Old Forest Current Condition: A Cumulative Effects Analysis for the Northeast RSEA Study Area

Final Report

Prepared for:

British Columbia's Environmental Stewardship Initiative:

Northeast Regional Strategic Environmental Assessment (RSEA)

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CONTEXT

The Northeast Regional Strategic Environmental Assessment (RSEA) Project Table determined that a robust cumulative effects analysis of current condition for old forest was a priority action item (Summer 2017). A Scope of Work document was created by the Biodiversity Working Group[1] (sometimes called the Old Forest Working Group), and two members of the working group (Rachel Holt and Dave Myers) were tasked by the group to gather the appropriate data and undertake the analysis on behalf of the Project Table.

Timelines: Preliminary results from the analysis were presented at the Oct 2017 Project Table meeting, and after review, were updated and presented at the November 2017 table meeting. A draft report was provided to the Biodiversity Working Group in Feb 2018, and a number of Working Group meetings were held to understand the metadata, and to provide additional input into the analysis. As a result of these meetings, an additional analysis was undertaken (adding in the THLB / Non-contributing landbase), and the need for a functional forest analysis identified. This work had to wait for the RSEA disturbance layer[2] to be completed, so that layer could be used as the best available information on disturbance for the study area. The functional forest analysis was created in the fall of 2018 and incorporated into this report (Spring 2019).

The Forest Biodiversity Working Group prioritised the cumulative effects analysis of old forest as a first step. However, the Working Group also identified that other values such as 'natural early' forest and riparian forest were also important in defining the ecological landscape in the northeast. This Old Forest report therefore reflects the first in a number of analyses outlined by the Scope of Work to assess forest biodiversity condition in the Northeast, and as such this report should be considered to be a base report to be built upon by further work on additional indicators (see Next Steps).

ACKNOWLEDGEMENTS

Members of the RSEA Biodiversity Working Group initially laid out the Scope of Work for this analysis (Summer 2017). One of the working group's recommendations was to request retired provincial regional ecologist Craig Delong to provide comment and to ensure that application of his Natural Disturbance Unit data was appropriate. Craig's input was included in this work.

This analysis of current condition used data compiled by ECORA (David Myers). ECORA also automated some of the data summaries, and created output maps as requested. ECORA created a comprehensive data dictionary that provides a summary of data used for this analysis. That data dictionary and other supporting maps, datasets and images are available online [OLD FOREST JUNE 2019[3]], and a summary provided in Appendix 1.

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[1] Representatives at the Biodiversity Working Group have changed over time – but have included: Lyle Gawalko (MoE), Anna Regnier (FLNRO), Rhonda Cage (FLNRO), Dan Bernier (HRFN technical), Rachel Holt (BRFN technical), Dave Myers (ECORA), Mark Van Tassel (FLNRO), Kelly Izzard (FLNRO – invited to input into data and methods), Angela White (FLRNRO) plus Craig Delong (invited comment on approach).

[2] The RSEA project team developed a composite disturbance layer based on publically available government data and which is to be used by all RSEA projects as best available data.

[3] This sharepoint site is an internal RSEA project website. Please contact the authors if external access is requested.

EXECUTIVE SUMMARY

This report is an output from the Northeast Regional Strategic Environmental Assessment (RSEA) Project Table. The RSEA Biodiversity / Old Forest Working Group devised a scope of work that directed the analysis, and the technical work was carried out by Ecora and Veridian Ecological Consulting Ltd. A number of presentations and draft reports have been presented to the Working Group and to the main RSEA Table for comment, direction and revision, culminating in this final report.

Why Old Forest: Old forests or 'old growth' forests are generally described as the forests that occur late in the successional cycle of a particular ecosystem. Old forests provide a wide diversity of individual values (e.g. unique stand structures), habitat for a diversity of species as well as unique species such as caribou, and specific processes (e.g. microclimate temperature regulation and thermal cover). Old forests also provide general and unique cultural values important to First Nations – and old forests were identified as a key value by all the Treaty 8 Nations at the RSEA Project Table.

Approach: The amount of old forest is the primary indicator used by the Province of BC and others both to manage for, and to assess the condition of, forested ecosystems. Old forest is both a 'coarse filter' management tool, and old forest itself has unique values and characteristics. Loss of old forest in relation to natural levels increases the risk to natural biodiversity – species, populations and functions (Province of BC 1995). Risk in this context is a combination of the probability and / or the potential extent of change in relation to elements of biodiversity being impacted or lost. In RSEA context, this is also a risk in relation to the ability to exercise treaty rights on the landscape.

This old forest analysis is predicated on the approach outlined in the Province of BC's biodiversity policy (Biodiversity Guidebook 1995), and modified for the Northeast by the provincial ecologist (C. Delong 2011). As an assessment approach this work is similar in concept to that outlined by the Provincial Cumulative Effects Framework for old forest[4], but may differ in a number of important ways, including a) using a natural benchmark (rather than provincial policy) to understand the implications of the results, b) considering the potential condition (functionality) of remaining old forest, and c) evaluating the effect of ecosystem conversion on the results of the analysis.

Analysis: How Much Old Forest Remains?

Results of the 'how much old forest' analysis are presented at multiple scales -

By Natural Disturbance Unit (NDU): In all NDUs, the amount of forest >140 years of age is less than the midpoint of the natural range (i.e. less than the average amount of forest >140 expected naturally). In most cases this difference is large, with the exception of the Moist Interior-plateau, and Omineca-Valley subunits where the differences are relatively small.

In all NDUs, the amount of forest >250 years of age is significantly less than the midpoint of the natural range (i.e. significantly less than the average amount expected naturally). For most NDUs, there is little or no old forest remaining at all (e.g. the largest unit the Boreal Plains – Upland has less than 0.0003% forest >250 years in age – compared with an expected 9% average; most of the other NDU's have a similarly very low percent of very old forest compared to the expected natural level.

[4] The BG CEF forest biodiversity (old forest) analysis has been under development since at least 2014, but no report has yet been released. These statements are based on an understanding of what is expected to be relased in the analysis.

Reporting analysis results by NDU is generally too coarse a measure to be ecologically meaningful particularly because of the very large size of the Boreal Plains – Upland NDU in particular. However, it does provide a sense of the very broad patterns across the landscape.

By Landscape Units within NDU[5]: this slightly finer scale analysis is more ecologically useful because it presents results on a scale that is more relevant to most species and to human use of the landscape. However, it is not sufficiently fine-scale to reflect real trends in real ecosystems - meaningful ecosystem level representation requires site series type ecosystem mapping which is currently unavailable, but under development for the RSEA Study Area.

For forests > 250 years in age, in almost all Landscape Units in all NDUs, there is significantly less forest >250 years old than found on average naturally, and in the vast majority of cases, the amount is lower, or far lower, than the bottom end of the natural range. For drier NDUs, the absolute amount of forest >250 is low to nil (often far less than 1%), so for example, on the Boreal Plains– Upland graphs there is no forest >250 visible. There are a number of reasons why there is little or no forests >250 remaining in these areas (which are discussed in the report body).

The pattern for forests >140 years is somewhat different – with more variability across different Landscape Units.

- For the drier NDUs there is a wide range in the amount of forest >140 years remaining in a Landscape Unit, from very little to more than predicted for each LU. However, in all these NDUs the majority of the Landscape Units are below the bottom of the natural range for forests >140 years;

- For the large landscape units in the centre of the study area (in Boreal Plains-Upland), the amount of forest >140 years is very low (often less than 10% and down to 1% for some Landscape Units), and typically below the bottom of the natural range for almost all the Landscape Units in this NDU;

- In the Northern Boreal Mountains NDU, three of four Landscape Units are at the upper end of the predicted natural range for >140.

Considering Forest Conversion: There is relatively little forest conversion in the RSEA study area, but where forest conversion has occurred its contribution to cumulative effects can be significant. In the Lower Beatton, Kiskatinaw, Dawson Creek, Blueberry and Kobes Landscape Units, there is a sufficiently large area of conversion to agricultural / rural that the percent or total area converted results in a more degraded picture of the percent old forest remaining. Ecosystem conversion is clearly important in a cumulative effects context.

Analysis: How much potentially Functional Old Forest Remains?

There is a large literature that discusses the different types of effects that can arise from loss of mature and old forest in the landscape. The direct effect of forest loss is that the total area of older forest declines. In addition, there are also secondary effects which are often referred to as fragmentation or edge effects. Fragmenting the forest causes the patch size of the remaining forest to be reduced, and

[5] Landscape Units are management units that were originally defined by the Ministry of Forests for applying and reporting out on landscape level targets, such as old forest targets (Province of BC 1995).

small patches have more 'edge' than large patches. "Edge effects" are created when the conditions adjacent to a forest travel some distance into the forest patch – often discussed as the Zone of Influence. The concept of interior forest conditions relates to forest that is far enough from an edge that the forest is unaffected by the 'edge effect'. The exact parameters that would be used to determine a single definition of functional forest is therefore complex, and is also value-specific. For example, what may constitute functional forest for a lichen would be different from functional forest seen through the eyes of a caribou or grizzly bear, or to a person undertaking a particular cultural practice.

In this analysis, we provide a range of options for defining the condition or 'potential functional old' forest by asking how much of the old forest is more than a certain distance away from an edge, based on buffering anthropogenic disturbances[6] by a range of widths (20, 50, 100 and 250 m wide). Note that seismic lines are not included as a disturbance in the functional forest analysis.

In the vast majority of Landscape Units, the amount of potentially functional forest is lower, or much lower, than the amount of old forest apparent in the base inventory. In some cases, the amount of reduction can be sufficient to move an Landscape Unit that appears to have old forest within the natural range, to an amount of potentially functional forest much lower than the natural range. These patterns are most significant in parts of the RSEA study area where disturbance footprint is the highest – for example, in the Boreal Plains-Upland NDU. Here, in the southern portion of the study area, the amount of old forest is already very low, but the vast majority of that forest is located less than 250m, and often less than 50 or 20m from a disturbance. This obviously has a wide variety of potential implications – which will be value and ecosystem specific.

The functional forest analysis could be refined in many ways (see Discussion), however, all areas where the amount of apparently functional forest is considerably less than that suggested by just forest data alone should be cause for concern with respect to cumulative effects management and old forest values. Looking only at the amount of old forest, and ignoring the potential condition of the remaining forest is clearly inaccurate for many, if not most, values. The importance of patch size, interior forest conditions, edge effects, microclimate changes and human disturbance are all known to impact many values in the forest. This analysis therefore provides some insight into how misleading it is to consider only the total amount of old forest present, without considering its condition.

Management Implications

This report defines old forest using single-age based thresholds (>140 and >250 years), as this definition allowed a clear comparison with the natural range as outlined by Delong (2011). This focus on older forests does not mean that other ages of forest are not important – for example, a next step identified by the Biodiversity Working Group was to understand the amount of natural early seral forest (e.g. unsalvaged burned areas), as these areas are also important for maintaining biodiversity values. In addition, for some Northeast ecosystems, old forests have operationally included younger deciduous forests >100 years (FLRNRO pers. comm.). This may be appropriate in some ecosystems but where this approach is taken, it is important to ensure that the retention targets used are generated using the same cut-off as the age of old contributing to that target. In addition, it is important to ensure that older

[6] The RSEA project team developed a composite disturbance layer which is to be used by all RSEA projects and was used in this analysis. For this analysis seismic lines were not included. Seismic lines can affect the potential functionality of the remaining forest – but due to the potential range of impacts of different types of seismic lines and the paucity of good data available, they were not included in this analysis.

age-classes are not overlooked and potentially lost from the landscape as a result of including younger forest as part of the old forest retention strategy.

This analysis does not differentiate old forest on the basis of fine-scale ecosystem variability such as site series or productivity. This is a significant gap since the values provided by old forest on a range of site types can vary extensively. In the management context, managing to maintain the full range of ecosystems within broader old forest categories will be important.

It is understood in BC that the further from the natural range of old forest, the higher the risk to biodiversity and all the other values that are dependent upon it (Province of BC 1995; Bunnell 1995). This report highlights where the risks to old forest and biodiversity are likely the highest, and provides information on where action is needed to start to reverse these trends for the Province's primary ecosystem and biodiversity management tool – old forest.

INTRODUCTION

Old forests or 'old growth' forests as they are often termed – are generally described as the forests that occur late in the successional cycle of a particular ecosystem. Old forests provide a wide diversity of individual values (e.g. unique stand structures), habitat for a diversity of species as well as unique species such as caribou, and specific processes (e.g. microclimate temperature regulation). Since the late 1980s a large body of literature has been developed on the importance of, and types of characteristics that define and characterise old forests in different ecosystems (for example: Franklin 1989, Franklin and Spies 1991, Hopwood 1991, MacKinnon 1998, Kneeshaw and Burton 1998, Holt et al. 1999, Burton et al. 1999, Braumandl and Holt 2000).

Definitions of old forest in the literature include those based on stand development (e.g. Oliver and Larson 1990); stand structural attributes such as larger older trees, complex canopy, larger snags and coarse woody debris, hummocky topography, lichens (Spies and Franklin 1988; Kneeshaw and Burton 1998; Braumandl and Holt 2000); or more simple age-based thresholds (e.g. Province of BC 1995; 1999). Age-based thresholds are used by the province because it is possible to identify 'old forest' for management purposes from existing maps, though many reports identify the need to also consider the functional attributes of forests managed for conservation (e.g. Kneeshaw and Burton 1998, Kremsater and Holt 2019 and many others). [See Limitations section of this report].

The use of old forest as a coarse filter management approach to maintain forest biodiversity has been embraced in BC and elsewhere. This approach was driven by acknowledgement that managers generally lack detailed knowledge of the very many individual values associated with forested ecosystems, but also acknowledges the practical difficulty of managing for individual species and attributes across large landscapes (e.g. Hunter 1991; Noss and Cooperider 1994; Province of BC 1995). For that reason, in the 1980s, the Province of BC adopted the use of a coarse filter approach based on emulation of 'natural conditions' as the model for management of forest ecosystems. This shift in management model, and has been the basis for land use planning and management, ecosystem-based management in the Great Bear Rainforest, and cumulative effects technical working groups since that time. The natural disturbance model approach is based on the notion that the closer an ecosystem is to its natural condition, the lower the risk, or the higher the probability that ecological functioning will continue.

Forest biodiversity and old Forest were identified directly, or indirectly, as a Value Component or useful indicator by all the First Nations at the RSEA table, and the RSEA Project Team supported an analysis of old forest current condition as an indicator for forest biodiversity for the RSEA study area. The Scope of Work created by the RSEA Working Group, and analysis is similarly based on the emulation of natural disturbance approach used by the BC Cumulative Effects Framework.

The objectives of this report are to:

- Assess the **amount of old forest** in the study area, compared to natural baselines
- Assess the **potential functionality of the old forest**, by examining how much old forest remains when non-natural disturbances are buffered by different widths. This examines the potential effects of fragmentation or edge effects on the remaining forest.

METHODS

DEFINING OLD FOREST

In forest management in BC, the Province uses age class definitions to identify different stages of successional development of forest (early, mid, mature and old). Typically, this is a single age threshold based on coniferous forest stands. For ecosystems that are defined by relatively frequent stand replacing events, the age of old forest is typically defined as forest greater than 140 years in age. For forest types defined by infrequent stand replacing events, the age of old is typically identified as stands greater than 250 years in age[7].

In Northeast BC, the age threshold of >140 years is typically used to define 'old', and for specific ecosystems, a more complex age class threshold has been used to reflect the variability in successional patterns observed for coniferous versus deciduous leading forest stands. For example, a more complex definition of old forest that has been used for some ecosystems is:

- coniferous forests greater than 140 years, deciduous stands greater than 100 years, and mixedwood forests greater than 120 years (e.g. Province of BC Undated[8]).

