Figure 5 – Channel feature photographs



(a) Riffle – pool sequence

(b) Headcut

(c) Variable width channel

(d) Undercut banks and organic bridge

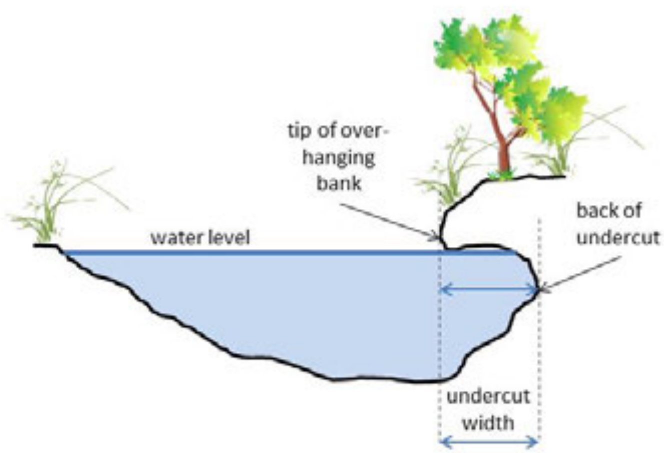


Figure 6 – *Reference points for measuring undercut width on a stream with an undercut only on a single side*

3.1 Determining the continuous channel class

From Table 2, the tally of features for seepage-fed and fluvial channels will vary between zero and eight for each class respectively. Based on this tally, the channel class should be obvious in the vast majority of cases. For example, in 2008 and 2009, the classification was completed in the Hinton region at 842 sites that were selected using a stratified random sampling method. Of those 842 sites, 281 were continuous channels that were further classified using the eight criteria from Table 2. Channel class determination was only made in the field when six or more of the eight criteria were met for a single class. Of the 281 sites with a continuous channel, 94% had six or more indicators for a single class and the remaining 6 % (16 sites) had five indicators for one type and three for the other. No sites were assigned as a tie. For those 16 sites with five indicators for one class and three for the other, the field crew completed a more detailed assessment of channel morphology. In the office, a geomorphologist reviewed the data and assigned the appropriate class.

Although the use of a detailed assessment of channel morphology is an option for sites that do not obviously fall into one class or the other, this extra work is difficult to justify. For sites that score with four indicators for each class, it may be more prudent to err on the side of caution and designate such sites as fluvial channels. Remember that transition locations between seepage-fed and fluvial channels are not stationary, and major runoff events can trigger the rapid upstream migration of fluvial channels followed by a prolonged retreat.

Strategies for achieving consistent application of the classification system should be applied. For example, establish a 10 km loop with at least 20 stream crossings that follows the road system in close proximity to headquarters. Have trainees stop at all stream crossings (which typically include an identification number painted on the structure), then walk upstream into an un-disturbed reach and complete the classification. Immediately review the classification calls that were made and inform trainees of the correct class. Proceed to the next location. This system was applied in 2008 and 2009 in Hinton and proved important. Other quality assurance measures could include requiring new crews to meet a certain classification accuracy in comparison to sites classified by the crews from previous years. The system may require some modification of indicators depending upon surficial material, bedrock geology, and relief. For example, indicators that refer to gravel and cobble may not apply in areas with extensive glacio-lacustrine deposits were sand is the largest stream bed material.

4.0 Conclusion

4.1 Applying this Foothills system into Boreal regions

Portions of this classification system, based on erosion-processes, should have application to any drainage network. An original classification for mountain regions described by Montgomery (1993), was adapted for use in the Foothills region by considering the different runoff and erosion processes between these two regions (McCleary 2011). These differences are reviewed because they are further amplified between the Foothills and Boreal regions. In mountain regions, runoff moves relatively rapidly from uplands into channels. In contrast, given the lower relief in Foothills, runoff moves slower and water may reside in wetlands before moving into an open channel. In high relief mountain regions, gravity drives surface erosion, landsliding, and soil creep across the upland portion of the landscape. In the Foothills, these upland processes are largely limited to over-steepened valley bottoms along large streams and rivers. Furthermore, any sediment generated by upland erosion often becomes stored within lower relief valley bottom landforms.

There are two important considerations when applying this Foothills classification into Boreal regions. First, the wet swale portion of the drainage network will have a much greater extent than in the Foothills. In areas of large plateaus, drainage features including topographic depressions and flow direction may be difficult to discern. As a result, upland sediment sources will be very limited and organic matter will be the dominant material entering most headwater stream channels. Secondly, salmonids are the dominant fish family in the Foothills. The habitat of rainbow trout and bull trout, the two most common native salmonid species in small streams near Hinton, has been closely linked to features associated with fluvial channels; hence, certain connections between presence of a fluvial channel and presence of fish habitat may be considered. However, boreal streams provide habitat for other fish families (e.g., minnow and stickleback) that are not specifically adapted to flowing water ecosystems. Thus, seepage fed channels may include all of the required habitat elements for various boreal region fishes.

4.2 Considerations for applying any channel classification system

Streams develop along a continuum from source to mouth and while various categories can be established based on established thresholds, stream classes cannot be considered discrete entities to the degree that plant and animal species are. Stream classification systems that emphasize correct identification to a given type inevitably end up with a large number of categories. For example, Rosgen (1994) identifies 94 different categories. Other classification systems that emphasize channel processes as opposed to correct identification have much fewer categories. For example, Montgomery and Buffington (1998) identify two main types – colluvial and fluvial channels – and further differentiate fluvial channels into seven additional classes. Where mapping and management applications are primary concerns, the systems with fewer categories and close links to channel processes have obvious benefits.

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6.0 Glossary

Bedload: sediment that moves in contact with the bed of the stream rather than in suspension.

Colluvial: accumulations of rock and debris from gravity driven erosion processes, such as landsliding and soil creep, that operate on hillslopes.

Ecosite: ecological units that develop under a similar climate, moisture and nutrient regime that are often named by a commonly occurring plant species (Beckingham et al. 1996).

Fluvial channel: a stream with sufficient power to regularly transport the material that forms the stream bed and alter the structure of the stream banks (Hassan et al. 2005). These streams have regularly spaced features such as riffle – pool sequences.

Headcut: an abrupt vertical drop in the bed of a stream. This active erosion feature appears as a small waterfall flowing over roots or the forest floor. This indicator of seepage-fed channels is a transient structure and can exhibit relatively rapid upstream movement during periods of high runoff. Groundwater seepage may also be present from the face or base of the head cut.

Seepage-fed channel: streams that lack sufficient power to regularly move bed materials (Hassan et al. 2005). In these channels, upland and ecological processes contribute to more complex channel morphologies than in fluvial streams. Streams lack the power to modify roots of streamside vegetation or transport large woody debris and hence these features exert major influence on channel structure.

Organic bridge: created when roots extend across a channel or large woody debris falls over a channel. The forest floor extends across the channel and the streambed remains continuous beneath the bridge. These features form in seepage-fed channels that lack sufficient power to prevent the growth of roots within the active channel. These features, when measured parallel to the channel in the direction of flow, can be as narrow as 0.2 m or cover a section of stream as long as 5-10 m. They can occur in channels with a bankfull width of 2 m or more.

Pool: a deep section of stream created by scouring flows typical of fluvial channels. Fallen logs that create dams can also create backwater pools on the upstream side of an obstruction; however, such pools should be excluded in the field survey because they occur in both seepage-fed and fluvial channels.

Riffle / step: local sections of stream where the gradient increases. Fluvial processes create recurring sequences of riffle–pools or step–pools. Gravel or cobbles often form the bed in these steeper sections with the size of the bed material typically larger than the bed material in adjacent pools. Steps may also be created by large woody debris in the streambed.

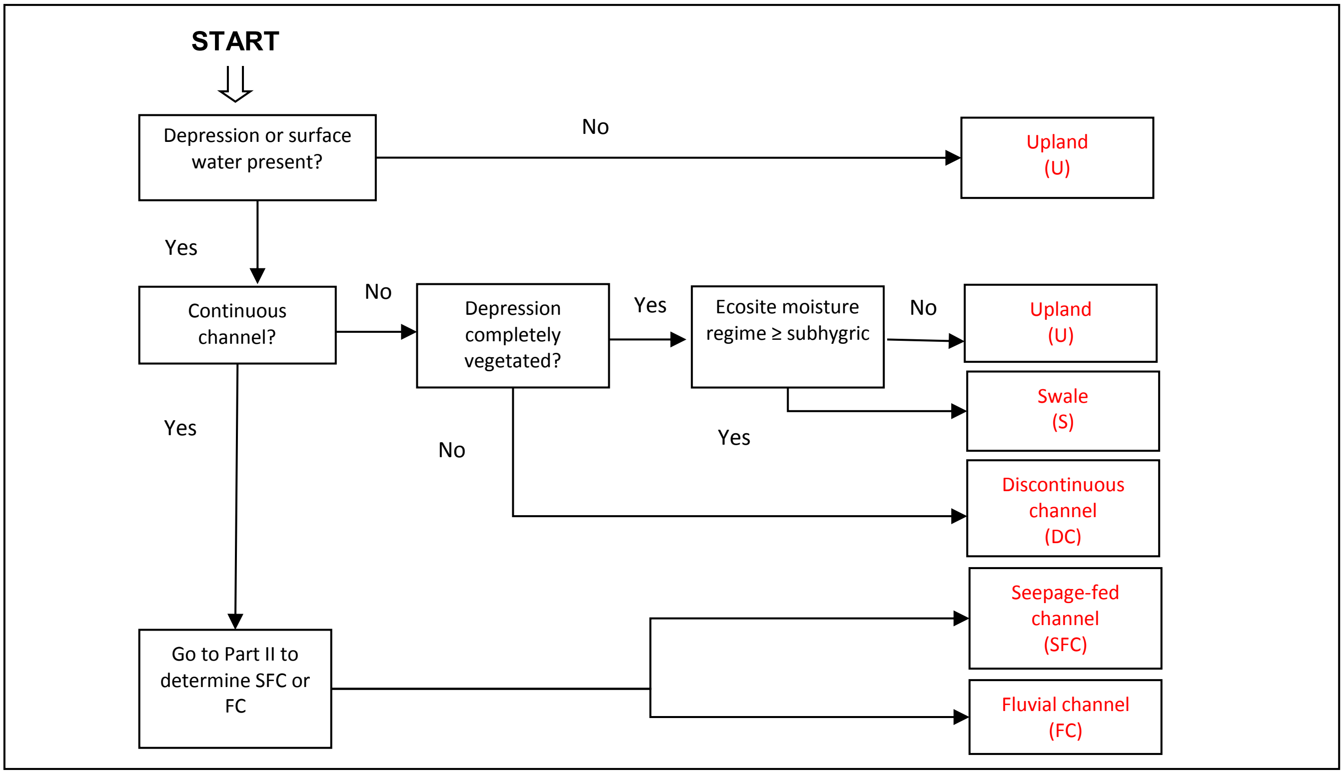
Appendix 1 – Field Card

Date:	Crew:	Site/GPS ID:	UTM:
Working Circle:	Compartment:	Road:	Crossing ID:

Ground Rules Classification:

Ephemeral	Intermittent	Small perm.	Large perm.	Avg. width (m):

Part I. Flowchart for Erosion Process Classification



Part II. Seepage-fed / fluvial channel feature tally table

Feature Number	Seepage-fed channel features	Fluvial channel features
1	Fine bed material collected from deepest part of channel is mostly silt and organic.	Fine bed material collected from deepest part of channel is mostly well-sorted sand.
2	Unconsolidated bed (i.e., surveyor's boot sinks to a depth > 10 cm).	Consolidated channel bed (i.e., surveyor's boot does not sink to a depth of > 10 cm).
3	No steps / riffles created by recently mobile gravel or cobbles.	Steps / riffles with regular spacing created by mobile gravel or cobbles.
4	No pools present.	Pools present with regular spacing.
5	Organic bridges present.	No organic bridges present.
6	Head cuts present.	No head cuts present.
7	Channel maximum width >3x the minimum width.	Channel maximum width <3x the minimum width.
8	Total undercut width > bankfull width.	Total undercut width < bankfull width.
Total		

Part III. Comments:

Erosion Process Class (circle one)

Upland	Swale	Discontinuous channel	Seepage-fed channel	Fluvial

Appendix 2

Example photographs showing a measuring tape at bankfull width (W_{bkf}) from fish inventories conducted by Foothills Research Institute in the Hinton region. Inventory identification number and bankfull depth (D_{bkf}) are also included in caption.