Although useful for management direction, this species-led definition did not lend itself to a clear analysis based on the definitions of 'natural' provided by Delong (1998; 2011), because the information given on expected natural levels of old forest does not apply to mixed aged definitions (i.e. it simply uses a single age to define old, rather than multiple ages). As a result, the analysis presented in this report is based on a single stand age (i.e. forests > 250 and forests >140 as provided by Delong) and does not differentiate between coniferous and deciduous-leading stand ages. This decision does not affect the trends in results found in this analysis since the benchmark of how much forest is expected naturally varies with the age of forest in question. For example, if we used a definition of >100 as forest of interest, the natural benchmark would also increase (because more forest >100 years are expected). For example, in the Boreal Plains NDU 17 – 33% of forests are expected >140 years while 28 – 48% of forests are expected >100 years under natural conditions.

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[7] https://www.for.gov.bc.ca/hfd/pubs/docs/mr/mr112/page14.htm

[8] Dawson Creek Timber Supply Area: Old Growth Management Project. Undated. Available at: https://www.for.gov.bc.ca/tasb/slrp/lrmp/fortstjohn/dawson_creek/docs/dc_old_growth_background.pdf

This analysis presents information on two categories for old forest: Forests >250 years in age, and Forests >140 years in age. The relevance of different ages of old forest varies based on the natural disturbance regime that defines different ecosystems. In wetter ecosystems we expect more older forest (because these forests are naturally disturbed less often) and in drier systems, we expect less very old forest due to the higher frequency of fire and other stand-replacing events. However, the patterns for both age-class groups of forest are relevant to understand in all ecosystems. Where very old forest is the dominant natural age class, it reflects the matrix of the landscape. Where very old forest is less naturally common, it becomes a rare stand type that provides particular characteristics (e.g. very old and / or large trees), or it exists predominantly in certain ecosystem types (e.g. wetter riparian systems).

Compiling Data on Old Forest

Data were compiled by ECORA. A data dictionary is available that outlines what layers were used to define the layers used in this analysis. (Summary in Appendix 1).

The summary statistics were completed by following a detailed methodology. This involved creating a resultant dataset using ESRI ArcMap software to overlay 19 key datasets (Shown in Appendix 1). The resultant dataset was input into a customized script which standardized and automated the calculation of numerous old forest parameters (summarized in Appendix 1), which generated an excel spreadsheet summarizing various old forest characteristics. To compliment these summary statistics, numerous maps were created to illustrate old forest characteristics for the study area, First Nation areas, and each of the 8 Natural Disturbance Units contained within the area of interest. A complete definition of all datasets and queries used to calculate old forest summary statistics is provided within a manually created data dictionary spreadsheet.

Defining the Baseline

Understanding natural disturbance patterns – i.e. events that alter the age of forests such as fires, insects, wind and disease - allows an estimation of how much forest greater than any particular age are expected to be present on the landscape on average, over time. The relationship between age of forest, fire return rate and how much forest is expected on the landbase at any one time is shown in Figure 1.

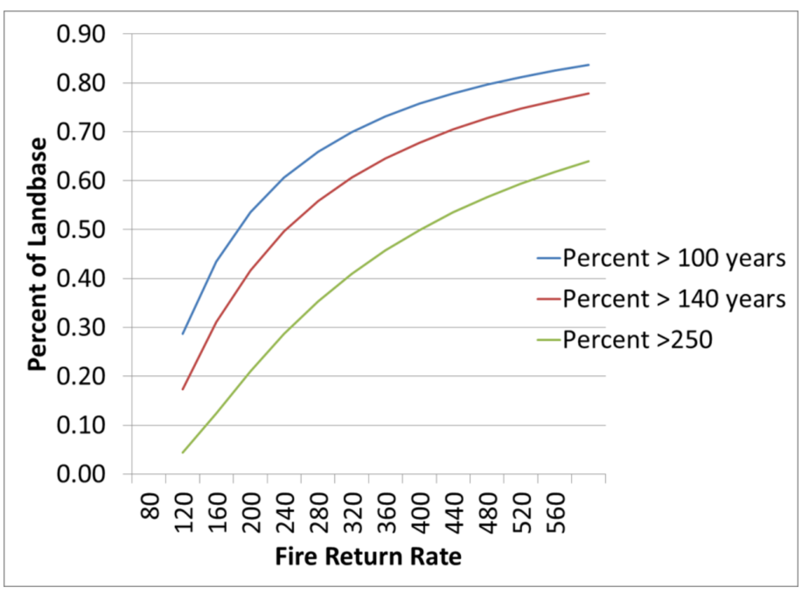


Figure 1. The percent of the landbase (vertical axis) to be found in different age classes can be estimated based on the fire return rate in years (horizontal axis).

BC's regional ecologist Craig Delong (1998; 2011) identified Natural Disturbance Units (NDU) for the northeast of BC. He defined NDUs based on areas characterised by a similar disturbance regime, and he identified 9 NDUs relevant to the RSEA Study Area – the largest unit is the boreal Plains-Upland (Figure 2).

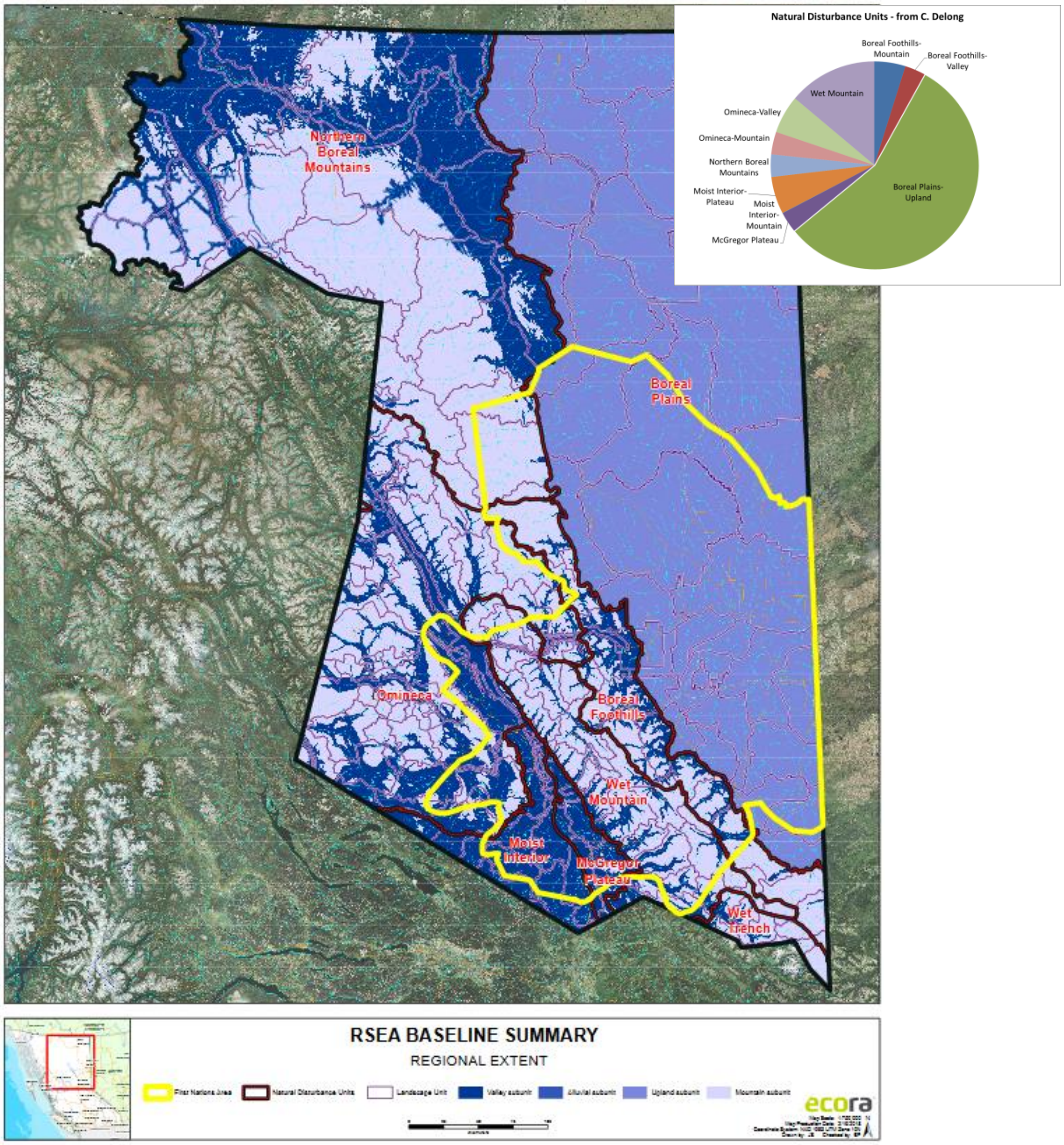


Figure 2. Distribution of Natural Disturbance Units within the RSEA study area (Delong 2011).

Delong provides data on the 'natural range' of forest in different age classes expected in each NDU under natural conditions. (Table 3 from Delong 2011; Appendix 2 this report). This 'range of natural', or 'natural range of variability (NRV), provides the appropriate baseline for determining the condition of the landscape, and each of the Results figures and maps are provided in relation to the NRV defined by Delong for that area of the landbase.

The geographic distribution of the Natural Disturbance Units is shown in the adjacent figure. The yellow outline highlights the composite study area of the NE RSEA Project.

In this report, this 'baseline' of natural levels of old forest is presented in a number of different ways (shown in Figure 3):

- as the midpoint of the range (for the NDU level coarse analysis)
- as the lower and upper bound for forests >140 and >250 (in the landscape unit/ NDU graphs)
- as four categories – less than the lower bound, bottom end of the range, top end of the range, and above the upper bound – for the summary figures on risk by watershed / NDU.

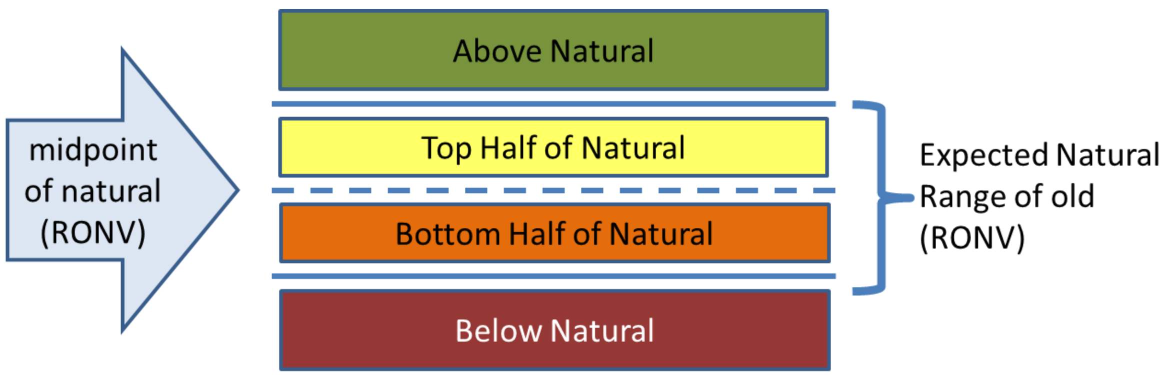


Figure 3. Various approaches to defining the natural baseline used in this report. (See Table 1, and Appendix 3 for summary of relevant numbers by NDU). The 'midpoint of natural' represents the average amount of expected old forest.

DEFINING FUNCTIONAL FORESTS

As outlined above, the amount of old forest on the landscape today can be compared with natural levels, and this provides one indicator of the current state of the landscape.

The RSEA Biodiversity Working Group also identified that it is also important to assess the condition of that remaining old forest. Forest Condition (or functional forest) can be assessed in a wide variety of ways, with potential attributes including patch size, interior forest, presence of invasive species, presence of physical or other disturbance. The exact parameters that would be used to determine a single definition of functional forest is therefore complex, and is also value-specific.

There is a large literature that discusses the different types of effects that can arise from loss of mature and old forest in the landscape (e.g. Findlay and Houlahan 1997; Forman and Alexander 1998; Trombulak and Frissell 2000; Fahrig and Rytwinski 2009). A direct effect from forest loss is that the total area of older forest declines – and this 'How Much Old Forest Remains' question is analysed in the main body of the old growth report. However, there are also secondary effects of development (harvest / roads / seismic programs etc.), which are often referred to as fragmentation or edge effects. Fragmenting the forest with cutblocks, roads, pipelines etc. causes the patch size of the remaining forest to be reduced, and small patches have more 'edge' than large patches. "Edge effects" are created when the conditions adjacent to a forest travel some distance into the forest patch. The concept of interior forest conditions relates to forest that is far enough from an edge that the forest is unaffected by the 'edge effect'.

The types of processes that are affected by edge effects include:

a) Effects on terrestrial species and habitat impacts including:
    - increased direct and indirect mortality for animals,
    - loss of suitable habitat,
    - degradation of habitat (e.g. avoidance of otherwise suitable habitat due to disturbance or edge effects such as micro-climate change),
    - loss of important structures such as wildlife trees – which are critical habitat for a large number of species - due to WorkSafe requirements (this effect can be very extensive in some areas),
    - barriers that prevent movement (due to avoidance of roads or physical barriers), and
    - fragmentation of remaining habitat – resulting in small patch sizes of remaining habitat and potential loss of connectivity across landscapes.

b) Hydrologic impacts such as
    - effects on waterflow,
    - increased sedimentation levels,
    - loss of hydrologic functions due to change or loss of stream pattern, and
    - barriers that prevent movement of species (e.g. for fish passage due to culverts),

c) Noise and pollution effects,

d) Invasive species incursions and movements

e) Dust effects on vegetation,

f) Effects on natural processes such as fire or predator prey dynamics (e.g. changing wolf movement patterns in a landscape and changing natural predation patterns), and natural connectivity of ecosystems.

The distance that fragmentation effects or edge effects travel into the forest varies with many factors, including the type of impact (e.g. microclimate, hunting pressure, light levels, dust etc.), and the species of interest. For example, we expect and assume variable effects of edges on grizzly bears, moose, regenerating spruce trees, mushroom species, beetles or caribou. See Figure 4 for some examples compiled from the literature.

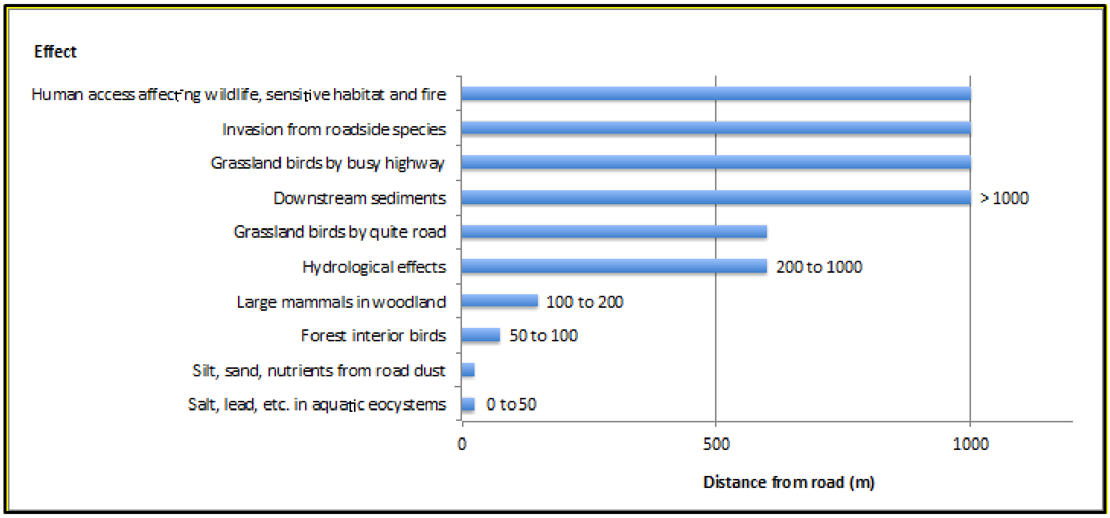


Figure 4. The distance that road effects 'filter' into adjacent areas differs for different values. Some general patterns are provided in the figure (above) for different types of effects (Figure from Daust and Morgan 2014).

How the functional forest analysis is undertaken in this work

This analysis asks the question – if the disturbance layer is overlaid over forest cover information, and then buffered to different distances (20, 50, 100 and 250 m) how much old forest remains unaffected by the different widths of buffer. Note that seismic lines were not included in the analysis which reflects the paucity of reliable data on seismic, since some seismic lines function similarly to roads whereas others are narrower and would have lower effect.

This analysis does not assume that the forest outside the buffer area (i.e. that is counted as potentially functional forest) has interior forest conditions – it just 'removes' forest from the tally that is within the length of the buffer.

The GIS images below demonstrate how the functional forest analysis works. The results from the 'how much' analysis above reflects the old forest shown in the top left image. As disturbances are buffered to different widths, the functional forest analysis counts the amount of remaining forest (see three images with increasing buffers). It does not suggest that the amount of forest reported on is actually functional (see bottom right – many small areas with no interior forest condition), but it does remove forest that may not be functional because of the effects of disturbance. More accurately the analysis reflects how much forest is removed because it is within the "buffer shadow".

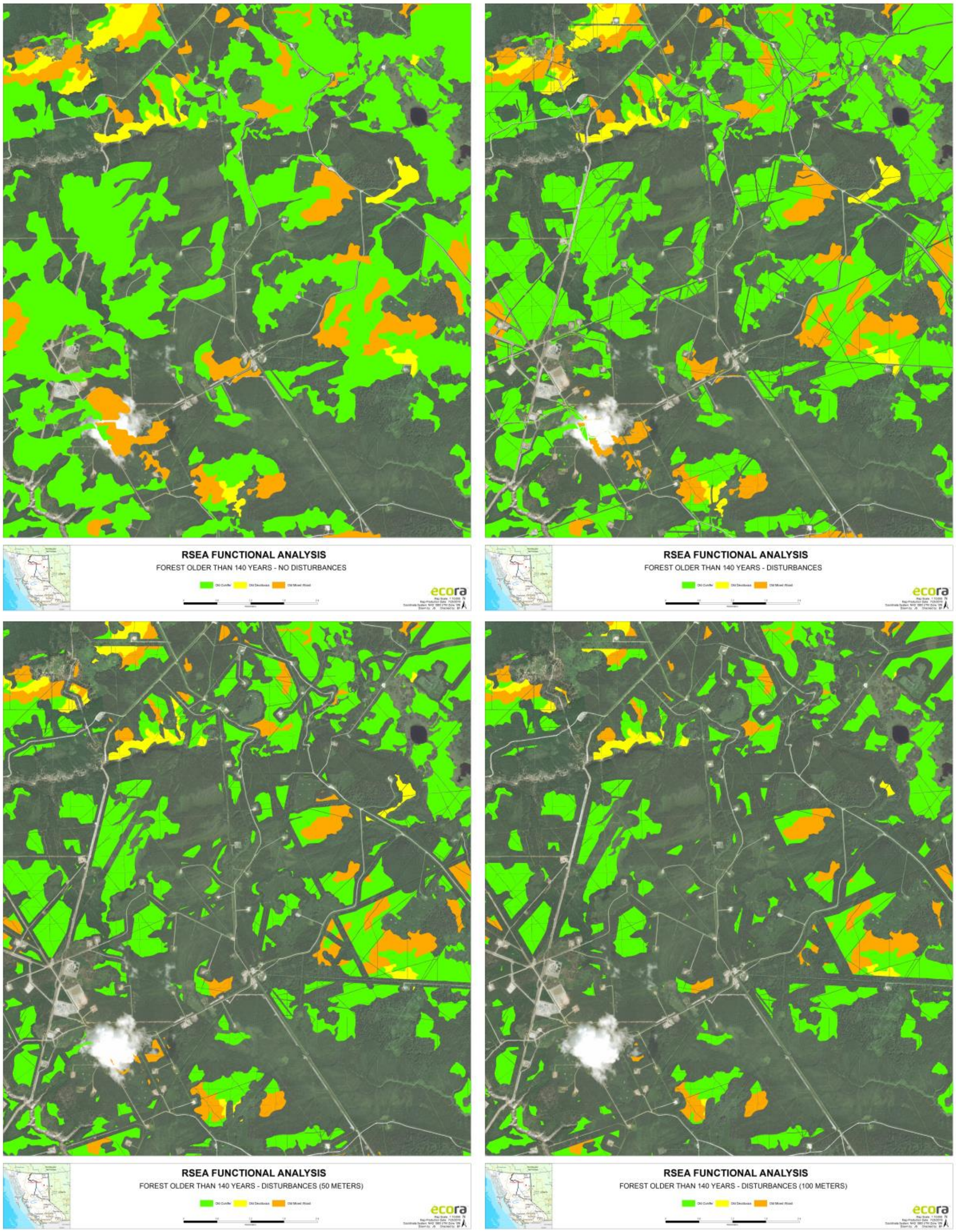


Figure 5. Old forests intersected with the disturbance layer. Top Left – old forest from VRI data set with no disturbance. Top Right - old forest with the RSEA disturbance layer overlaid. Bottom Left – disturbance layer buffered by 50m, and 100m (Bottom Right).

Scales of Reporting

Results are presented:

- **by Natural Disturbance Units**. This is a coarse level of analysis that is more appropriate for some NDUs than others, due to the very wide range in size of area associated within the different units. For example, the Boreal Plains NDU is (in total) ~8 million ha, with ~4.1 million ha in this study area. Reporting out on this massive area may allow important trends at smaller scales to be masked, and is a scale that is irrelevant to most species.

- **By Landscape Units within Natural Disturbance Units.** Landscape Units are management units that were originally defined by the Ministry of Forests for applying and reporting out on landscape level targets, such as old forest targets (Province of BC 1995). They were generally defined based on ecological factors such as watershed boundaries, but may not always encompass single watersheds. There are 86 Landscape Units that fall within the study area, of which 4 are less than 1000ha (i.e. slivers). On average, the remaining units are around 100,000ha but with some significant large outliners (such as the Blueberry, Tommy Lakes, Lower Beatton and Trutch Landscape Units which are 730,000, 500,000, 500,000 and 340,000 ha respectively).

Watersheds, or OGC watersheds would be an alternate 'midscale' unit analogous to the Landscape Unit, but OGC watersheds (which were included in the excel dataset) do not cover the entire RSEA study area so could not be used in this reporting.

Defining Risk

In the Results, the percent old forest is presented in relation to the expected natural range of old forest on the landscape. Because old forest is the coarse filter mechanisms for protecting general biodiversity on the landscape, as the amount of old forest gets further away from the natural level, this increases the risk to ecological integrity in the ecosystem (Province of BC 1995). However, this report does not suggest specific risk thresholds that make risk high, or low. However, the Interpretation section in the Discussion provides some insight into the factors that may lead to statements of absolute risk.

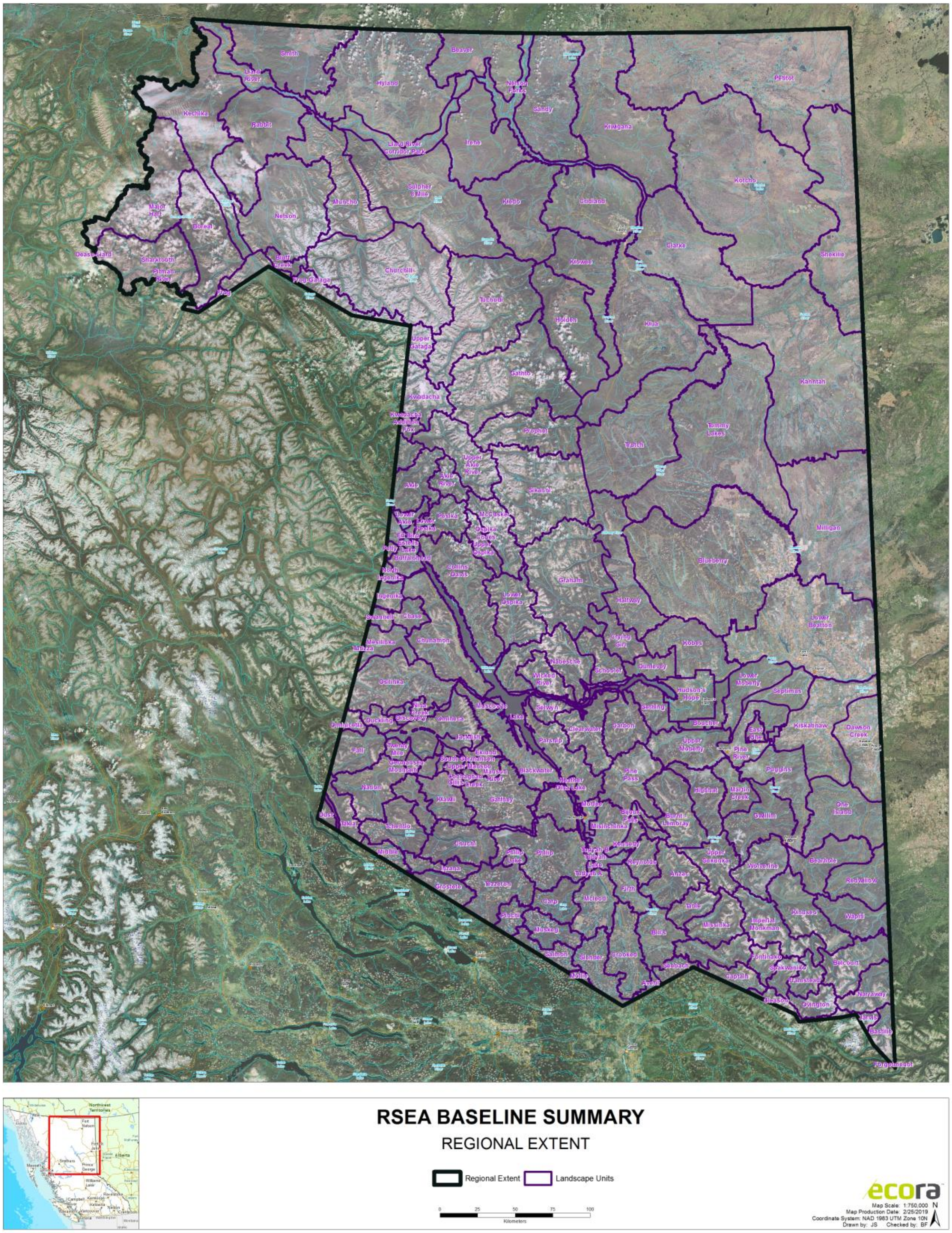


Figure 6. Landscape units within the RSEA region. This area is larger than the study area reported on in this analysis (see Figure 2 for study area boundary). (A zoomable version is available on the sharepoint site)

Results: Understanding the Landbase

Definitions of Forest Landbase

A first draft old forest analysis (Oct 2017) was undertaken on a definition of the 'forest' that did not differentiate on the basis of the commercial viability of that forest, only that it was defined by a tree dominated ecosystem (i.e. was not 'non-forest, or a water dominated ecosystem). RSEA Working Group members requested that additional landbase definitions were included, in particular the Crown Forested Landbase (CFLB), and the Timber Harvesting Landbase (THLB). The CFLB is a smaller subset of the ecological 'forest landbase' and the THLB is a further subset of the CFLB – and describes areas where harvesting is more likely, although harvesting may occur anywhere in the CFLB unless an area is explicitly constrained (e.g. is a Protected Area).

Sensitivity analyses were run on all three of these different ways of describing the forest, and a summary is provided in Figure 7. Figure 7 tallies the number of landscape units within each Natural Disturbance Type where the amount of old forest in the landscape unit is below, above, or within RONV, for each of the three definitions of forest.

Overall, the risk category of each landscape unit in relation to natural are very similar, irrespective of which landbase definition is used. There are a few minor changes in landscape unit risk – where individual landscape units change which risk category they land in. For example, as expected, the THLB tends to have higher risk (e.g. see Boreal Plains example in Figure 7), but the results are very dependent on what percent of the CFLB is THLB, and how the distribution of CFLB and THLB differs across different Landscape Units.

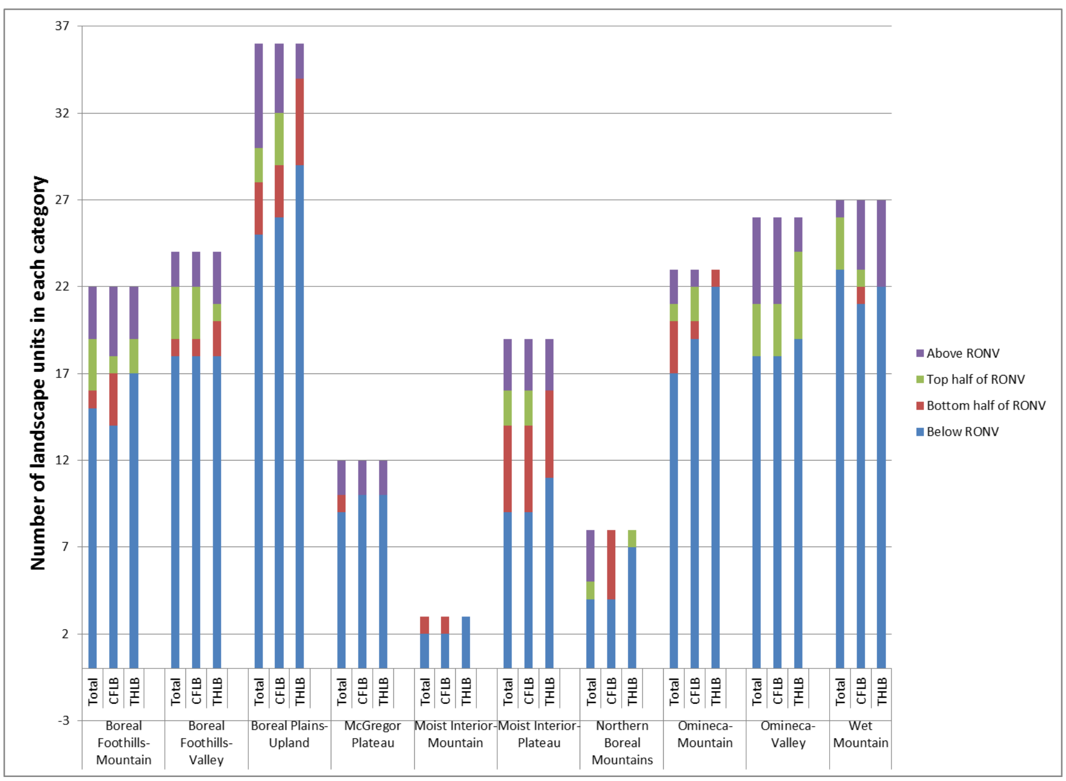


Figure 7. Distribution of landscape units in each risk category – for three overlapping parts of the landscape (Total Forest, CFLB and THLB) for all the NDUs.

As a result of the information shown in this sensitivity analysis, the remainder of the results are provided for the whole forest landbase (as defined by ECORA script, see Appendix 1), and we do not repeat the very similar results for the CFLB and THLB separately.

Regional Patterns

Figure 8 shows the amount of area associated with each Natural Disturbance Unit, and what types of broad ecosystems and land use designations are present there. Most of the NDUs are primarily 'forested', with less than 10% non-forest identified in each. In addition, there is both private land (non-ALR) and Agricultural Land Reserve (ALR) primarily in the Boreal Plains-Upland NDU.