Site 202006. Unnamed; Wbkf=1.4m; Dbkf=0.90m.

Site 202001. Unnamed; Wbkf=4.7m; Dbkf=0.50m.

Site 202017. Unnamed; Wbkf=1.8m; Dbkf=0.49m.

Site 202045. Unnamed; Wbkf=1.3m; Dbkf=0.78m.

Site 202053. Unnamed; Wbkf=2.0m; Dbkf=0.63m.

Site 202060. Lambert; Wbkf=3.3m; Dbkf=1.08m.

Site 201022. Unnamed; Wbkf=5.1m; Dbkf=0.57m.

Site 201023. Unnamed; Wbkf=0.8m; Dbkf=0.6m.

Site 201059. Baril; Wbkf=5.7m; Dbkf=1.8m.

Site 201068. Lambert; Wbkf=4.4m; Dbkf=1.12m.

Site 201071. Antler; Wbkf=9.3m; Dbkf=1.02m.

Site 201079. Unnamed; Wbkf=1.6m; Dbkf=0.58m.

Appendix B

SPATIAL CLASSIFICATION OF RIPARIAN AREAS – HINTON FMA

Spatial Classification of Riparian Areas across Hinton Wood Product's FMA

Final Report

November 5, 2013

Produced by GreenLink for
Hinton Wood Products

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Summary

This project created a data layer which accurately represents riparian areas within the Hinton Wood Products (HWP) Forest Management Area (FMA). Five riparian area categories were identified: fluvial, seepage, isolated wetland, complex, and upland. Digitization and interpretation were completed using high resolution digital aerial photography viewable through the DAT/EM Summit Evolution system, which was synchronized with digitizing software Arc Map (V9) or MicroStation (V8). LiDAR-derived DEM (Digital Elevation Model) were the primary reference data. The DEM was at a high resolution (sub-metre) and exposed very slight changes in topography. Other data inputs included: NetMap hydrology, an Erosion Based Channel Classification (EBCC) mode, and the HWP Ecosite Classification Layer (ELC). The top of the contemporary hydrological slope was used as riparian boundary as much as possible. Where there was no definable slope, interpreters used the imagery and followed ecosite determinates and vegetation. The advanced technology and high resolution reference material has produced a final mapping product that is far more accurate and precise then previous riparian mapping products.

Total Riparian Area by Category across HWP's FMA

Riparian Categories	Area (hectares)	Proportion of FMA (%)
Fluvial	123,170	12
Seepage	227,210	22
Isolated Wetland	6,503	1
Upland	676,831	65
Complex	295	0
Total	1,034,010	100

1.0 Introduction

Hinton Wood Products (HWP) is moving toward the adoption of natural disturbance based forest management practices. When feasible, harvesting will be planned and conducted so that the resultant forest condition approximates what likely would have occurred under natural disturbance processes (particularly fire). The full implementation of this plan requires the development of a new riparian management strategy to allow for the introduction of disturbances within riparian areas. This is in contrast to Alberta's current Operating Ground Rules strategy, which prohibits harvesting within fixed-width distances (buffers) along watercourses unless a variance has been approved by the Alberta government.

Implementation issues with fixed-width buffers include:

1. Areas immediately adjacent to watercourses have typically become dominated by more mature and old forests than would have occurred if the main natural disturbance, fire, had been allowed to continue.
2. Fixed-width buffers rarely align with any real ecological or biological feature on the ground.
3. Fixed-width buffers rarely align with the reality of practical boundaries for harvesting operations (e.g. the buffer ends in the middle of a steep slope or extends far beyond what is warranted from an ecological perspective).
4. Due to the serpentine routes of watercourses, ground delineation of fixed-width buffers is unnecessarily time consuming and difficult.

HWP desires to develop a Riparian Management Strategy that incorporates accurately defined ecological riparian areas to replace the fixed-width buffer system. The new riparian classification system is based on interpreted transitions in landforms and landscape ecology. It incorporates the latest computing technology and remote sensing data to provide a comprehensive inventory of riparian areas. The final GIS layer produced from this project will directly contribute to HWP's 2014 Detailed Forest Management Plan (DFMP).

2.0 Project Work Plan

The HWP Forest Management Area is comprised of four natural subregions: Lower Foothills, Upper Foothills, Subalpine, and Montane. The contrast in topography across these four regions influenced how the project was completed. The west portion of the FMA (dominated more by Subalpine and Upper Foothills) has well-defined relief (slopes and valleys) which in-turn enabled a well-defined digitization product. The east portion of the FMA has more even terrain and riparian digitization required close attention to attributes which suggest a change in ecosite.

For production purposes, the FMA was divided into 13 watersheds (Figure 1). Summary statistics of these areas can be found in the results and discussion portion of this report. The project was completed on a watershed basis, meaning interpreters would fully digitize and classify one area at a time to maintain understanding and consistencies within and between watershed subcategories. Work was carried out starting from the west and working eastward.

Figure 1 – *Watershed subcategories used for production purposes*

3.0 Input Data Sources

Reference data used for this project was obtained from HWP. All data sources used are or were based on technologies that provided the most recent and accurate data to the interpreters.

3.1 Project Production Software

The project was created using a combination of DAT/EM Summit Evolution (DAT/EM 6.8) synced with either MicroStation (Bentley Systems, Inc. V8) or ArcGIS (Esri, ArcMap 9.3.1). The digitization process was done completely through MicroStation, while the attribution of the resulting polygons was done inside ArcGIS.

3.2 LiDAR Digital Elevation Model

"Light Detection and Ranging" (LiDAR) is a remote sensing technology that emits a light pulse from an airborne craft to the ground and then captures the return distance between the two. This technology creates a data layer that can be used to create a three-dimensional image of the landscape (Figure 2). LiDAR pulses are conical in shape and they record both the highest and lowest return per pulse, thus creating a "full feature" data layer containing both returns. The lowest returns are considered as ground and are amalgamated to create the "bare earth" data layer. Lastly, a "hill-shade" function is applied to the "bare earth" file to create the three-dimensional appearance.

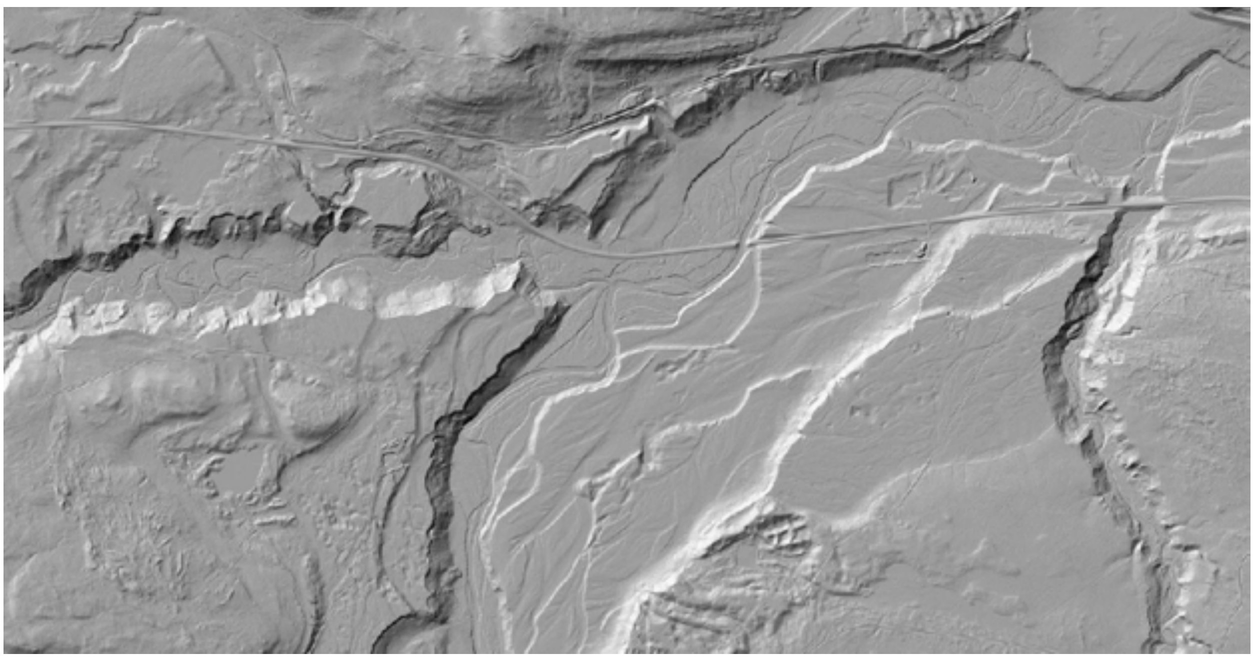

Figure 2 – *Screenshot of LiDAR derived DEM (bare earth) model used for this project.*

The LiDAR-derived DEM was obtained by HWP in a data exchange with Alberta Environment and Sustainable Resource Development (AESRD) and was collected at a resolution of 1.2 to 1.8 returns per square meter.

The DEM layer was also the main data input for Netmap and the Erosion-based channel classification (EBCC) model, described below.

3.3 Vegetation - Imagery

The imagery used for this program was high resolution (~35 cm) three-band (red, green and blue) stereo pair aerial photography taken with an ADS80 digital camera, flown in October 2010. The photography is created as a TIF file and comes with support and control files for editing purposes. All of this information goes into DAT/EM Summit Evolution where the TIF files are geospatially corrected. Models are then created out of the overlapping TIF files to create the three dimensional images. Finally, the correct datum is used for the specific data using Summit Evolution Professional.

3.4 NetMap

Earth Systems Institute developed a model called NetMap to digitize the location of watercourses directly from LiDAR digital elevation models (DEM) (Benda and McCleary 2012). NetMap is capable of discerning great detail within watersheds, even to the point of picking up very subtle drainage channels. However, due to these subtleties, some of the predicted channel locations at the peripheries of the channel network do not actually contain channels and others may not be accurately located. NetMap channel locations become increasingly more accurate as the watershed size increases, and accuracy is very high for continuous channels. A NetMap watercourse layer specifically designed for the Hinton FMA was completed late in 2012 and it provides the most comprehensive watercourse inventory ever completed on the FMA.

3.5 Watercourse Erosion-Based Channel Classification

Dr. Rich McCleary, while working for the Foothills Research Institute, developed an Erosion-Based Channel Classification (EBCC) system for the Alberta Foothills, which classifies watercourses into channel classes (McCleary 2013) based on surface erosion processes. HWP adopted the EBCC system because it has several advantages over the Width-based Channel Classification (WBCC) system currently used by the Alberta government, including the following:

a. The EBCC system is ecologically based because it reflects erosion processes. An ecological classification system makes it easier to recognize and conserve ecological functions.
b. The EBBC system supports consistent classification of channels in the field when compared to the WBCC system. Channel width variability, especially for smaller channels, makes it hard to consistently classify channels using the WBCC system.
c. The EBCC system was designed to be used with outputs from LiDAR-based watercourse delineation models (like NetMap), which makes it possible to automate watercourse classification for large areas. The WBCC system was not as suitable for automated classification, although it can be done using NetMap.

The EBCC model was calibrated for, and applied to, the HWP NetMap watercourse layer where it classified NetMap into four categories (McCleary 2013):

1. <u>Hill-slope</u> (called Upland in the field manual) – Drainage features are absent. Surface erosion is driven by overland flow and tree root throw. On LiDAR-generated stream network maps, false channels may appear on uplands.