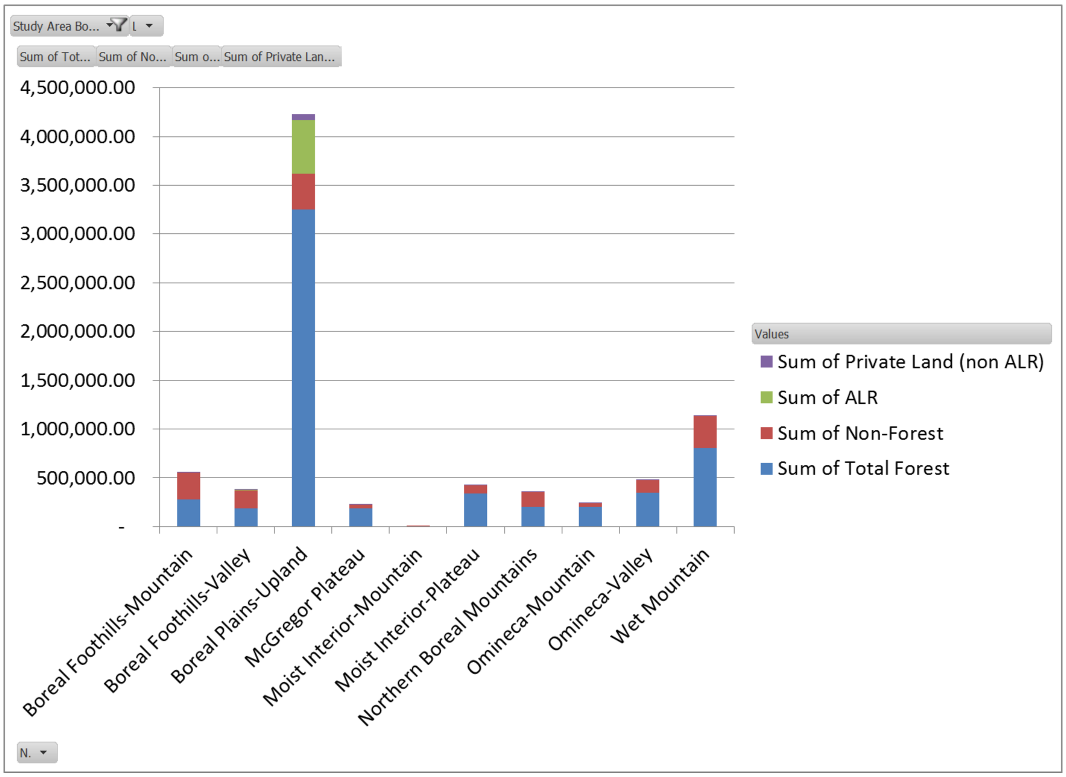


Figure 8. Size of the Natural Disturbance Units within the RSEA study area, and their composition.

Most of the NDUs, within the study area, are similarly sized (~less than 1,000,000ha), with the exception of the disproportionately large Boreal Plains-Upland NDU which is ~4.1 million ha in the study area and covers more than 8 million ha in total.

At this scale, there is little or no private and ALR lands in any of the NDUs, with the exception of the Boreal Plains-Upland, which has both private land (non-ALR) and ALR.

Within the Boreal Plains- Upland NDU, the distribution of private and ALR land is primarily located in a limited number of locations – in particular Dawson Creek, Kiskatinaw, Blueberry, Lower Beatton and with minor amounts in other Landscape Units (Figure 9).

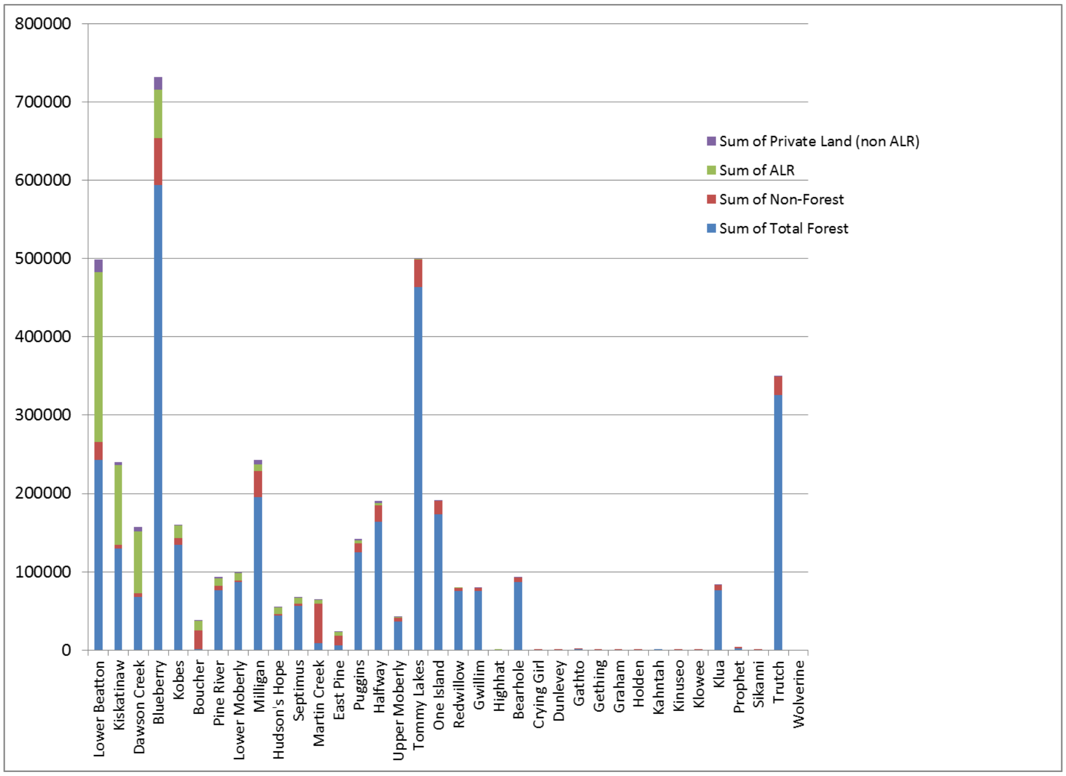


Figure 9. Landscape Units within the Boreal Plains – Upland NDU, showing Total Forest area, non-forest area, Agricultural Land Reserve Area and Private Land (non-ALR) area). Landscape Units are shown in order of the total area of forest land conversion.

RELEVANCE OF ECOSYSTEM CONVERSION TO UNDERSTANDING PATTERNS OF OLD FOREST

Ecosystem conversion is relevant to any calculation of how much old forest remains in an area, as it is important not to fall into the 'sliding baseline' trap of changing the denominator as land is converted, as shown in the example below:

Watershed is 100,000 ha – it is all forested

"20% old growth" means there are **20,000** ha of old forest available to provide habitat and old forest conditions.

Watershed is 100,000 ha – it is 40% forest and 60% agriculture

Forest – 40,000ha

20% old forest means there are **8000** ha of old forest to provide habitat and old forest conditions.

Agriculture – 60,000ha

For the majority of this study area, land conversion is relatively minor or not relevant. But for a limited number of Landscape Units in the study area, the amount of private and ALR land is fairly significant (Figure 7). Table 2 below summarises data for the Landscape Units that may be affected by the sliding baseline denominator issue, within the Boreal Plains – Upland NDU. Table 2 compares percent old forest calculations for the potentially affected Landscape Units, including and not including the effects of conversion to agricultural land.

For forests >250, the percent of very old forest does not change depending on the denominator used (i.e. conversion or not), simply because there is little or none of this age class of forest remaining. However, the percent old forest >140 years in age does change depending on whether the whole landbase or only the remaining forested landbase denominator is used. The percent change is small (e.g. 1.3 to 2.6% for the Lower Beatton – highlighted in blue in Table 2), however this reflects an absolute difference of about twice as much old forest based on the different denominators. For other Landscape Units such as Blueberry, the total percent changes relatively little (10.2 to 9%) but because the watershed itself is so large (~732,000ha in size) the absolute area of converted land is large (~78,000ha). The biological effect of that area of land conversion may not well reflect the actual ecological implication suggested by the apparently small percent change metric.

The remaining analysis in this report calculates percent old forest using the full denominator (forest + ALR + Private). As outlined above, the use of this denominator only affects the calculation of percent old forest in the limited number of watersheds shown in Table 2. And for most of these, there is a percent change difference, but this doesn’t generally affect which broad category of risk the Landscape Unit lands in. However, there is clearly an implication to biodiversity and old forest of ecosystem conversion and this should be accounted for in any old forest cumulative effects assessment.

Table 1. The difference in percent old forest based on including land converted into private or ALR. The last four columns show the differences in the calculation when only the 'forest' is used as the denominator (*denom* in the table), versus when the Forest + Private land + ALR are used as the denominator. Comparison results are highlighted in grey (for forests >250 years) and in blue (for forests > 140 years).

	Forest	Non-Forest	ALR	Private (non ALR)	Forest + Private + ALR	Area Forest >250	Area Forest >140	% Forest >250		% Forest >140	
LU		Non-Forest	ALR	Private Land (non ALR)	For + Private + ALR	Forest>250	Forest>140	Forest only denom	Full landbase Denom	Forest only denom	Full Landbase Denom
Lower Beatton	243,010	22,536	217,493	16,318	476,822	2	6,420	0.0	0.0	2.6	1.3
Kiskatinaw	129,714	5,053	101,440	4,244	235,398	-	1,518	-	-	1.2	0.6
Dawson Creek	68,067	4,364	79,041	6,010	153,117	2	805	0.0	0.0	1.2	0.5
Blueberry	593,649	60,101	61,758	16,880	672,288	63	60,404	0.0	0.0	10.2	9.0
Kobes	134,483	8,682	15,800	741	151,024	17	26,874	0.0	0.0	20.0	17.8
Pine River	76,200	5,922	9,384	1,594	87,178	-	9,534	-	-	12.5	10.9
Lower Moberly	86,622	2,467	9,144	102	95,868	-	2,459	-	-	2.8	2.6
Milligan	195,756	32,832	8,847	5,284	209,886	3	19,694	0.0	0.0	10.1	9.4
Hudson's Hope	43,795	1,840	8,535	181	52,511	-	3,647	-	-	8.3	6.9
Septimus	56,365	2,829	8,047	165	64,577	-	1,767	-	-	3.1	2.7
Halfway	164,072	20,501	3,273	3,035	170,380	325	57,096	0.2	0.2	34.8	33.5

Results: Amount of Old Forest

Amount of Old Forest: summarised by NDU

The NDUs are very different in size and distribution. Boreal Plains- Upland unit is the largest at ~ 4.1 million ha in size (within the RSEA study area only), whereas the Boreal Foothills – Valley is less than 200,000ha. The ecological relevance of summing at these very different areal extents is very different. From an ecological or cultural perspective having particular values, or functional landscapes 'close to where you need them' is most relevant.

Historically, over time, we would expect natural resources to move across the landscape based on the natural disturbance regimes (e.g. a local fire would alter the location of forest types) over the landscape. On average, old forests would be expected to the distributed relatively evenly across the broad NDUs. As a result, summing the amount of old forest by NDU for the largest of the NDUs shows general patterns, but is not very useful in understanding trends in the availability of resources at a more human or animal scale (e.g. smaller watersheds or smaller landscape units). These data rolled-up by NDU are provided here since they show overall patterns, and also because this is the scale used to summarise information in provincial management tools (e.g. the OGC Area-Based Analysis (ABA)).

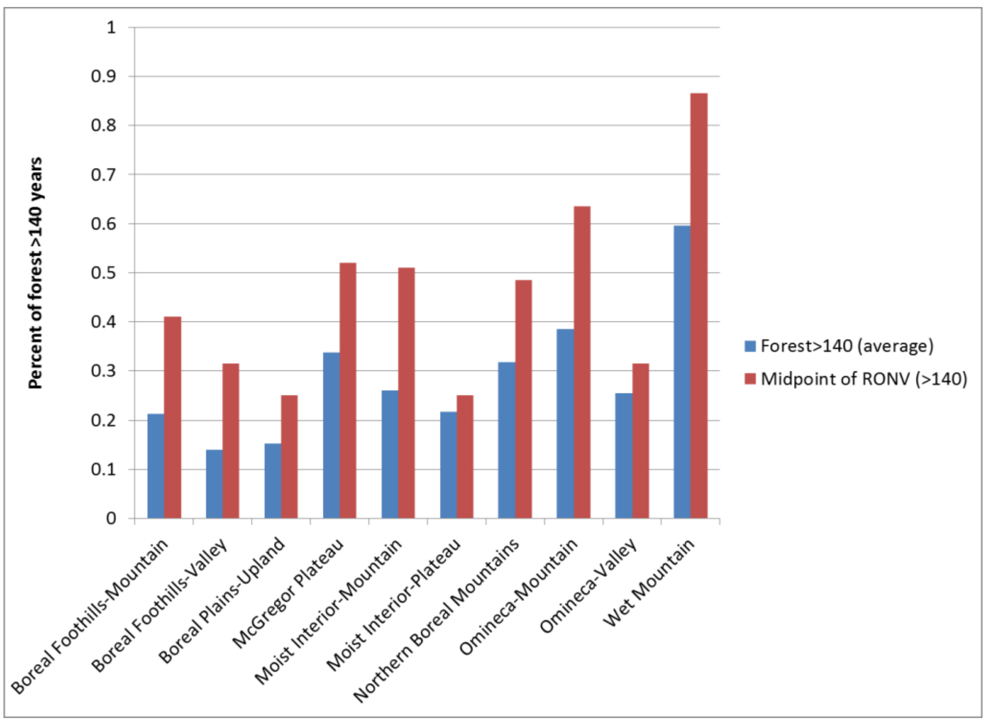


Figure 10. The percent old forest >140 years in age averaged for the NDU. Compares the current condition (% old forest today), with the mid-point of the natural range (from Delong 2011).

In all NDUs, the amount of forest >140 years of age is less than the midpoint of the natural range. In most cases this different is large, with the exception of the Moist Interior-plateau, and Omineca-Valley subunits where the differences are relatively small (Figure 10).

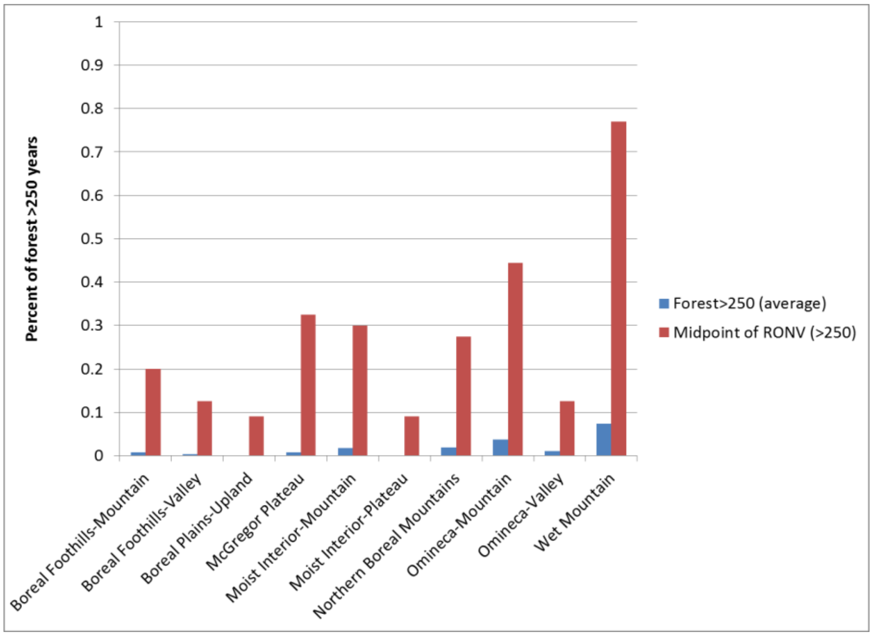


Figure 11. The Percent old forest >250 years in age averaged for the NDU. Compares the current condition (% forest >250 years today), with the mid-point of the natural range (from Delong 2011).

In all NDUs, the amount of forest >250 years of age is significantly less than the midpoint of the natural range (Figure 11). For most of the NDUs, there is little or no old forest remaining at all (e.g. the largest unit the Boreal Plains – Upland has less than 0.0003% forest >250 years in age, compared with 9% expected naturally; most of the other NDU's have a similarly very low percent of very old forest compared to the expected natural level).

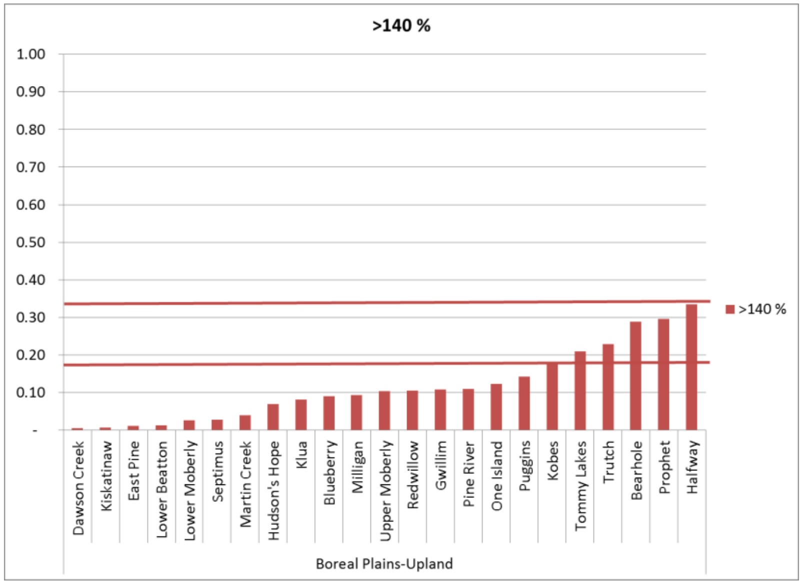
Amount of Old Forest: Summarised by landscape unit within NDU

The following pages show results for the current condition of Landscape Units within Natural disturbance Units, for forests >140 and >250 years in age. The graphs for Natural Disturbance Units are provided side-by-side for forests >140 and forests >250. The name of the NDU is provided on each graph, and all the graphs show the following information (Figures 12):

The natural range from Delong is shown in the horizontal bars on each graph. Note that only Landscape Units with greater than 1000ha of area are shown, as some 'slivers or small areas are created from the intersection between the study area boundary, Landscape Units and NDUs.

From the graphs, you can see the overall trend of percent old forest within each NDU, in relation to the natural range.

Figures 12. ***The percent of old forest in each landscape unit, within each NDU. On all the graphs, for each Landscape Unit (on the horizontal axis), the percent old forest >140 is shown in red and percent old forest >250 is shown in blue (on the vertical axis).***


>140 %
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Dawson Creek
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East Pine
Lower Beatton
Lower Moberly
Septimus
Martin Creek
Hudson's Hope
Klua
Blueberry
Milligan
Upper Moberly
Redwillow
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Pine River
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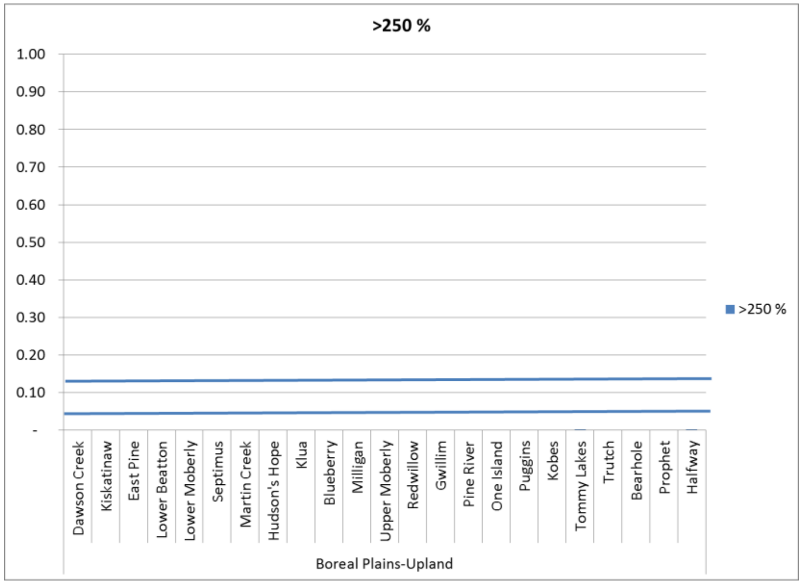
Puggins
Kobes
Tommy Lakes
Trutch
Bearhole
Prophet
Halfway
Boreal Plains-Upland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Lower Moberly
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Blueberry
Milligan
Upper Moberly
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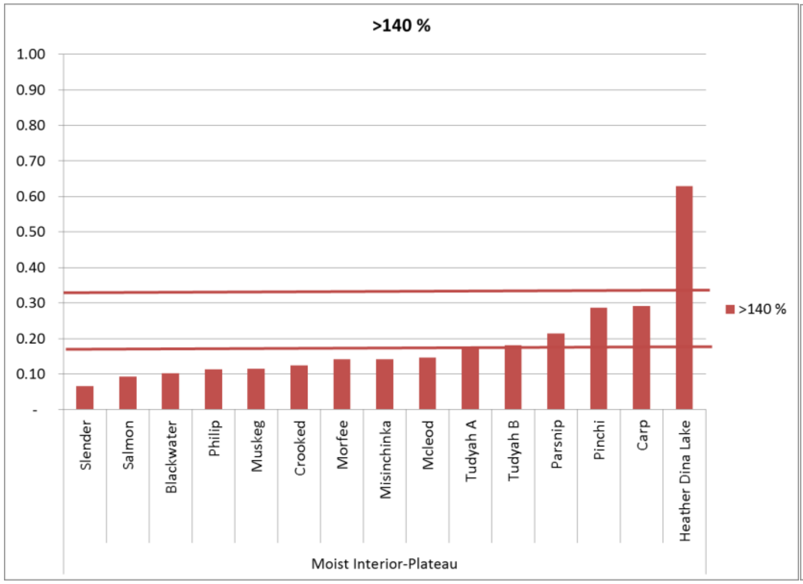
Boreal Plains-Upland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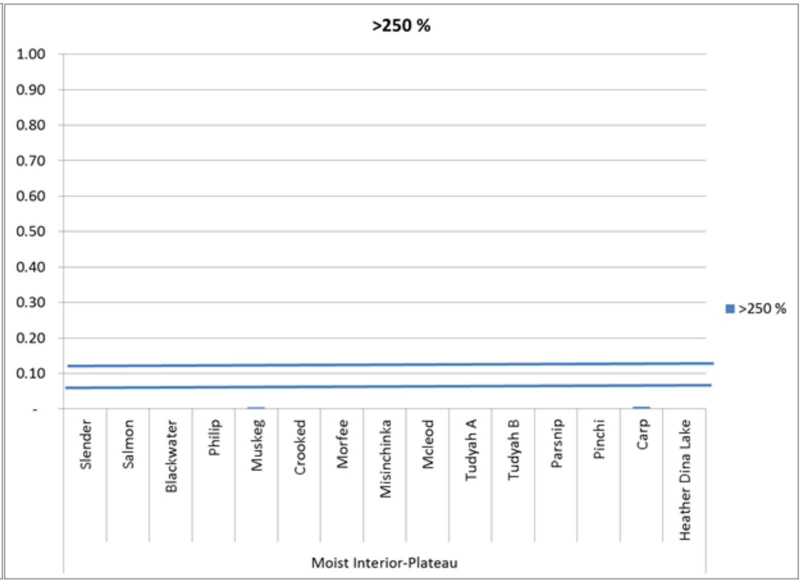
Moist Interior-Plateau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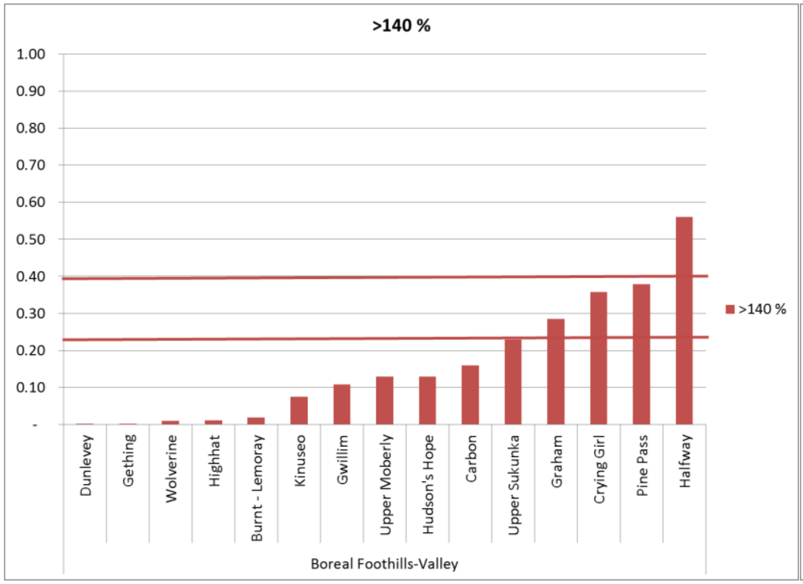
Moist Interior-Plateau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Crying Girl
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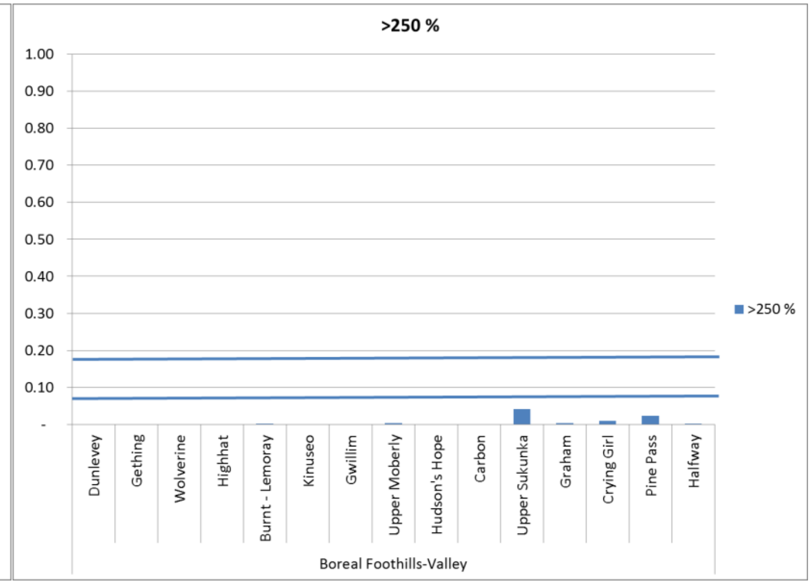
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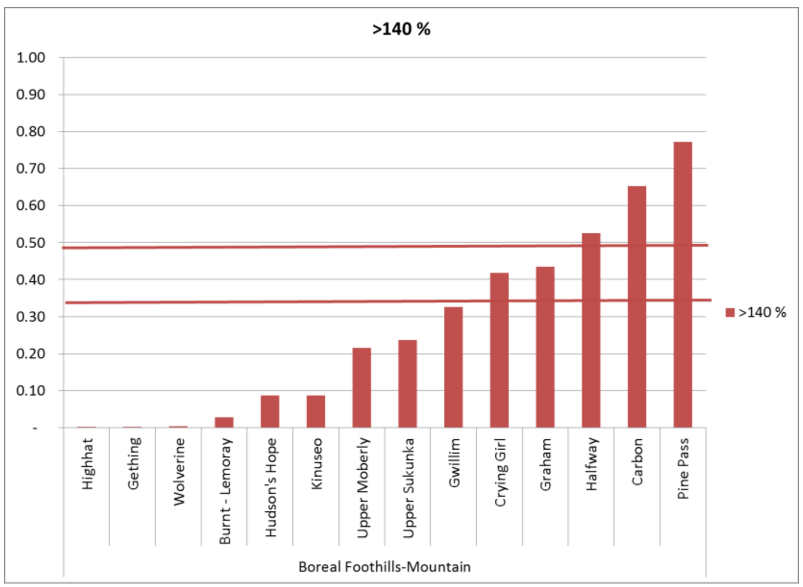
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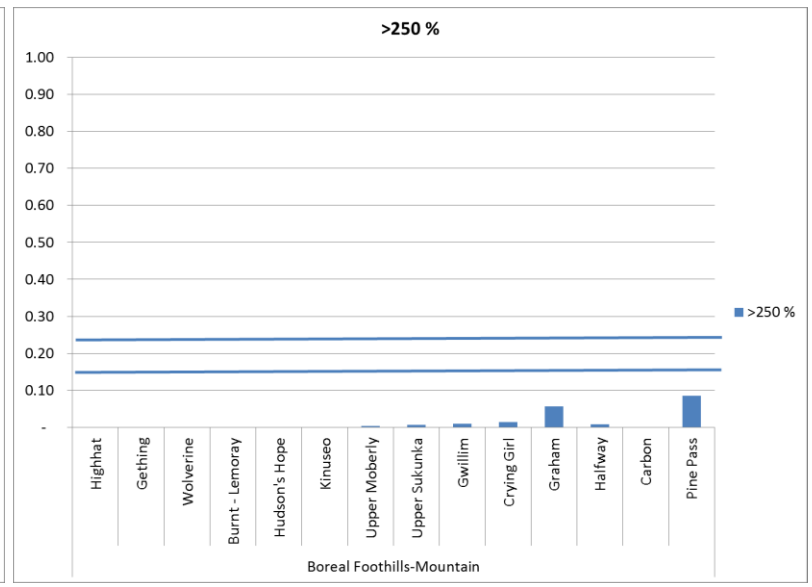
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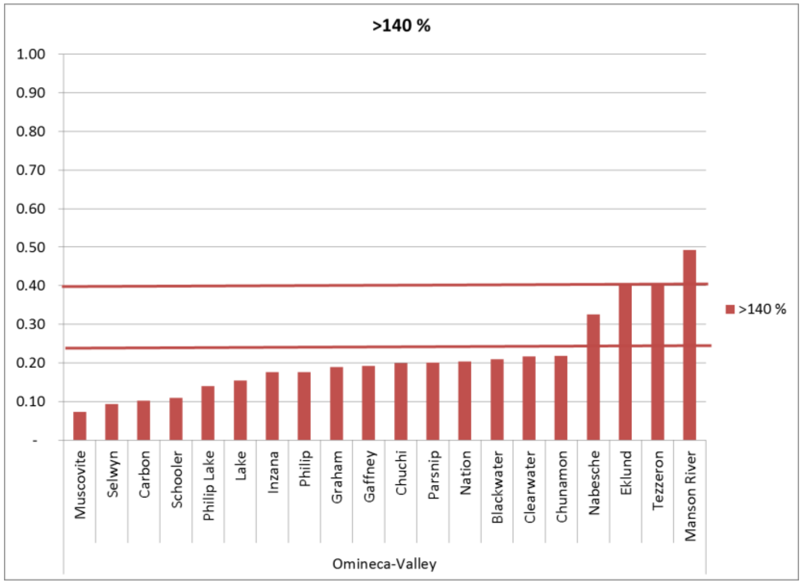
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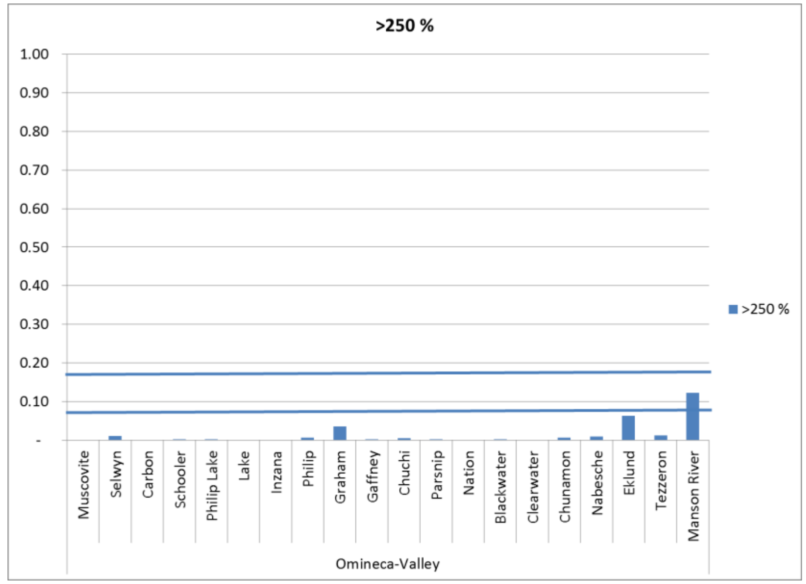
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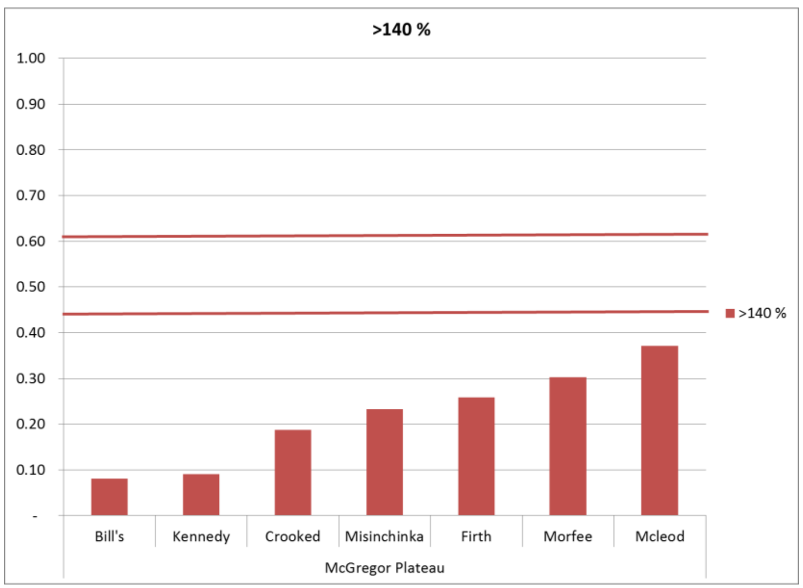
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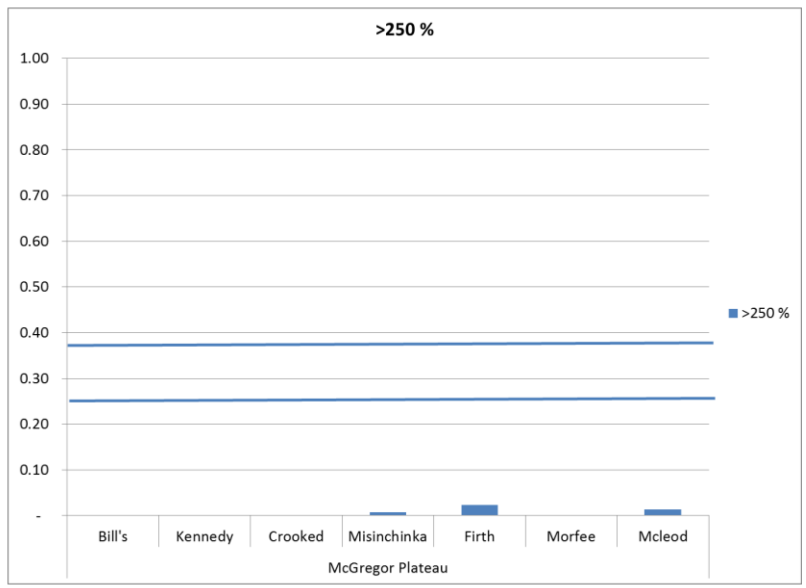
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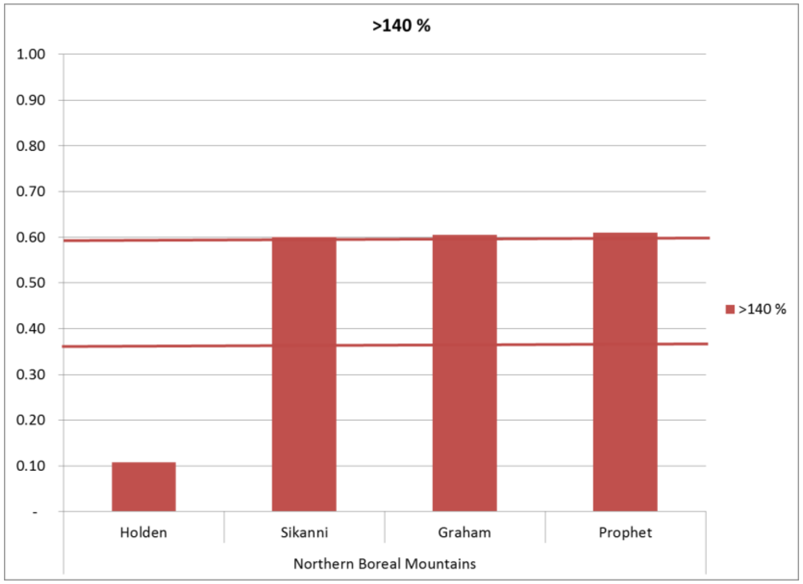
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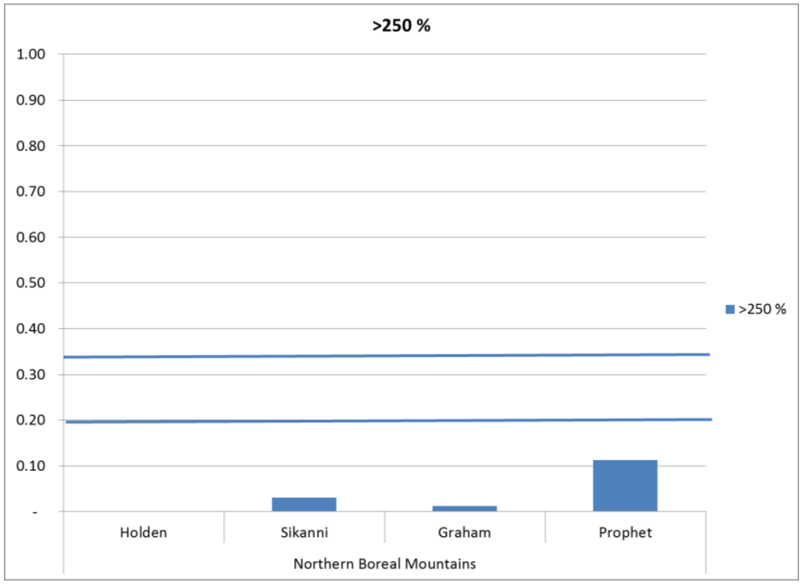
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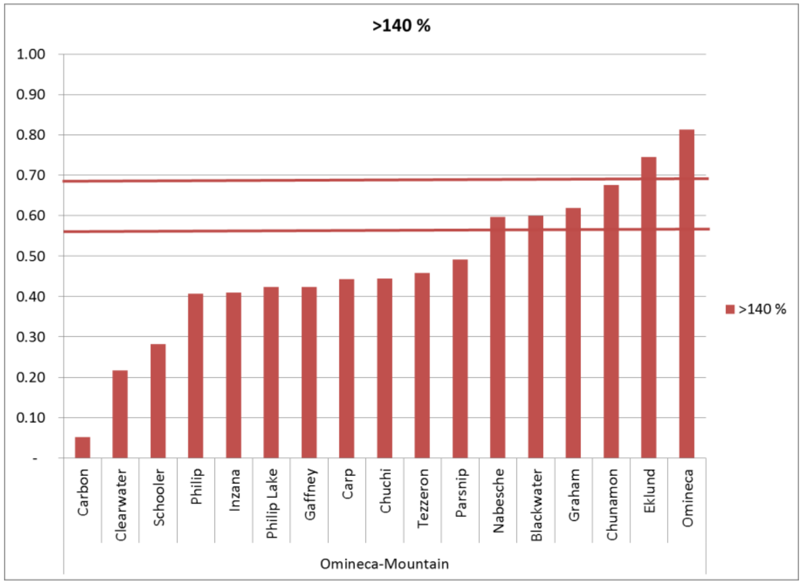
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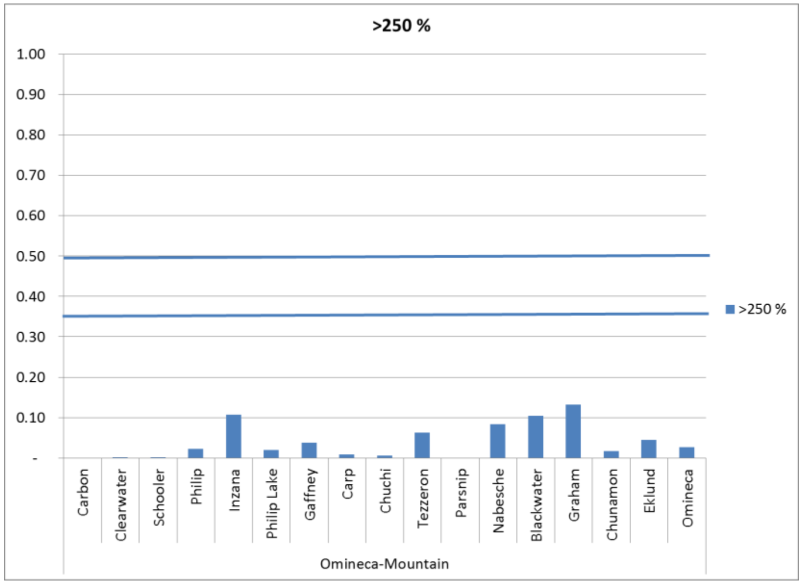
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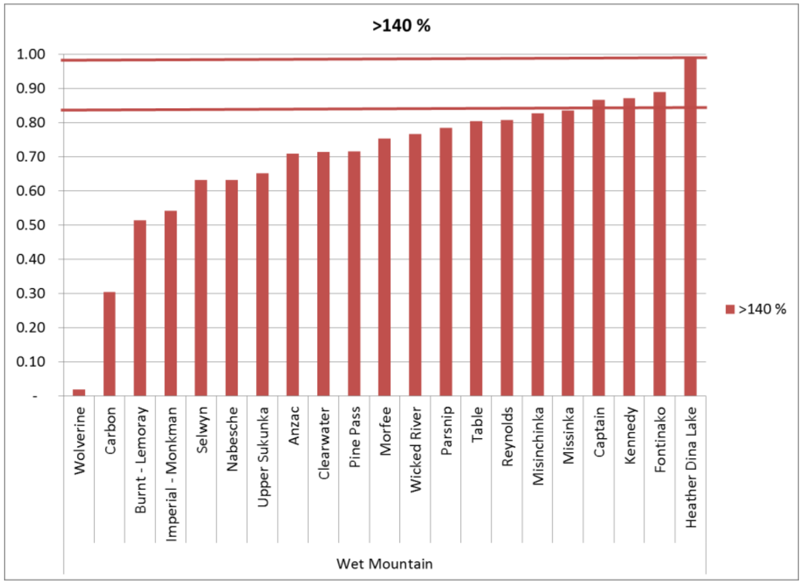