2. <u>Swale</u> – Historically, channels extended into these areas to remove material and create an obvious depression. Soil is sufficiently wet to support hydrophytic vegetation. These areas are susceptible to compaction and subsequent erosion. The modeled “swale” category also included the discontinuous channel field classification, which is described as a drainage feature that includes alternating sections of channel and vegetated ground.

3. <u>Seepage-fed channel</u> – A channel with a continuous bed but insufficient stream power to transport larger streambed material including gravel and cobbles; hence, these channels typically lack bed features (e.g., regular sequences of pools and riffles) that Foothills fish are adapted to. Sediment is transported as suspended load and bedload; however, only the smaller streambed material is mobile on an annual basis with larger clasts (e.g., cobbles and boulders) remaining stationary for long periods of time.

4. <u>Fluvial channel</u> – A channel with a continuous bed and sufficient power to transport most of the material that it flows through. Sediment transport includes suspended and bed load. Bedload transport is not limited to fine material, and includes larger size materials such as gravel.

Figure 3 on page 5 illustrates typical output from the NetMap model based on the EBCC system. Using the EBCC system, seepage-fed and fluvial channel classifications are roughly analogous to “Transitional” and “Permanent” watercourses under the current Alberta ground rule channel-width classification (McCleary 2013).

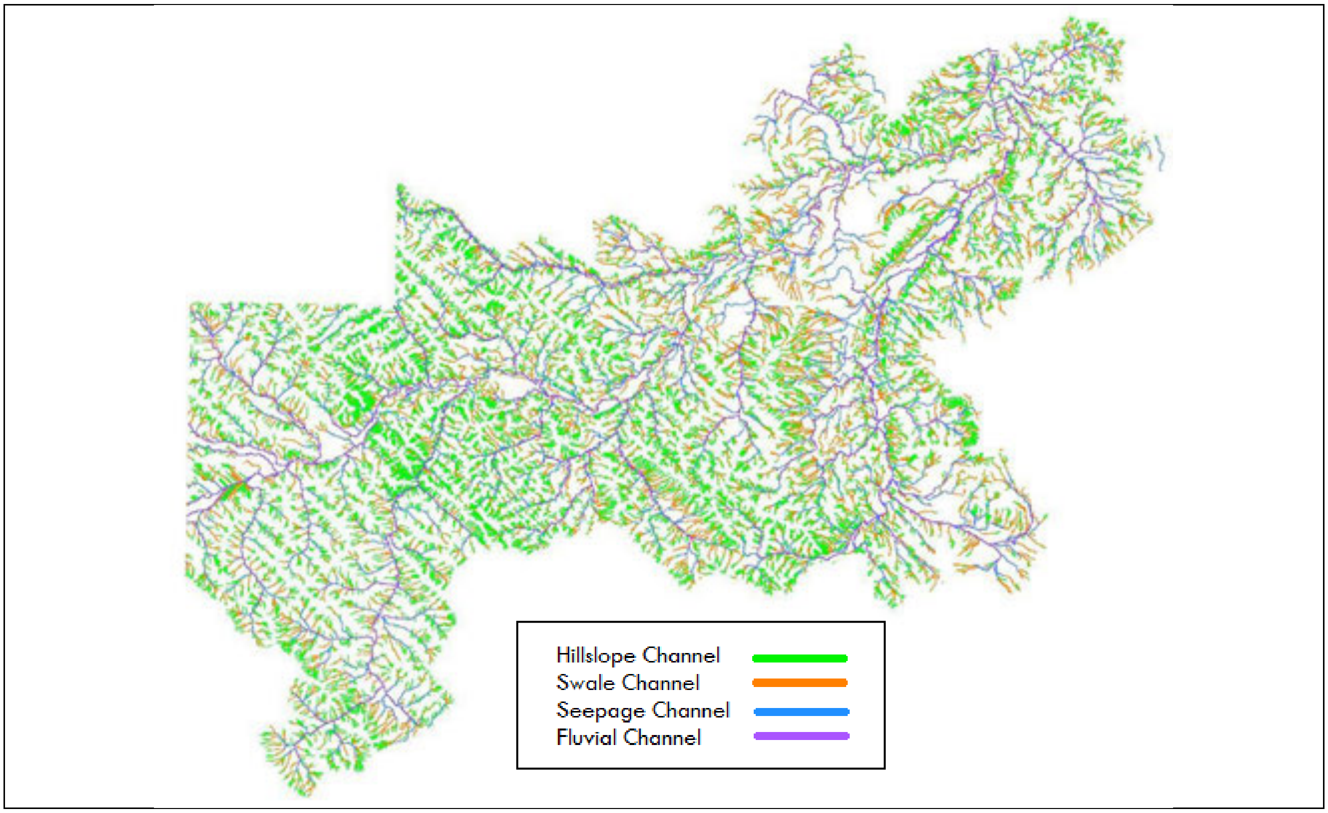

Figure 3 – *NetMap channels with EBCC system applied to the Upper Wildhay watershed compartment.*

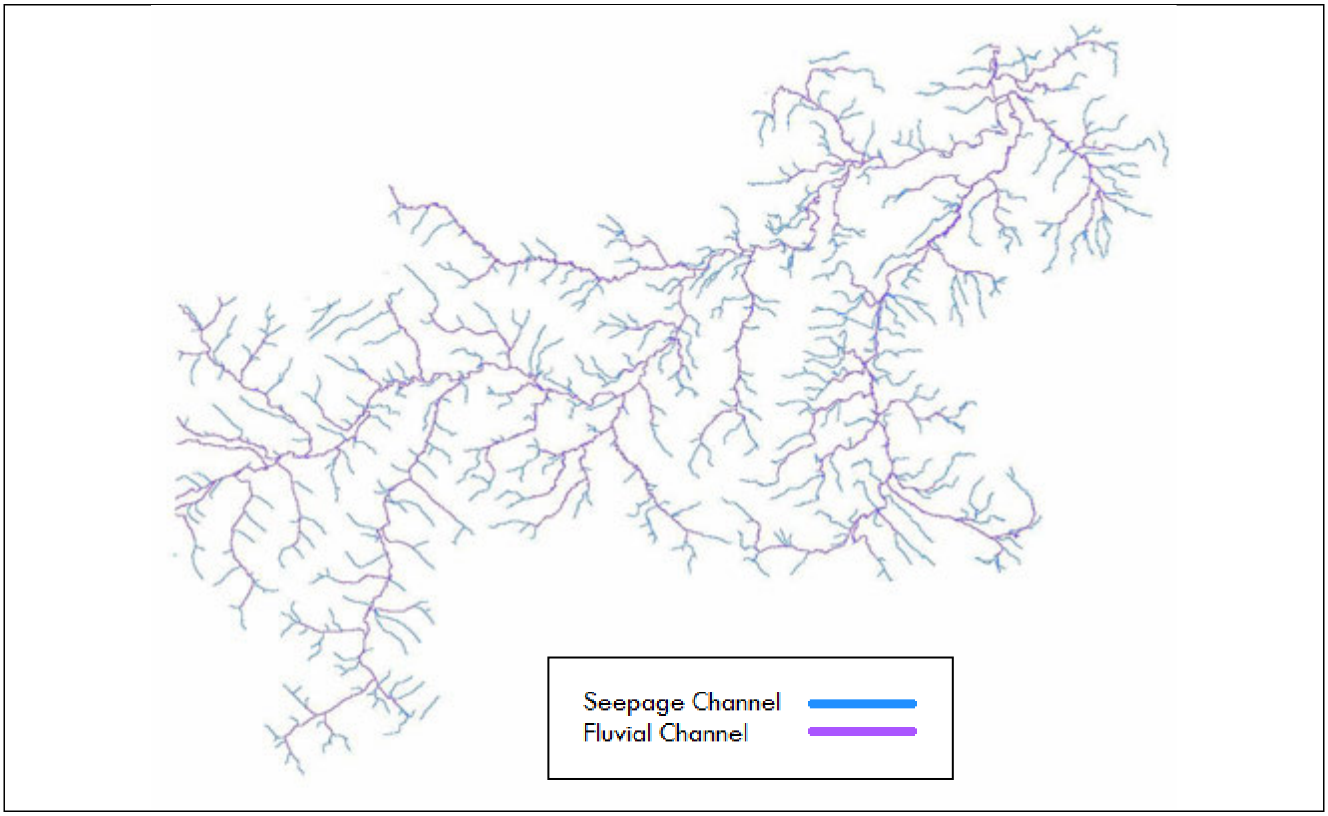

Figure 4 – *NetMap Channels with EBCC system applied to Upper Wildhay watershed compartment without "hill-slope" and "swale" categories. This is an example of the EBCC categories considered for digitization.*

Riparian areas adjacent to smaller watercourses (i.e. EBCC hill-slope and swale classifications) were typically not mapped in this project for two reasons:

a. Intermittent and Ephemeral watercourses (under the Alberta ground rules) typically do not require fixed-width buffers; and,
b. There was little mappable riparian area in those locations.

Figure 4 illustrates typical output from the NetMap with the hill-slope and swale categories removed.

3.6 Ecological Land Classification

HWP's Ecological Land Classification (ELC) is an inventory layer of mapped ecosites based on the Field Guide to Ecosites of West Central Alberta (Beckingham and Archibald 1996) classification system. The classification was matched to the Alberta Vegetation Inventory (AVI) layer and supported by approximately 30,000 field survey plots to confirm moisture and nutrient regime, which are key aspects of the classification system. To simplify the information used from the ELC layer to only applicable polygons, all polygons with less than a 7 moisture class (in reference with the Field Guide to Ecosites of Northern Alberta by Beckingham and Archibald, 1996) were removed. This was roughly analogous to ecosites that were equivalent to wetlands as defined in the Canadian Wetland Classification System (Adams et al. 1997).

4.0 Classification Methods

The purpose of the project was to accurately and precisely map the riparian areas within HWP's FMA into four riparian categories and a fifth non-riparian category (termed "upland") for the remaining landbase. The interpreter's focus was aimed towards specific landforms and ecosites that were indicative of riparian areas. Landforms of focus were:

- steep eroded banks caused by water activity and adjacent to water channels
- slumping soils
- flat wetland, fen and bog formations
- lakes and ponds

Ecosites of focus were:

- moisture regimes 7 or greater (Beckingham and Archibald 1996)
- varying nutrient regimes

The top of the contemporary fluvial slope was used for the majority of boundaries. Contemporary fluvial slope was defined by the proximity to the water source as well as the vegetation and ecosite types. In many situations there existed several historical fluvial slopes; in these areas, vegetation inventories were consulted to determine the current ecosite factors involved. Due to the variability and movement of the riparian process over thousands of years, there is often several locations interpreters might place a boundary while only looking at the "bare earth" LiDAR model; however, after consulting the 3D imagery, it becomes quite apparent that only one of the fluvial slopes is currently applicable as a riparian boundary. The upper-most slopes were often found to be created by glacio-fluvial activity and were no longer applicable to riparian processes and functions, whereas the lowest slopes sometimes failed to represent the entire riparian area as they did not include flood plains.

The definitions of the four riparian categories and the fifth non-riparian category are outlined below:

4.1 Fluvial Riparian

Fluvial riparian areas were defined as the area immediately adjacent to an EBCC-defined fluvial channel. This designation also includes riparian areas surrounding standing bodies of water such as lakes or ponds that have a fluvial channel flowing in or out of them. The top of the contemporary fluvial slope was the main driver in the fluvial boundary; however, ecosite (i.e. ELC) was referenced regularly to ensure consistency and accuracy.

4.2 Seepage-fed Riparian

Seepage-fed riparian areas were defined as the area immediately adjacent to an EBCC-defined seepage-fed channel. They were often closely associated with discontinuous channels and water source areas in poorly drained areas with minimal erosion potential. Ecosite boundaries, as well as the top of the associated contemporary slope, were used to determine the location and extent of the boundary.