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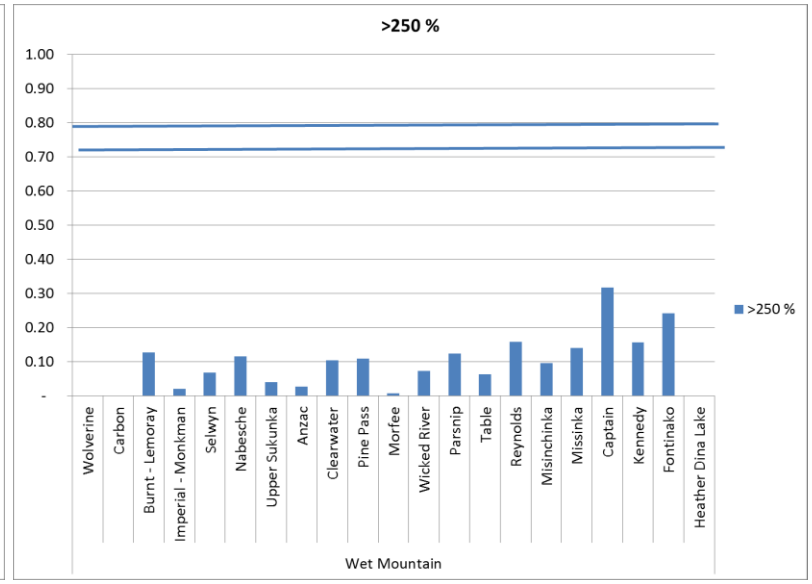

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Imperial - Monkman
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Pine Pass
Morfee
Wicked River
Parsnip
Table
Reynolds
Misinchinka
Missinka
Captain
Kennedy
Fontinako
Heather Dina Lake
Wet Mountain

Trends for Forests >250 years in age

For forests > 250 years in age (shown in Blue in all the graphs above), almost every combination of broad NDU and for all Landscape Units in all NDUs, there is significantly less forest >250 years than the natural range. In the vast majority of cases the amount is lower, or far lower, than the bottom of the natural range. For drier NDUs, the absolute amount of forest >250 is low to nil (often far less than 1%), so for example, on the Boreal Plains – Upland graphs there is no forest >250 apparent on the graph. There are a number of reasons why there is little or no forests >250 remaining in these areas:

- Lack of management direction. For most of the Northeast ecosystems, and certainly for all the drier ecosystems, management strategies for old forest identify targets for forests >140 years in age, but do not provide management direction for forests >250 years[9]. As a result, older, higher productive wetter stands would have been targeted for harvest and so are now rare or non-existent on the landbase;

- The VRI data may fail to identify some very old forest stands, since relatively little effort is put into differentiating stands older than 140 years in age.

For some of the wetter NDUs there are higher levels of forest >250 years remaining. This is as expected,

as they would naturally have had more of this forest type than drier ecosystems. For example the Wet Mountain NDU has the highest remaining levels for very old forest, considerably higher than most of the other NDUs, and Captain LU has the highest level with just over 30% forest >250 years; see air photo of Captain LU showing cutblocks in an old forest matrix). However, for all Landscape Units, there is still considerably less old forest >250 years than predicted level of 74 – 80% old forest, based on a stand-replacement natural disturbance rate of 900 years (Delong 2011).

Trends for Forests >140 years in age

The pattern for forests >140 years is somewhat different – with more variability for the pattern between Landscape Units. Depending on the NDU, the pattern of forests >140 differs in relation to natural.

- For the drier NDUs, in particular Boreal Plains-Upland, Moist Interior Plateau, Boreal Foothills-Valley, Boreal Foothills-Mountain, Omineca-Valley, Omineca-Mountain and McGregor Plateau – there is a wide range in the amount of forest >140 years remaining, from very little to more than predicted for each LU, but in all these NDUs, the majority of the Landscape Units are below the bottom of the natural range for forests >140 years;

[9] Caribou management guidelines provides direction for older forest in some forest types / areas within this region, and management direction in the Omineca has not been reviewed for this analysis.

- For the large landscape units in the centre of the Boreal Plains-Upland, the amount of forest >140 years is very low (often less than 10% and down to 1% for some). Old forest is outside the lower bound of natural for most Landscape Units in this large NDU.

- In the Northern Boreal Mountains, three of four Landscape Units are at the upper end of the predicted natural range for >140, but the amount of very old forest >250 years is significantly lower than predicted. The three – Sikanni (shown below), Prophet and Graham - have very little CFLB and generally low history of harvest. It is likely in this case that the low level of forest >250 years in this area may be explained by lack of differentiation in the VRI with respect to age, or may be explained by fire history between 140 and 250 years ago. Holden LU (the fourth unit in the Northern Boreal Mountains) has low levels of old forest compared to natural and a history of forestry activity is seen in this area.

LEFT: Sikanni LU outlined in Red.

GEOGRAPHIC DISTRIBUTION OF OLD FOREST BY LANDSCAPE UNIT

The two maps below show the distribution of old forests across the northeast, and for the RSEA study area. Figure 13 shows forests >140 years in age and Figure 14 shows forests >250 years in age (note this is a subset of those shown on Figure 13).

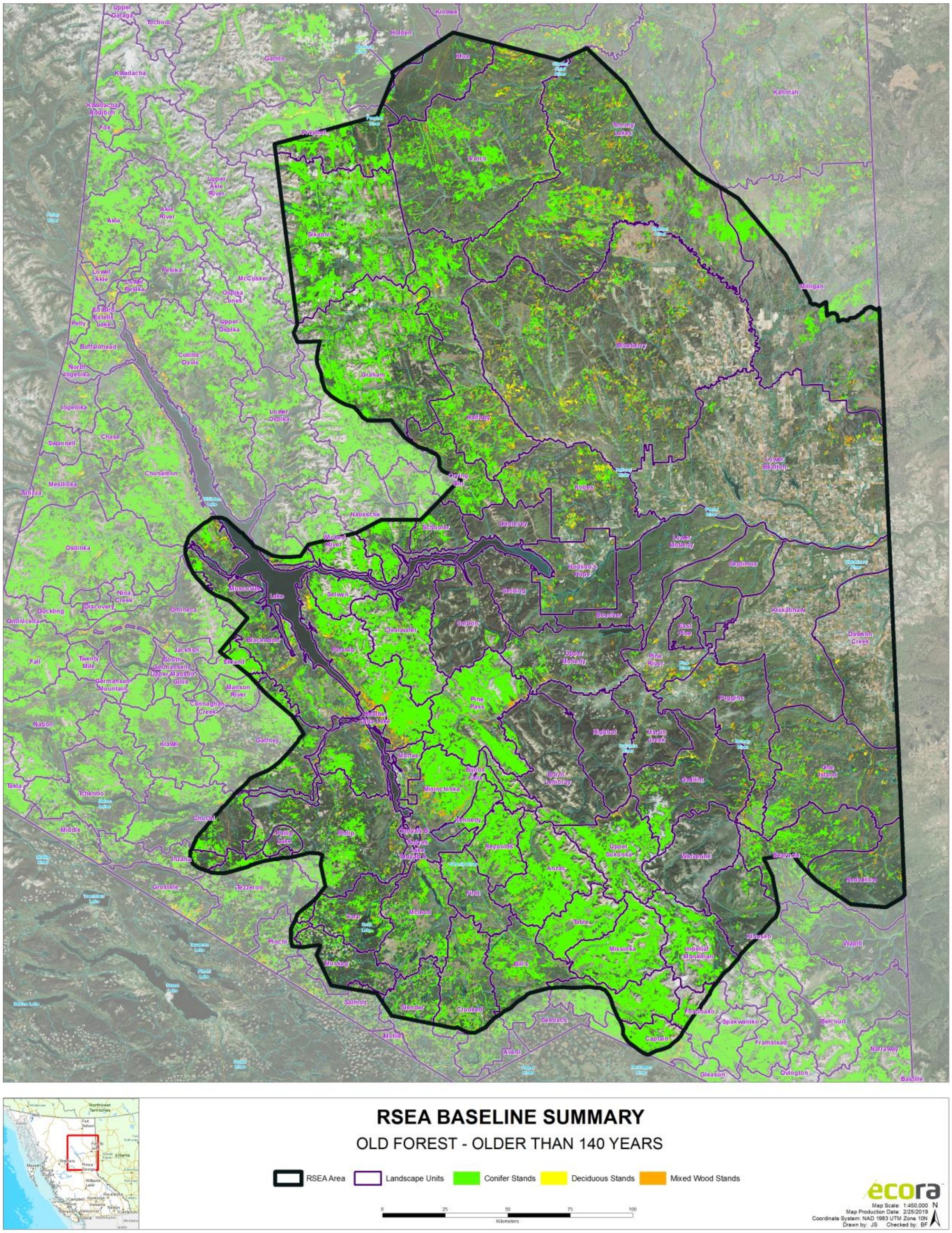


Figure 13. Distribution of Forest >140 years in the northeast, showing the study area[10].

[10] High definition PDFs are available on the sharepoint site that can be used to zoom in to areas of interest.

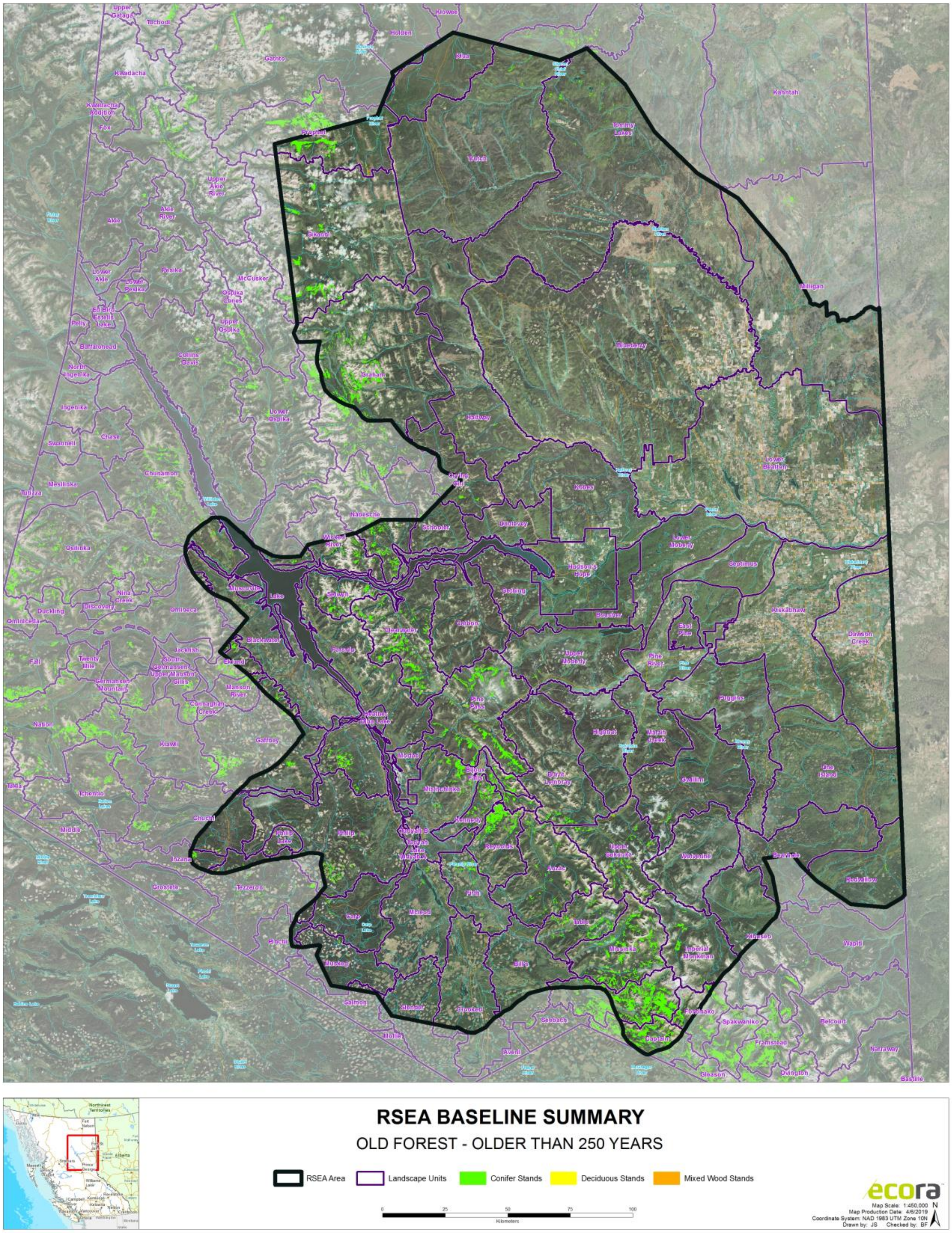


Figure 14. Distribution of Forest >250 years in the study area.

The following maps show the same data as outlined above, but shows the spatial distribution of landscape units, with each LU coloured in relation to whether the level of old forest is below the natural level (RONV), in the bottom half of RONV, in the top half of RONV, or above RONV.

Figure 15. Deviation from natural (risk) for Landscape Units, for forests >250 years in age.

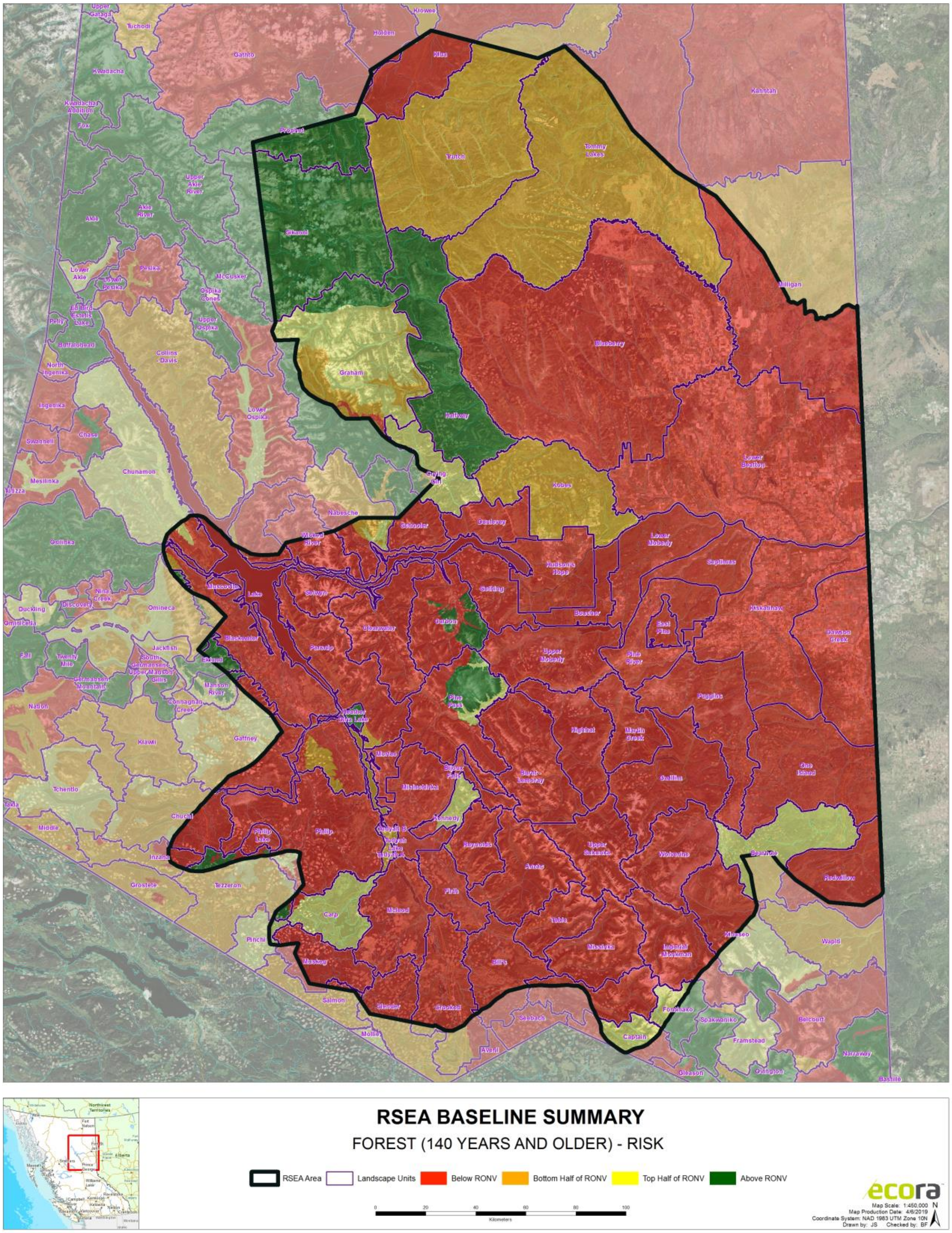


Figure 16. Deviation from natural (risk) for each Landscape Unit, for forests >140 years in age.

RESULTS: AMOUNT OF FUNCTIONAL FOREST

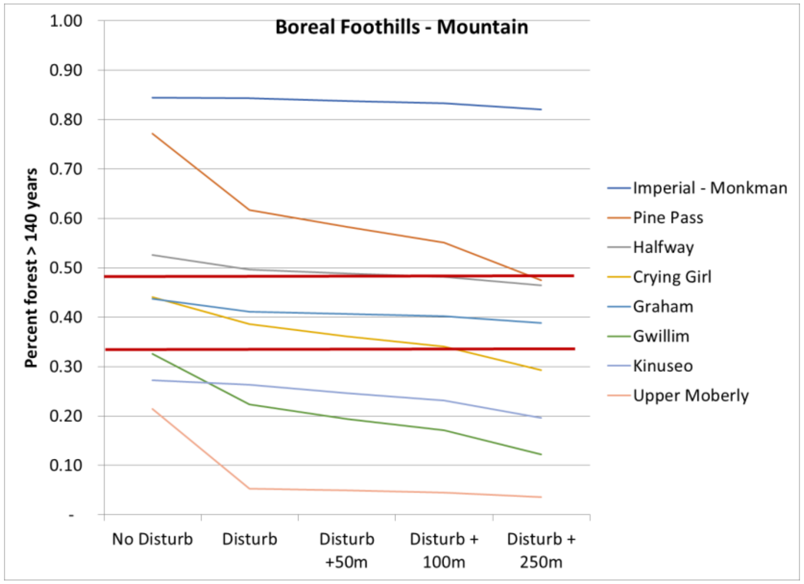
The functional old forest analysis builds on the methodology used above, and asks how much of the old forest shown in the base analysis *may* be in good condition, or 'functional'. This analysis looks at the coarse scale effects of applying different buffer widths to the RSEA disturbance layer, to investigate a range of potential outcomes based on different assumptions of what constitutes functional forest. It is intended to provide insight into the potential effects of disturbance on forest condition in different areas within the study area, but not intended to provide a definitive answer to 'how much functional forest is present?'.

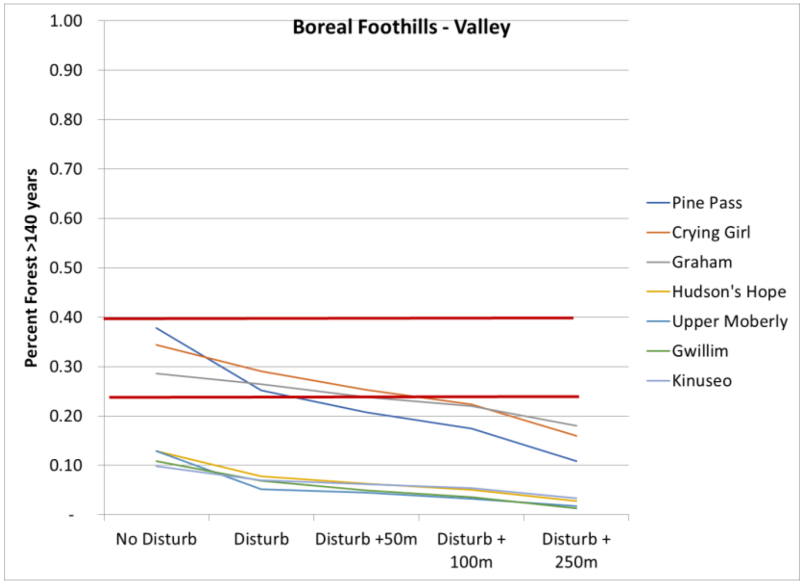
Graphs for every NDU / LU combination are shown below. Only results for landscape units >10,000 ha within the study area boundary are shown. The graphs below use generally the same format as the main old forest results above. For each Landscape Unit within each Natural Disturbance Unit, the percent old forest remaining under 5 scenarios is shown –

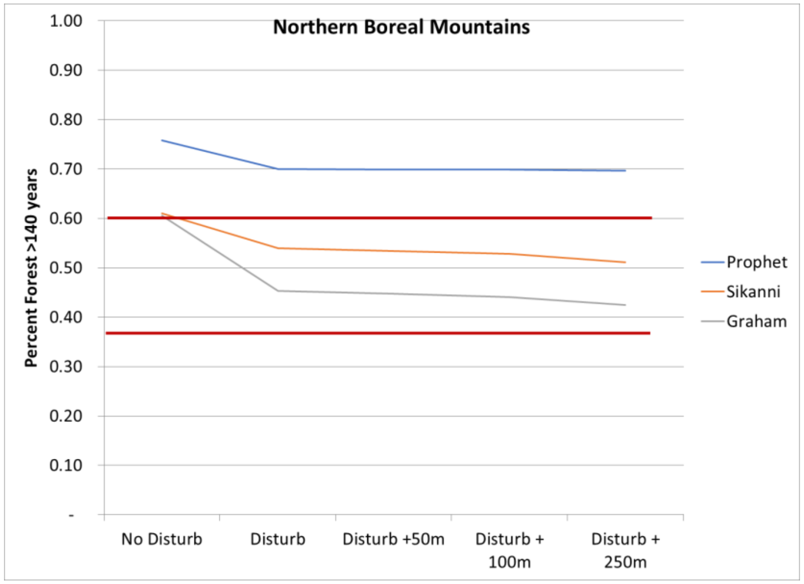
- No Disturb = amount of forest >140 years, from forest cover only [these are the data presented in the 'how much old forest' analysis in this report].
- Disturb = VRI forest cover layer intersected with the disturbance layer. No buffering is used, but the disturbance layer is more up to date than the VRI layer, so some forest that appears in that data is not actually present once the RSEA disturbance layer is overlaid.
- Disturb+50 = disturbance layer buffered by 50m. Forest >140 years and greater than 50m from the disturbance is shown.
- Disturb+100 = disturbance layer buffered by 100m. Forest >140 years and greater than 100m from the disturbance is shown.
- Disturb+250 = disturbance layer buffered by 250m. Forest >140 years and greater than 250m from the disturbance is shown.