4.3 Isolated Wetland

Isolated wetland areas were defined as wet areas completely surrounded by upland features. The main difference between seepage-fed and isolated wetland features is that seepage zones eventually flow horizontally into fluvial features, whereas isolated wetlands do not visibly drain over the surface of the landscape. Ecosite boundaries were usually used to determine the location and extent of the boundary.

4.4 Complex

Complex areas were defined as riparian areas that could not be accurately represented by any other category due to the large upland component mixed in with riparian features, resulting in areas that could not be accurately digitized. The complex classification was only used in a 295 hectare area located in the middle of the Upper Wildhay River drainage basin. The area contained very gentle and hummocky slopes consisting of upland vegetation interspersed with immediately adjacent riparian areas. These areas require additional field investigation to map riparian versus upland and determine any future management objectives. The entirety of the "complex" category is within the Switzer Park boundary and therefore will likely not pose management issues.

4.5 Upland

Upland areas were defined as all areas that were not classified as riparian. Riparian areas are impacted by natural fluctuations in open water flow volume and are often drastically different from uplands in that they are affected by higher erosion probability, high water table, and the ecological inputs provided by water movement. In contrast, upland areas were well-drained locations largely unaffected by hydrological processes other than surface flow from precipitation.

5.0 Digitization Methods

Digitization is the process by which interpreters trace a boundary line around a feature to depict the feature border. The success of this project largely depends upon having an accurate and comprehensive inventory of watercourse locations, making digitization the highest priority. Every boundary line was scrutinized to ensure the most appropriate representation of the associated riparian area.

Terrain forms (such as slope breaks) often provide a clear indication of the location of the riparian area. The LiDAR-derived Digital Elevation Model (DEM) was the primary information source used in digitization. The data provided highly accurate topographic information, which in turn was used to make the critical relief distinctions required to distinguish riparian areas from non-riparian areas. The DEM allowed interpreters to clearly and precisely digitize the riparian boundary, as landforms created by water activity were easily identified. The DEM was powerful enough to allow interpreters to notice small striations (10cm deep) in the ground made by bulldozers on cutlines as well as right-of-ways and other anthropogenic disturbances. Anthropogenic disturbances were easily discernible from natural water based disturbance due to the linear and clean-edged nature of anthropogenic activity. The high resolution made water-based erosion and active slumping easy to identify. The DEM clearly shows the terrain forms of riparian areas, and with the help of the other reference data layers (e.g. 3D imagery, EBCC model, NetMap, etc.), riparian areas were comprehensively and accurately identified by the interpreters.

This level of resolution was found to provide sufficient visual indications of landforms in and around riparian areas. LiDAR technology provides information previously unattainable to the forest industry, without which this project could not have been completed at the scale and accuracy desired.

The use of 3D imagery was valuable for identifying vegetation species distinctions between ecosite breaks, which in turn allowed for a more defined and consistent digitization of contemporary fluvial and seepage-fed channels.

The DEM was the main driver behind the digitization of riparian areas; however, when the topography was flat, elevation changes could not be reliably used to identify riparian areas. Instead, the imagery was solely referenced to identify higher vegetation associations with ecosites, which in turn were associated with riparian function. Thus, interpreters identified factors indicative of soil nutrients and moisture (i.e., tree species present, non-tree vegetation, and visible water). The high resolution imagery allowed the interpreter to make these calls with greater confidence than with previous technologies.

The EBCC model was critical for the project digitization, as it simplified the riparian classification process as each channel was defined and mapped over the FMA area. It also ensured interpretation consistency, not only from day-to-day, but between interpreters as well. The riparian classification was directly related to the EBCC; however, if necessary, the interpreter would override the EBCC model call. Each channel was scrutinized by interpreters to determine if the current was strong enough to transport sediment and other unconsolidated material downstream. Factors such as channel width, flow, erosion potential, flood potential, large debris piles and topography were examined to determine a channel's ability to pass sediment and debris.

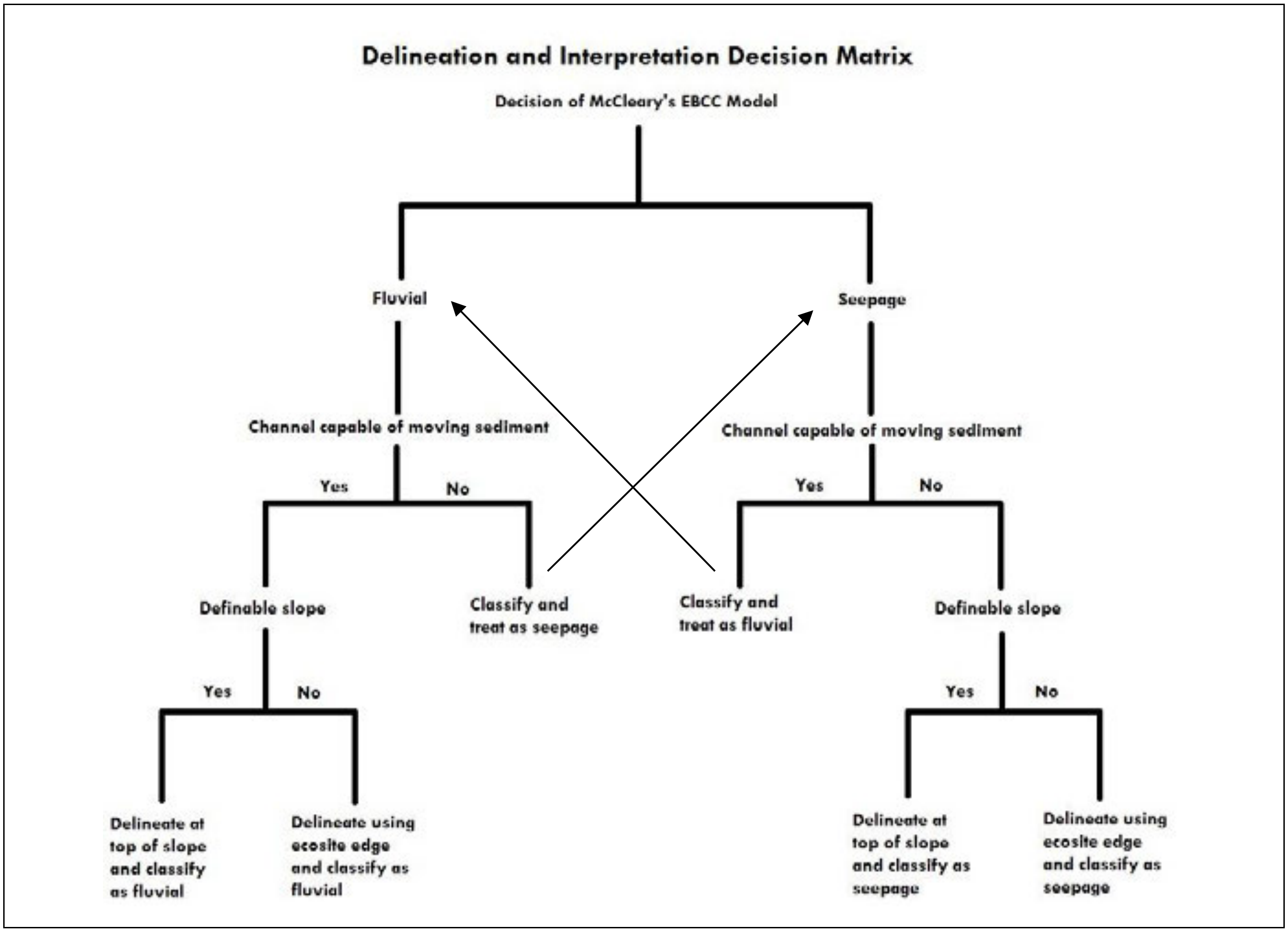

Figure 5 – *The chart illustrates the basics of the mental process interpreters went through whilst delineating the riparian areas. At the top of the chart is the decision of the EBCC model to classify a channel as either fluvial or seepage. Every intersection on the chart after the first is a decision made by the interpreter. The diagonal arrows indicate the instances when the EBCC model would incorrectly classify a channel and the interpreter would reconsider the assessment.*

The ELC was used as a reference to guide or validate riparian boundaries during digitization. In a few cases, the ELC line work was accurate and representative and it was used as a riparian boundary. The ELC provided important productivity value to the project in that it offered a baseline from which to start. However, it was only a guide for the majority of the project. The ELC segmented the landscape sufficiently enough to allow interpreters to easily and quickly understand complex areas that would otherwise have taken longer to comprehend and properly digitize.

Figure 5 illustrates the decision matrix used by the interpreters when defining each riparian area.

5.1 Digitization process

The 8-step digitation process is described below:

1. Digitization began at the obvious upstream end of an EBCC-defined fluvial channel in one of the 13 watersheds illustrated in Figure 1.
2. Digitization continued downstream on one side of the fluvial channel until an EBCC seepage-fed channel was encountered. Top of the contemporary fluvial slope was used as boundary unless ecosite determinants depicted otherwise.
3. When an EBCC seepage-fed channel was encountered, interpreters continued the boundary line around the seepage feature accordingly until the boundary reached back to the point of origin where the seepage-fed and fluvial channel met.
4. At this point, the interpreter needed to determine the validity of the EBCC transition call. If the EBCC call was accurate in depicting the transition, the interpreter would simply close off the fluvial and continue on. However, if the EBCC failed to appropriately depict the transition, interpreters would ignore the EBCC call and continue to a point where the transition was warranted based on the previous definitions of "fluvial" and "seepage-fed" channels (note: the EBCC was not altered during this project to match the final riparian mapping product). If the EBCC call did match the correct transition location, interpreters digitized the boundary between the seepage-fed riparian area and the fluvial riparian area, crossed the boundary, and continued downstream along the fluvial channel.
5. When the most downstream portion of the fluvial channel was reached there was often extensive seepage-fed riparian to be digitized. Once the seepage-fed riparian and transition were mapped, interpreters would continue the fluvial boundary back upstream towards the starting point.
6. If the downstream boundary of the watershed was the FMA boundary, interpreters closed the polygon. If the riparian boundary continued into other watersheds within the FMA, interpreters still closed the polygon to the watershed and later re-connected it to the riparian polygon in the adjacent watershed. This also applied to upstream riparian boundaries where they left the FMA or crossed watershed boundaries.
7. Digitization of isolated wetlands was completed constantly throughout the project. Whenever an interpreter noticed an isolated wetland, he would stop what he was doing and complete the digitization of the isolated wetland before continuing with fluvial or seepage-fed boundaries. This ensured that no isolated wetlands were missed during digitization.
8. When all the riparian areas in the watershed were completed, interpreters moved on to the next watershed, and so on.

5.2 Digitization of Fluvial Features

Fluvial features identified by the EBCC model and confirmed by the interpreter were usually easy to digitize in the hilly western area of the FMA due to the observable erosion evidence and easily definable slope. In these cases, the top of the slope was used as a reference for drawing the line between riparian and non-riparian classifications (Figure 6). In flatter terrain where the slope breaks were not as pronounced ecosite indicators such as vegetation cover types, nutrient, and moisture regimes were relied upon to a greater degree to ensure an accurate capturing of the riparian area. Confidence in doing this was gained through the use of high resolution photography and interpreter’s general understanding of ecosite transitions and how they relate to riparian function. Interpreters continually compared the DEM with the imagery to ensure a consistent and accurate product.

Generally the terrain over the FMA tended to become more even moving east (flat terrain) from west (steep terrain), therefore digitization of fluvial features became more dependent on ecosite (as opposed to the LiDAR DEM) as interpreters worked from the steeper western half of the FMA towards the flatter eastern half.

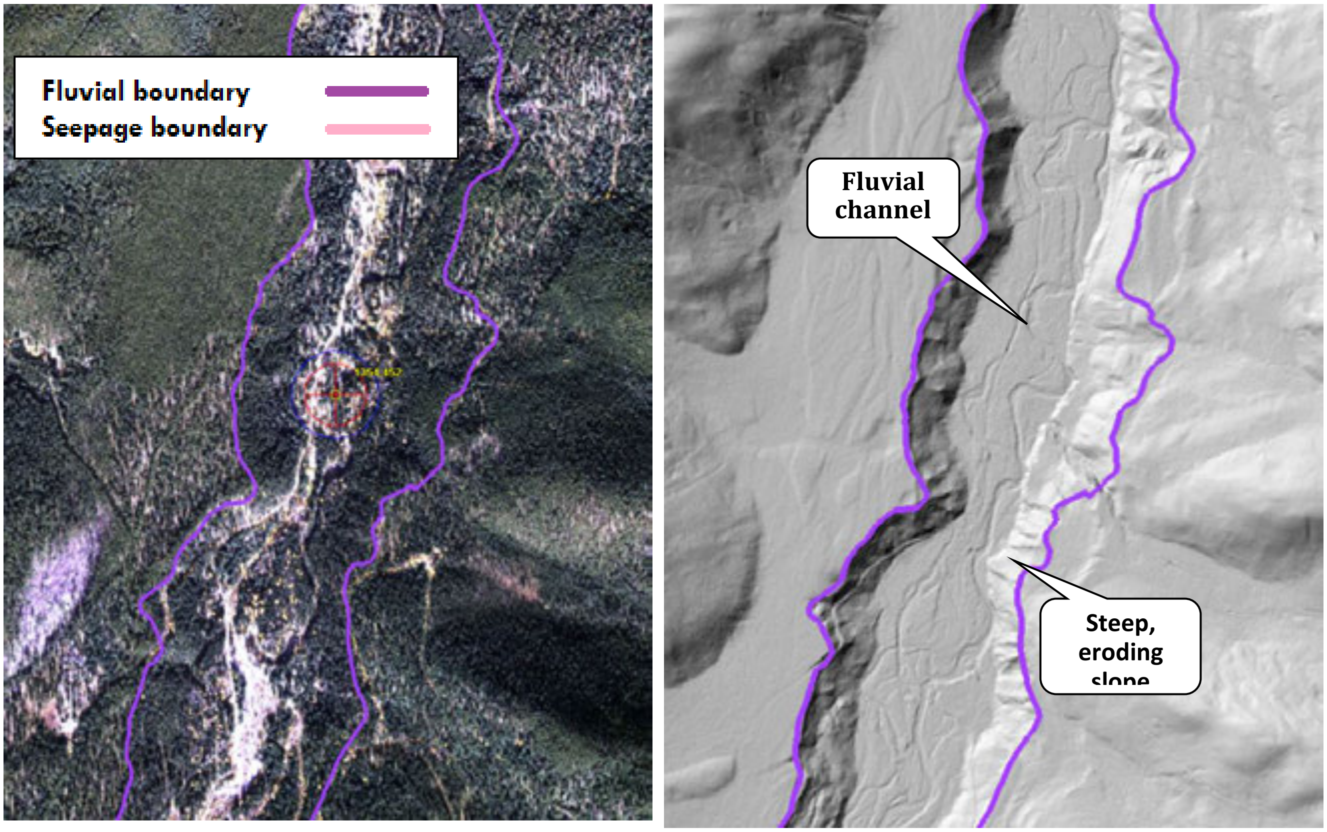

Figure 6 – *DAT/EM (imagery) and MicroStation (DEM) screenshots of a typical fluvial feature. Notice the steep, eroded banks caused by the cutting power of flowing water. Within the fluvial feature there is a majority white spruce forest with some other upland species such as pine, aspen and balsam poplar. The associated ecosite is rich and wetter than the adjacent majority lodgepole pine forest on the top of the riparian banks in the upland portion. On the imagery there is a cursor with three circles around it; the blue circle is two hectares, the red circle is one hectare and the yellow inner circle is 0.02 hectares.*

5.3 Digitization of Seepage-fed Features (Including Isolated Wetlands)

Seepage-fed channels were identified by the EBCC model and confirmed as seepage-fed by the interpreters before the boundaries were digitized. When a slope could be clearly seen, the riparian boundary was drawn at the top of the slope. Where there was no slope associated with the riparian feature, ecosite determinates, such as vegetation cover and moisture regime, where used to determine the boundary lines.

Seepage-fed riparian features tended to be associated with flatter topography, poorer nutrient regimes, and poorly drained soils. Therefore, the riparian digitization was often intricate and could extend a significant distance from the watercourse. In contrast, fluvial riparian features tended to be more tightly defined by steeper topography and associated with richer site nutrients with moderately to well-drained soils.

In general, seepage-fed digitization was more highly dependent on ecosite determinates and therefore the imagery was more heavily relied upon. The erosive power of fluvial features allowed for the majority of fluvial digitization to be completed using the DEM, drawing the boundary at the top of the slope. Figure 7 illustrates the placement of a typical seepage-fed riparian boundary.

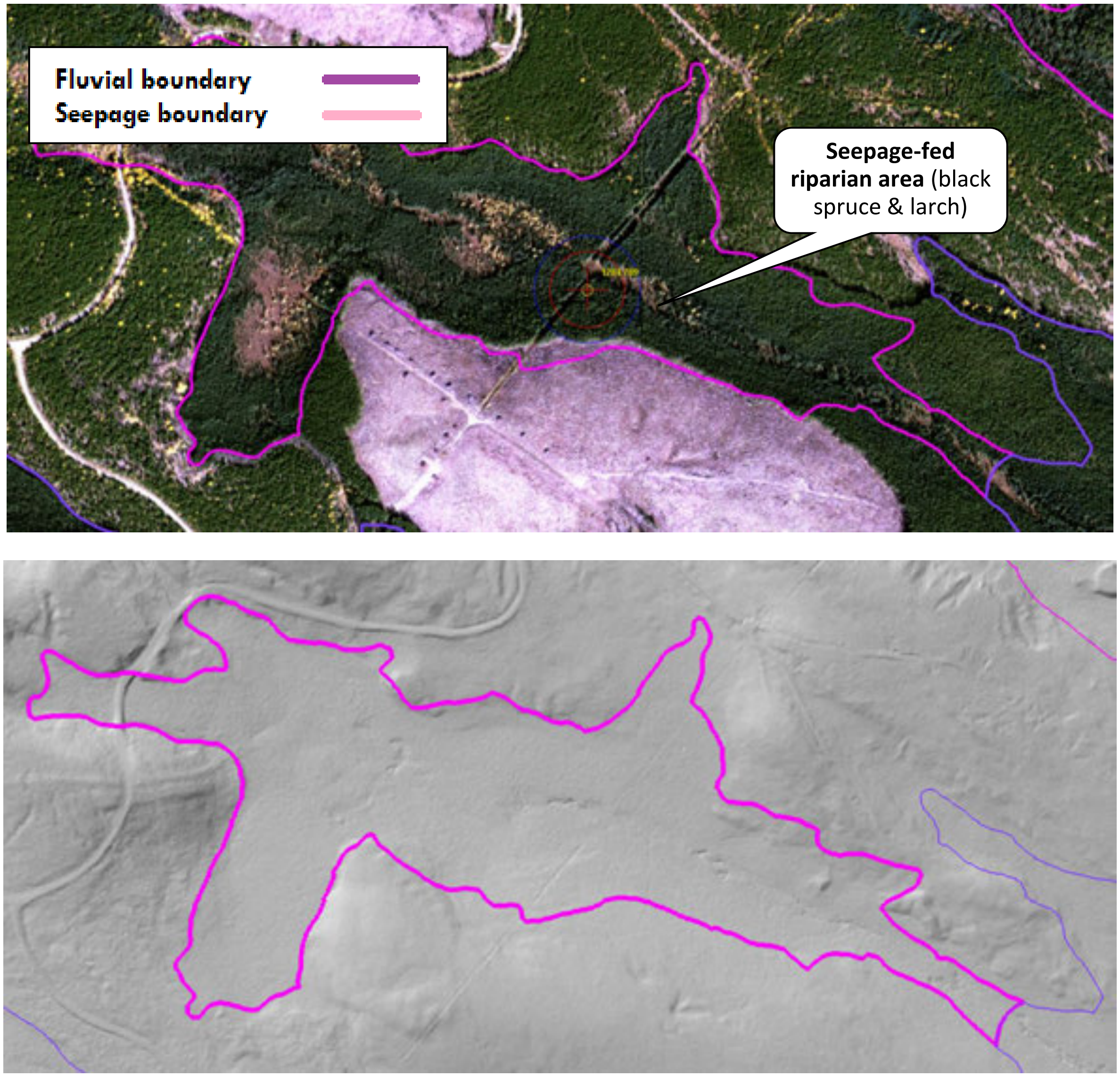

Figure 7 – *DAT/EM (imagery) and MicroStation (DEM) screenshots of a typical seepage-fed feature. Within the seepage-fed boundary (pink) there is an area of wet, poorly drained, and poor nutrient soil with the majority of the vegetation being black spruce. This site has no discernible slope associated with the riparian function; therefore, the boundary was digitized at the ecosite edge. On the outside of the seepage area there is a previously harvested upland feature with a majority of lodgepole pine. The ecosite edge is easily identified in this scenario. On the imagery there is a cursor with three circles around it; the blue circle is two hectares, the red circle is one hectare and the yellow inner circle is 0.02 hectares.*

5.4 Digitization of the Transition between Fluvial and Seepage-fed Features

Usually the transition from seepage to fluvial occurred at or near the convergent point of two or more seepage channels (bottle neck). In many situations the transition zone was accurately represented by the EBCC model; in these cases, the interpreter would follow the direction of the EBCC and draw the transitional line where the EBCC indicated. However, if the EBCC model was considered to be incorrectly representing the transition point, then the interpreter would simply determine the most appropriate location for the transition based on the definitions of seepage-fed and fluvial areas. When interpreters needed to move transitional lines away from where the EBCC model indicated, interpreters used relief as well as ecosite to identify the point of transition. Good indicators of a transition were where two or more seepage channels converge, relief tended to level out and/or where ecosite transitioned from a rich to a poor nutrient regime.

It should also be noted that throughout the entire digitization process, fluvial riparian areas took precedence over seepage-fed areas. Figure 8 illustrates some typical riparian transition zones.

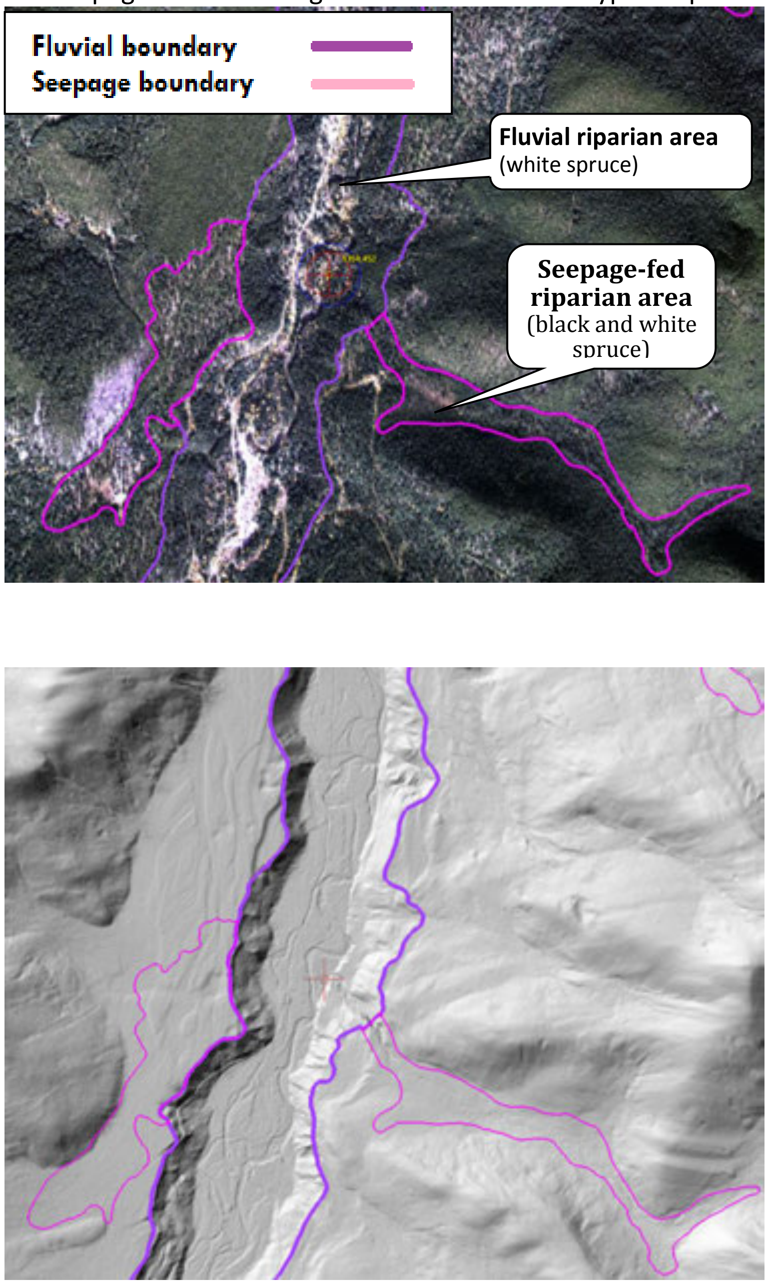

Figure 8 – *DAT/EM (imagery) and MicroStation (DEM) screenshots of a typical fluvial and seepage-fed transition area. The stream channels are not referenced in this figure. The purple boundary indicates the fluvial area and the pink indicates the seepage area. Within the fluvial area erosion and sharp steep banks are evident, whereas the seepage areas have more even terrain and less evident stream channels. On the imagery there is a cursor with three circles around it; the blue circle is two hectares, the red circle is one hectare and the yellow inner circle is 0.02 hectares.*

6.0 Classification Issues Encountered

6.1 The NetMap Watercourse Location and EBCC model

Some data difficulties in the interactions between NetMap and the EBCC model were observed:

1. NetMap contains some inaccuracies with regard to watercourse location, which are common to DEM-modelled watercourse layers. For instance, sometimes anthropogenic disturbances, such as ditches and quarries, where digitized as channels. These situations were easily identified and fixed and did not negatively impact the final product in any way (Figure 9).
2. On expansive, flat, wet terrain, the EBCC model sometimes classified non-channeled seepage areas as fluvial channels. Although careful observation was required, for the most part these situations were relatively easily identified and occurred primarily in the non-operable wet areas.

When identified, interpreters defined the fluvial boundary at the appropriate representative point, where the criteria for fluvial and seepage zones converged (Figure 10).

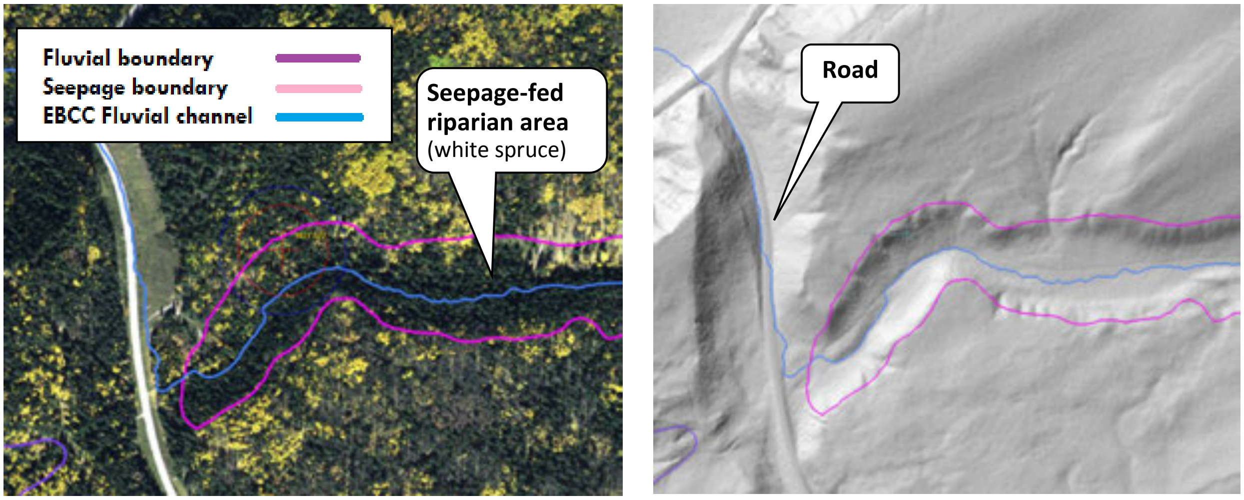

Figure 9 – *The EBCC mode l(blue line) incorrectly classifies a road as a seepage channel. The interpreter digitized the boundary at the top of the slope and cut the seepage area off when it intersected the road. At the intersection of the road and seepage channel, the channel had petered out and the boundary was drawn.*

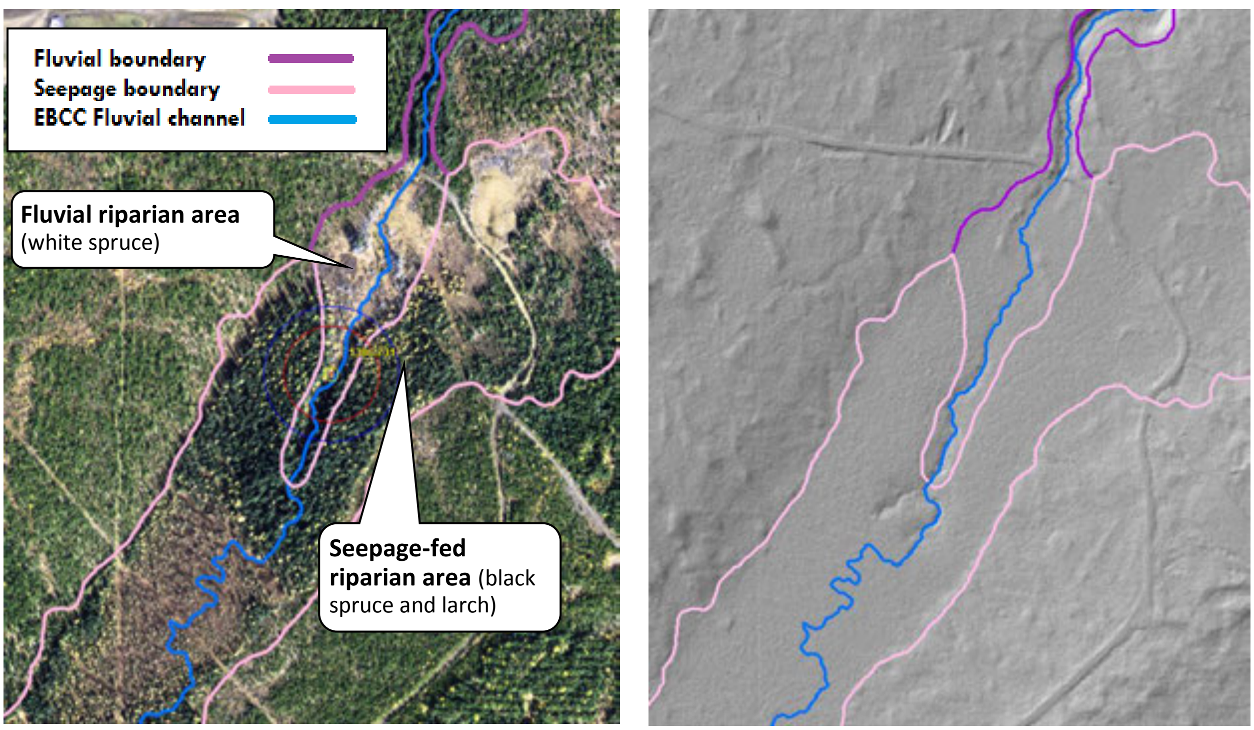

Figure 10 – *The EBCC model incorrectly classifies a seepage-fed zone as a fluvial. The blue line represents the EBCC model fluvial channel. As seen on the figure, interpreters cut the fluvial boundary off at the appropriate point. This is the appropriate point for a categorical transition because: the terrain leveled out where there was no longer a discernible slope associated with the riparian function, the ecosite changed from a rich, moderately well drained site into a nutrient moderate-to-poor site with poor drainage, and the riparian area began to fan out from the channel.*

6.2 Anthropogenic Issues

Quarries created an issue as they often intercept riparian areas. Any line taken to the edge of a quarry was closed at the disturbed edge and continued on the other side. Any wetlands found to enter into quarries were also closed at the quarry edge (Figure 11).

Towns and hamlets created similar issues. Boundaries were drawn as close as possibly to the historical riparian area, but this was more challenging in densely populated areas due to the heavy landscaping that often occur in these areas (Figure 12).

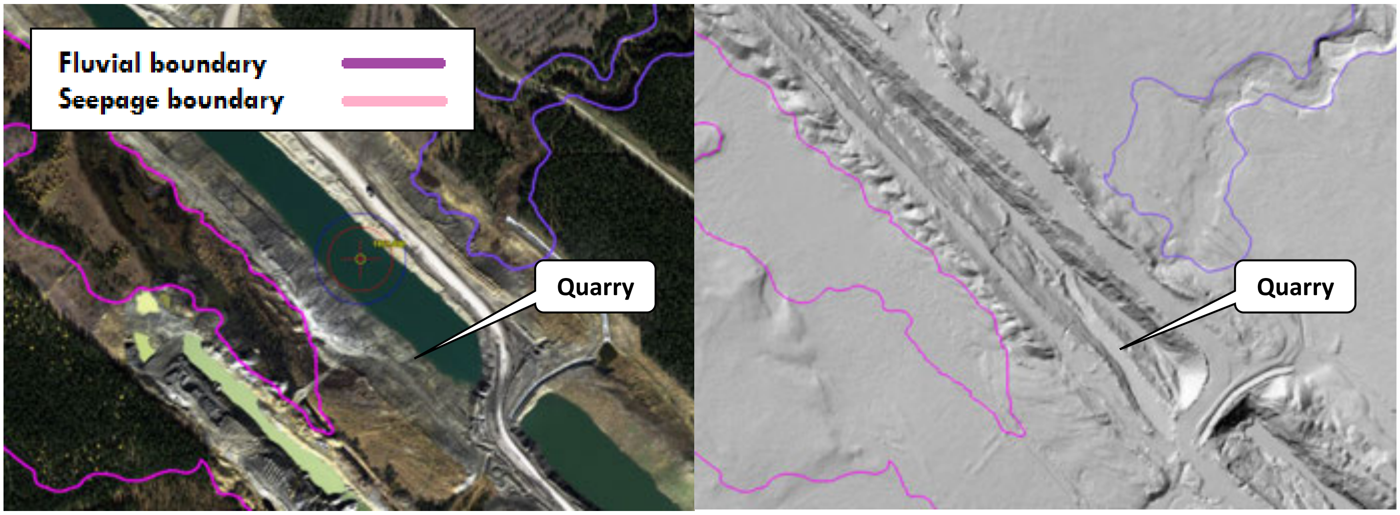

Figure 11 – *Seepage-fed and fluvial riparian areas run into a quarry and are cut off at quarry boundary. On the imagery there is a cursor with three circles around it; the blue circle is two hectares, the red circle is one hectare and the yellow inner circle is 0.02 hectares.*

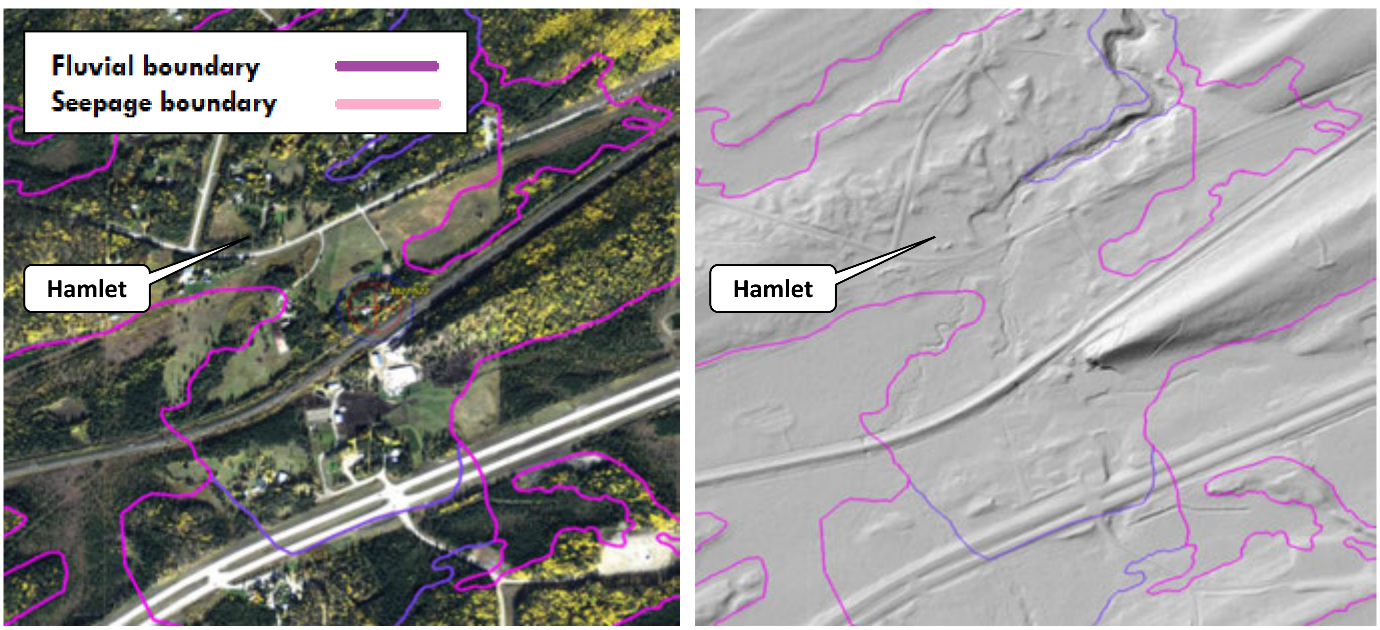

Figure 12 – *Hamlet within fluvial and seepage-fed riparian areas*

7.0 Results and Discussion

There is a general spatial trend in the amount of seepage-fed features present on the landscape, from both west to east and south to north. This is because as you move away from the Rocky Mountains, the terrain levels, resulting in a higher density of seepage-fed features. As you move closer to the mountains, the higher relief allows for water to drain quickly, which in turn reduces the amount of seepage-fed features.   For example, the lowest proportion of seepage-fed, and greatest proportion of fluvial, is found in the Upper Berland River basin (Table 1 and 2), located in the Upper Foothills Natural Subregion on the west side of the FMA. In contrast, the Lower McLeod River, located on the east edge of the FMA, has an almost equal proportion of fluvial to the Upper Berland River basin, but contains the largest proportion of seepage-fed of all the 13 watersheds. This is largely due to the generally flatter topography and the parent material of the Lower McLeod River area, which restricts drainage therefore favoring more seepage-fed and wetland features.

The reference information used and methods employed for this project proved highly successful within the constraints of the devised classification system. The projects tools and input data were useful and specific enough to pick up small scale differences between watershed basins. The subsequent riparian map is more detailed and spatially accurate than traditional riparian mapping products and should dramatically improve the understanding forest managers have of Hinton FMA, allowing for more informed, and therefore, more accurate and appropriate management decisions in the future. Tables 1, Table 2, and Figure 13 summarize the results of this project.

It should be noted that for the purpose of this project all the subtracted areas within the FMA (e.g. Switzer Park and other parks, Town of Hinton, Quarries, Hamlets, etc.) were considered as part of the FMA. This allowed for fluidity while digitizing and consistency of product. To remove these areas from the FMA and digitize around their boundaries would have increased complexity and created a non-seamless product with large information gaps in the resulting layer. Statistical differences between the current riparian layer and a riparian layer with these non FMA areas removed would be negligible. The only proportional change that may be noticed is a small percentage drop in fluvial classifications on the overall landbase. On a watershed by watershed basis, larger proportions of fluvial area will be missing from the Upper Wildhay, Upper Athabasca and Lower McLeod River Compartments due to Provincial Parks and the Town of Hinton.

Table 1 – *Summary of the 13 watersheds into the area (hectares) occupied by each riparian spatial category*

Watershed	Fluvial	Seepage	Isolated Wetland	Upland	Complex	Grand Total
Brazeau/Pembina River	7,783	13,352	214	52,532		**73,882**
Edson/Windfall	5,295	10,591	464	48,365		**64,714**
Erith River	14,391	40,072	488	84,003		**138,954**
Lower Athabasca River	6,757	10,968	343	49,319		**67,387**
Lower Berland River	7,679	17,048	600	34,380		**59,708**
Lower McLeod River	7,571	15,537	410	29,167		**52,685**
Lower Wildhay River	13,786	25,693	950	72,210		**112,638**
Mid Athabasca River	15,146	29,995	816	65,429		**111,386**
Mid Berland River	4,788	12,593	335	31,270		**48,986**
Upper Athabasca River	9,036	12,838	519	54,307		**76,700**
Upper Berland River	3,962	3,523	9	19,415		**26,910**
Upper McLeod River	18,589	21,032	769	95,117		**135,507**
Upper Wildhay River	8,388	13,968	587	41,317	295	**64,554**
Grand Total	123,170	227,210	6,503	676,831	295	**1,034,010**

Table 2 – *Summary of the 13 watersheds into the percent area occupied by each riparian spatial category*

Watershed	Fluvial	Seepage	Isolated Wetland	Upland	Complex	Total
Brazeau/Pembina River	10.5%	18.1%	0.3%	71.1%		100%
Edson/Windfall	8.2%	16.4%	0.7%	74.7%		100%
Erith River	10.4%	28.8%	0.4%	60.5%		100%
Lower Athabasca River	10.0%	16.3%	0.5%	73.2%		100%
Lower Berland River	12.9%	28.6%	1.0%	57.6%		100%
Lower McLeod River	14.4%	29.5%	0.8%	55.4%		100%
Lower Wildhay River	12.2%	22.8%	0.8%	64.1%		100%
Mid Athabasca River	13.6%	26.9%	0.7%	58.7%		100%
Mid Berland River	9.8%	25.7%	0.7%	63.8%		100%
Upper Athabasca River	11.8%	16.7%	0.7%	70.8%		100%
Upper Berland River	14.7%	13.1%	0.0%	72.1%		100%
Upper McLeod River	13.7%	15.5%	0.6%	70.2%		100%
Upper Wildhay River	13.0%	21.6%	0.9%	64.0%	0.5%	100%
Grand Total (ha)	11.9%	22.0%	0.6%	65.5%	0.03%	100%

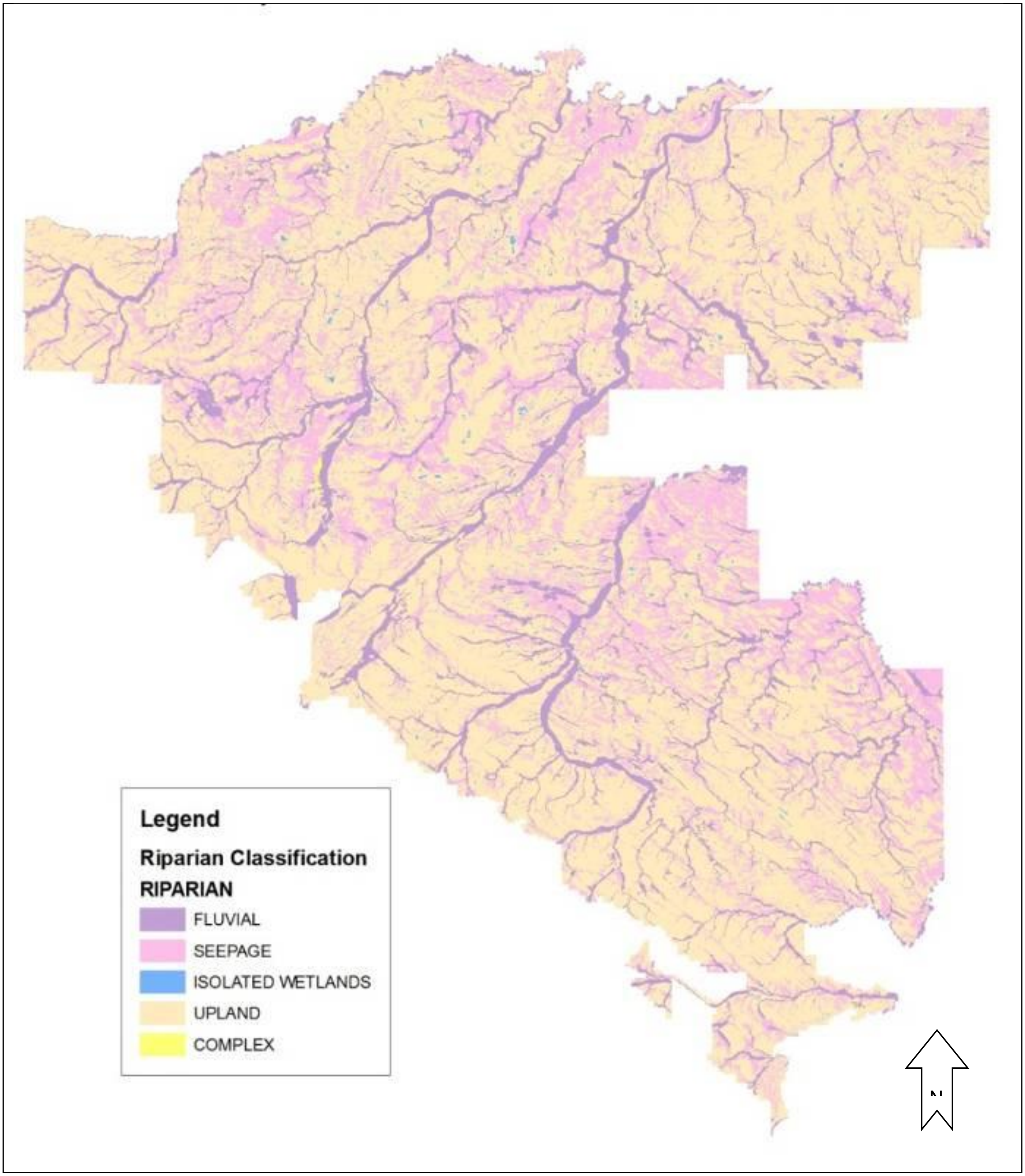

Figure 13 – *Final map product of riparian classification for the West Fraser Hinton FMA*

8.0 Quality Control

All inventories conducted by GreenLink Forestry Inc. are done by interpreters trained and competent to do the work. GreenLink takes an important interactive approach to address quality control and consistency. This means that the project's interpreters re-calibrated with one another on an ongoing basis. Internal quality control at GreenLink was heavy at the beginning of the project. An experienced interpreter would check in with interpreters several times daily to discuss the more complex issues and ensure that the scope and breadth of the work being done was consistent and accurate. Front end loading of the quality control process ensured that all work from beginning to end was competed correctly and under the same specifications.

GreenLink considers transparency of the inventory as a vital constituent to good quality control as well as facilitating good client-government relations. Therefore on-going internal audits were conducted and all serious issues were progressively reported to Hinton Wood Products throughout the project. HWP also conducted independent audits to validate both the digitization and classification, and invited AESRD staff on-site to see firsthand how the project was being carried out. GreenLink was also invited, and participated in, an HWP/AESRD meeting in Hinton to demonstrate the technology central to this project. This multi-stage, multi-agency, quality control process minimized the risk of producing an inconsistent product.

9.0 Project Personnel

- **Derek Fisher, RPFT (AB, SK) (GreenLink Forestry Inc. Principal)** (AVI-Alberta, FRI-Ontario, VRI-British Columbia and Wetland certified) has been the Principal of GreenLink Operations since 2002 and provided the guidance and interpretation quality control on the project and made sure the program was on time and budget. Derek also helped review some of the spatial datasets that where received by GreenLink from Hinton. For the 10 years prior, Derek has managed inventory projects in Alberta, British Columbia, Saskatchewan, NWT, Idaho, Argentina and northwestern Ontario for both corporate and Government Clients. Derek has been extensively involved over the last 12 years providing inventories in the softcopy (Softcopy) environment to B.C, Alberta, and Idaho clients. Derek has also provided the forest industry riparian classification using more conventional means of classification in the past.

- **Matthew Kristoff, BScF, FIT (Inventory Forester)** has been with GreenLink since November 2012 as an Inventory Forester, working with softcopy forest digitization and interpretation. His experience includes cutblock and road layout, water crossing assessments, timber cruising and wildfire management with AESRD. Current projects include softcopy digitization for inventory purposes, cut block and retention updates as well as photo interpretation. Matthew is one of the personnel responsible for completing the riparian classification.

- **Colin Paranich, BScF, FIT (Inventory Forester)** has been with GreenLink since November 2012 as an Inventory Forester, working with softcopy forest digitization and interpretation. His field experience is quite extensive, focusing mostly on wildfire management with AESRD, along with basic vegetation surveys and timber measurements. As a recent graduate from the University of Alberta his studies have focused heavily on ecological and environmental aspects of the industry, as well as the economic and managerial side as well. Colin is one of the personnel responsible for completing the riparian classification.

- **Rhoda Ginther (GIS Technician)** was responsible for the many GIS requirements this project had. She has over 17 years experience using *ArcInfo* on both P.C. and NT Workstation platforms. She also has 13 years' experience using MicroStation. Other duties have included quality control on all digital products as well as processing data programming and general GIS functions.

- **Hinton Wood Products Staff:** Glenn Buckmaster, Richard Briand, Rick Bonar, Pat Golec, and Aaron Jones all contributed to this project.

10.0 Glossary

- **Classification** –The assigning of categories (fluvial, seepage, isolated wetland, complex, upland) to digitized areas.
- **Definable slope** – Any sharp change in topography on the LiDAR - DEM that appears to be created, or largely affected by water activity. Evident due to erosion, slumping and/or adjacency to water features.
- **Digitization** –The placement of a boundary line that separates two or more features exhibiting different characteristics. Where the line was drawn on the map.
- **Discontinuous Channel** –A drainage feature that consists of channel and vegetated ground. Also referred to as Intermittent in the Alberta Operating Ground Rules
- **Ecosite** – Ecological units that develop under similar environmental influences (climate, moisture, nutrient regime, etc.).
- **Ephemeral** – Water drainage that flows below the ground surface or on the surface only during snow-melt and rainfall run-off events. There is generally no eroded channel development and the drainage path is usually vegetated with hydrophytic plants that markedly differ from surrounding ecosites.
- **Large/ Small Permanent** – Watercourse channels with sufficient flow to transport sediment and bed materials. Large permanent are considered >5.0 meters wide, while small permanent are classified between 0.7 and 5.0 meters.
- **Riparian** – "Riparian lands are transitional areas between upland and aquatic ecosystems. They have variable width and extent both above and below ground. These lands are influenced by and/or exert an influence on associated water bodies, which includes alluvial aquifers and floodplains, when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes." (Clare and Sass 2012)
- **Seepage-fed Channel** – Streams that lack sufficient power to regularly move bed materials. Also referred to as Intermittent and transitional in the Alberta Operating Ground Rules.
- **Swale** – Depressional features created by extreme events during previous climate regimes that are completely vegetated and lack and opening channel.
- **Water table** – The level below which the ground is saturated with water.
- **Water Source area** – An area where the soils are water saturated and surface or subsurface flow is occurring.

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<u>APPENDIX 3</u>

Natural Disturbance Salvage SOP

Natural Disturbance Salvage SOP

1.0 Purpose:

The purpose of this SOP is to outline operational procedures to address timber salvage after a stand-replacing event. This operational procedures will ensure that retention within the overall disturbance event is planned to approximate natural disturbances, combining green (undisturbed) retention with partially disturbed and completely disturbed retention.

2.0 Definitions

a. Natural Disturbance – A natural disturbance is an agent that causes trees and other vegetation to die. On the Hinton FMA natural disturbance agents include fire, wind (stem breakage and blowdown), ice/hail, flood, landslide, avalanche, insects, and disease.

b. Stand-Replacing Natural Disturbance – A stand-replacing natural disturbance is a disturbance where >50% of trees have been killed or severely damaged by the disturbance in an area larger than one hectare.

c. Timber Salvage – Timber salvage is the harvest and utilization of merchantable timber that was killed or injured by stand-replacing fire, insects, disease, blowdown, or other natural disturbance agents. HWP defines damaged timber as an area ≥ one hectare in size where ≥ 50% of the trees are dead or dying. Damaged timber does not include areas less than one hectare in size or individual trees that die in forest stands as a result of natural processes (endemic losses).

3.0 Application

The SOP applies to all natural disturbances that occur on the Hinton FMA, and are known to HWP, which fit under the definition of a stand replacing disturbance. The minimum size of a stand replacing event is one hectare, but smaller disturbances can be considered along with adjacent areas (e.g. blowdown along block boundary), but would not be tracked with the unsalvaged natural disturbances VOIT.

4.0 Natural Disturbance Awareness

There are a number of different mechanisms for learning about natural disturbances that occur on the FMA and fit the definition of a stand-replacing event. These mechanisms include:

- Fires as tracked by ESRD (annual reporting of all fires that occurred on FMA).
- MPB mortality as tracked by ESRD (annual aerial surveys and mapping of damaged stands).
- Blowdown and other disturbance types noted as they occur. These are picked up in ESRD annual aerial surveys, ongoing management implementation, and inventory updates (e.g. air photo updates).
- Staff reports – often HWP's staff are the first to notice smaller natural disturbance events such as hail, floods, and blowdown.

5.0 Stand Operating Procedure

This section outlines the procedures to take when a stand-replacing natural disturbance event takes place and a decision is made to initiate timber salvage operations.

5.1 Salvage Opportunity Assessment

Define the disturbance and timber salvage opportunities. The following information should be collected and assessed:

- Type of disturbance (e.g. fire, blowdown, etc.)
- Map the size and type of disturbance
- Volume/area of potentially salvageable merchantable wood
  - Species
  - Product mix (sawlog, pulplog, deciduous)
  - Degree of damage (e.g. charring from a fire)
  - Time since disturbance

- Fiber quality current and trajectory (e.g. shelf life)
- Area of damaged non-merchantable but productive (contributing landbase) that may need assisted regeneration.
- Access
    - Existing
    - Need for additional access if any
    - Cost for additional access
    - Need for special access considerations (e.g. stream crossings, pipelines, wetlands, etc.)
    - Haul distance and haul cost
- Operable land considerations
    - Slope and associated logging cost
    - Operating season (summer, winter, marginal)
- Other considerations
    - Wildlife (e.g. caribou, swans, etc.)
    - Recreation
    - Aesthetics
    - Historical and Cultural Resources
    - Aboriginal consultation

5.2 Make Decision to Salvage or not Salvage the Disturbance
Based on the salvage opportunity assessment, a decision will be made on whether or not the natural disturbance event will be salvaged. If it is not salvaged, the event should be entered into HWP's event catalog.

5.3 Disturbance Event Analysis
If the event is large enough, carry out a NEPTUNE analysis of the disturbance event (disturbed, island remnants, matrix remnants). This information will be entered into HWP event catalog (see Target #9 in the DFMP).

5.4 Develop a Salvage Plan
A salvage plan will follow the same format and procedures as a Forest Harvest Plan. The following bullets provide additional direction regarding harvest layout:

- Identify operable damaged timber (potential salvage harvest) and non-operable damaged timber (no salvage harvest, potential reforestation need).
- Identify undamaged merchantable timber and potential operations.
    - General direction is to minimize green timber harvest and retain it for future harvest.
    - Include green timber in harvest plan if it is necessary or desirable to harvest now (consider age, operating season, trapped wood, etc.)
- When planning a salvage block or blocks, generally follow the patterns created by the disturbance, with an emphasis on salvage of merchantable and operable damaged timber, plus the portion of green timber that makes sense to cut now versus later.
- Retention within blocks should generally be toward the high end of what would be done in a green timber harvest plan.
- Retention within salvage blocks should be anchored on green timber islands within disturbed patches where those exist, with at least some damaged timber added to the islands to make them bigger and representative of both green and damaged.
- Retention within salvage blocks should include patches of damaged timber, especially where there are no green islands to work with. Pick the patches first in locations where there are other reasons to leave a patch (e.g. non-merchantable or smaller timber, non-desirable species such as deciduous or fir, steep areas, heavily damaged timber (charring, breakage, etc.), etc.).
- Develop a preliminary salvage plan, which identifies all potential areas to be harvested, including dead, partially dead, and green.

5.5 Salvage Plan Analysis

Once a preliminary salvage plan has been completed, the following steps should be taken:

- Carry out a NEPTUNE analysis of the preliminary salvage plan disturbance event (disturbed, island remnants, matrix remnants). Split the disturbed patches into two categories: disturbed by the natural disturbance and salvaged, and disturbed by the natural disturbance and not salvaged.
- Compare results to target of at least 25% of natural disturbance events unsalvaged based on a 20 year rolling average.
- The plan and analysis results should show good levels of retention in a variety of patch sizes and shapes well distributed. If this is the case the plan should be accepted and laid out in the field.

5.6 Salvage Plan Layout

During the layout of the salvage plan, the following steps should be taken:

- Look for additional retention opportunities and needs as part of the layout process and lay them out. Layout should be somewhat more detailed than done for normal practice. Layout all the retention patches and locations of roads, decking areas, etc.
- Update the plan to incorporate field modifications.
- Redo the Neptune analysis on the final laid out plan.

5.7 Harvest Operations

During harvest operations, the following direction should be followed:

- Operators should be instructed to leave clumps and singles throughout the blocks, focussing on large trees (>20 cm dbh) and trees that either had previous defects (snags, stubs, forks, heavy branching, etc.) or have defects as a result of the natural disturbance (e.g. broken stems from wind or other physical damage).
- Leave as much of the standing and downed dead wood in place as practical and safe to do so.
- Do not chase a few merchantable stems in patches where most of the trees are dead or damaged, or where there is lots of healthy understory.
- Consider leaving some ESRD approved wildlife specific debris piles, or spreading CWD back over the block, to maximize retention and minimize need for pile burning.
- Reclaim all temporary roads as soon as harvest and reforestation operations have been completed.

5.8 Reforestation

Reforestation of salvage blocks should take advantage of opportunities from the natural disturbance itself.

- No site preparation and leave for natural if the area was burned, or direct planting if needed to supplement anticipated natural regeneration.
- Protect viable understory if the disturbance was a type that killed overstory trees (e.g. MPB, blowdown).
- Site preparation should minimize the destruction of wood left in blocks. If there is too much wood consider direct planting or other ways to ensure regeneration while retaining the wood on site.
- Also consider assisted reforestation needs in disturbed areas that were not salvage (e.g. seeding or direct plant).

5.9 Monitoring and Reporting

All disturbance events need to be tracked and reported on annually in HWP Stewardship Report and every five years in the DFMP Performance Stewardship Report. HWP maintains an event catalog database that tracks all events, patches, island remnants and matrix remnants. All natural disturbance events must be tracked in this event catalog.