On each graph, the natural benchmark – (the max and minimum of the range of natural variability) is shown in red solid lines (from Delong 2011).

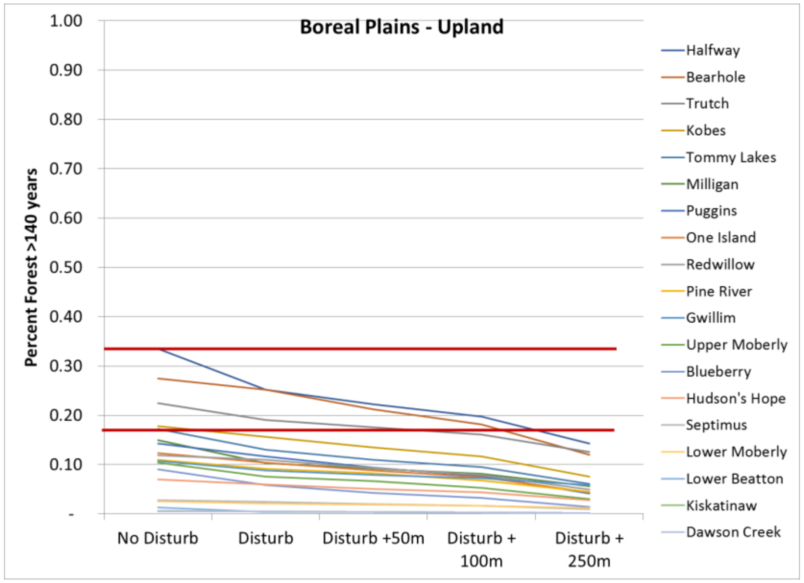
Data are shown by Landscape Unit within the NDU – the Landscape Units are listed in the legend in the same order as they are shown on the graph for ease of reading.







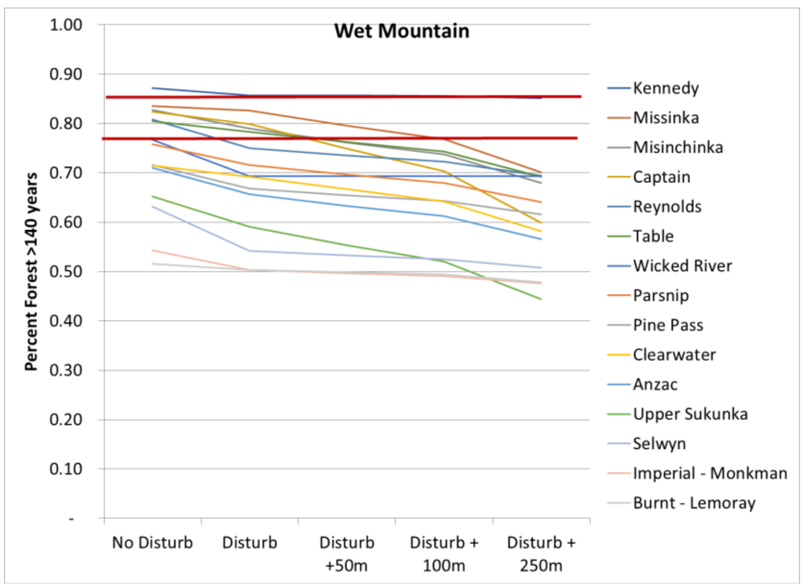
Some of the more mountainous NDUs have high levels of older forest, and this forest is relatively unimpacted by disturbance and appears to be largely functional (using the definitions used here). For example Imperial-Monkman LU in the Boreal Foothills-mountain NDU. Similarly, the Northern Boreal Mountains Landscape Units all generally retain their apparent high condition when disturbance is included. The Wet Mountain NDU also has higher functional forest levels This is because it is impacted by forestry activity, but not the extent of other disturbances present elsewhere on the landscape. In contrast, other areas show a significant reduction in the apparent amount of forest, when its potential functionality is considered. For example, three Landscape Units in the Boreal Foothills – Valley NDU appear to have old forest amounts within the natural range (see above), but when the forest within the disturbance layer buffer is not counted, the amount falls below the natural level (e.g. Pine Pass, Crying Girl LU).

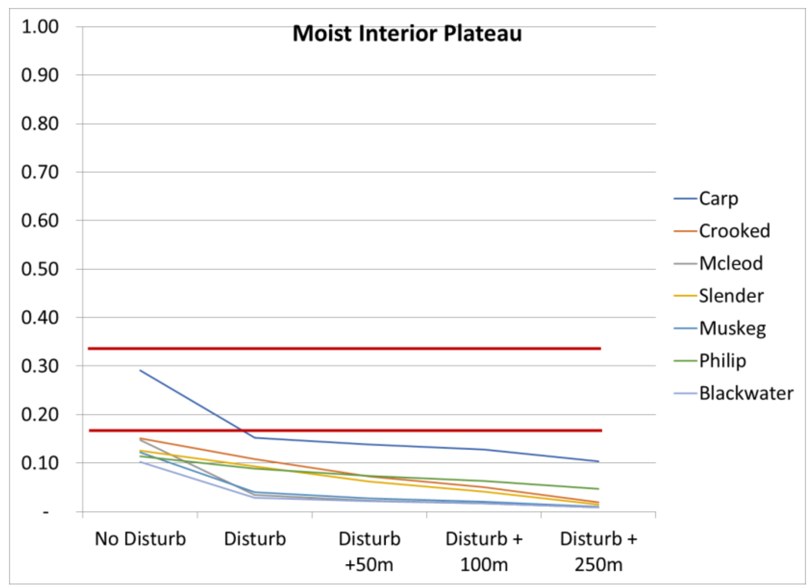


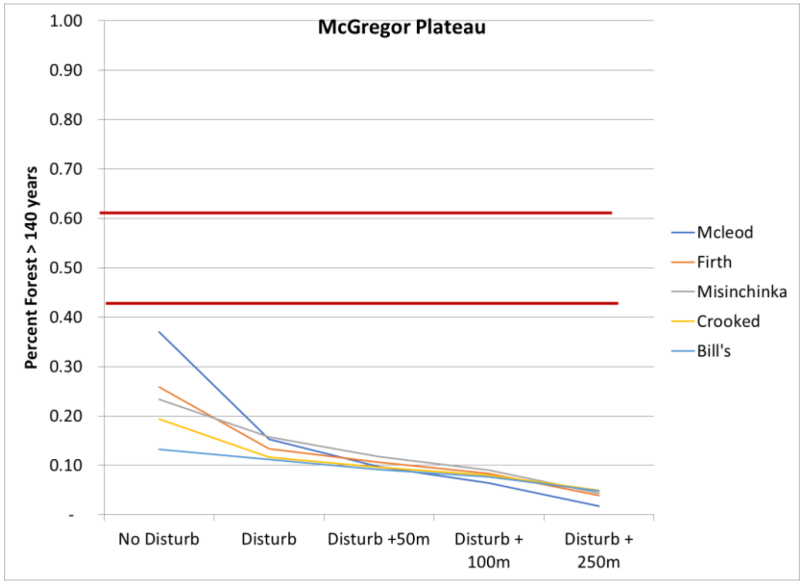
In the Boreal Plains Uplands (the largest NDU within the RSEA study area), almost all the LUs have less old forest than natural before the forest functionality is considered. And all the LUs show a further decline in potential functional forest with increasing buffer width.

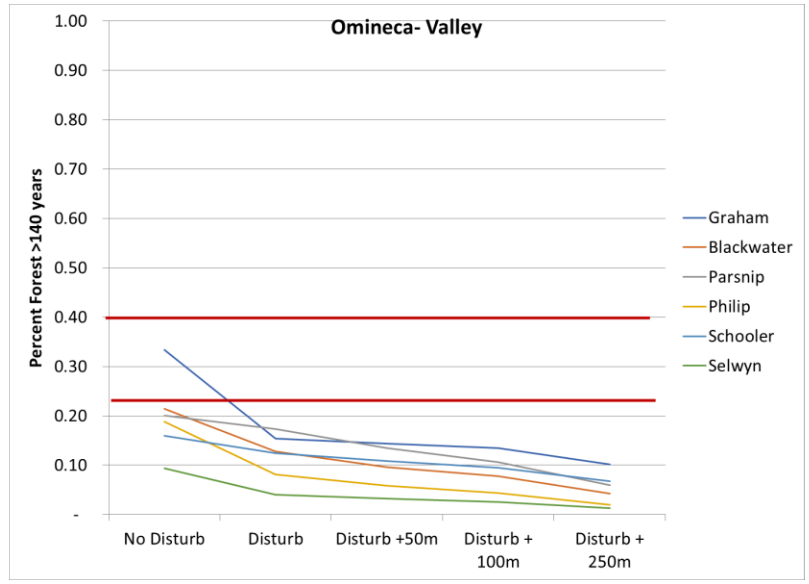
Dawson Creek, Kiskatinaw and Lower Beatton LU (bottom lines) have a very low amount of old forest remaining (<2%) before considering functionality, and adding the disturbance layer and any buffer effects effectively removes all the old forest.

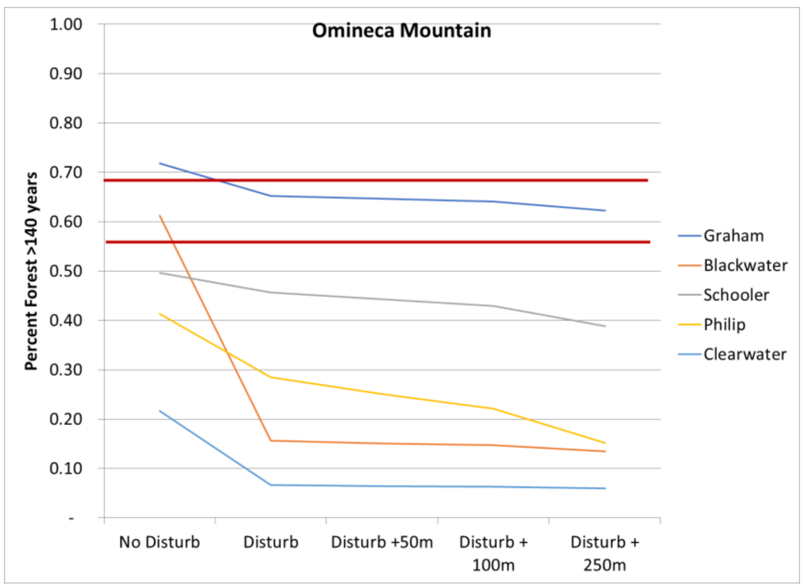
In the Halfway LU (top line) forest cover data shows the highest amount of mapped old forest in the NDU, but adding the disturbance layer and buffers reduces the apparent amount of functional forest significantly in this LU. With no consideration of disturbance, it appears that the amount of old forest is at the high end of the natural range. Using a 50m buffer the amount of old forest is at the bottom end of the natural range, and using a 250 buffer the amount of old forest is considerably lower than natural.











In the Omineca NDU, the two subunits (valley and mountain) show different trends in apparent functional forest. In the Mountain unit, the forests are relatively intact, and applying buffers to the disturbance layer causes relatively little reduction in the amount of apparent functional old forest. In the Valley subunit, adding the disturbance layer itself pushes the amount of old forest outside the natural benchmark. In this case, this is the effect of a severe pest outbreak captured in the disturbance layer.

What does the Functional Analysis tell us?

In general - looking at potential forest condition by buffering disturbances by different amounts, results in a lower estimate of the amount of potentially functional forest than is suggested by looking only at the forest cover data alone. The specific effects vary by Landscape Unit within each NDU, and areas with significant disturbance are most significantly affected while mountainous areas are least affected.

This analysis does not take into account a many variables relevant to forest condition, for example, it 'takes away' forest within the buffers, but does not look at the remaining area of forest and say whether it has interior forest conditions or not. In many cases only slivers of forest remain once buffered disturbance is accounted for. As a result, the graphs shown above may over-represent how much actual 'functional' forest remains on the landscape. The analysis also does not look at connectivity of the remaining forest, which is a very significant factor affecting landscape functionality (e.g. Dawson, 1997).

Conversely, the analysis does not differentiate between different types of disturbance and differences in the likely effect on function. There are many different types of disturbance represented in the disturbance data, and they are all considered of equal importance in this analysis, though they are clearly not all equal. There are two main types of disturbance – linear corridors (roads, pipelines, other corridors) and forest harvest blocks. These two types of disturbance have some similar and some very different types of impacts on species and processes. The effects of clearcuts in a primarily older forested landscape have a different effect on functionality of remaining forest than will the effects of high density linear corridors in a landscape that is already dominated by younger forest. In addition, temporal effects will also vary. Forest management causes edge effects and fragmentation of remaining forests, but those effects change over time as forest stands regrow over 100 years. The severity and temporal effects of gas development are potentially very different with hard conversion from a forest stand to a well pad, and no reforestation requirement for many disturbed areas.

Note that this analysis does not ask whether the remaining forest has interior forest conditions. A patch size, or interior forest analysis is significantly more complex than the relatively simple 'buffering' analysis undertaken here. However, the figures show that there are very few options for larger forest patches remaining in many parts of the study area, particularly where cumulative development has occurred (e.g. within the plains and lower mountain ecosystems).

The approach taken in this analysis is intended to be coarse scale and to reflect a range of potential outcomes when considering whether the forest remaining in a landscape is functional. The definition of what is 'functional forest', as discussed above, is species and context specific. These results are not intended to be a definitive statement about which buffered disturbance results may be most accurate or relevant – the interpretation of the results will differ, depending on the lens they are looked through.

Notwithstanding these comments on variability in interpretation, all the areas where the amount of apparently functional forest is considerably less than that suggested by just forest data alone should be cause for concern with respect to cumulative effects management and old forest values. Looking only at the amount of old forest, and ignoring the potential condition of the remaining forest is clearly inaccurate for many, if not most, values. The importance of patch size, interior forest conditions, edge effects, microclimate changes and human disturbance are all known to impact many values in the forest. This analysis therefore provides some insight into how misleading it is to consider only the total amount of old forest present, without considering its condition.

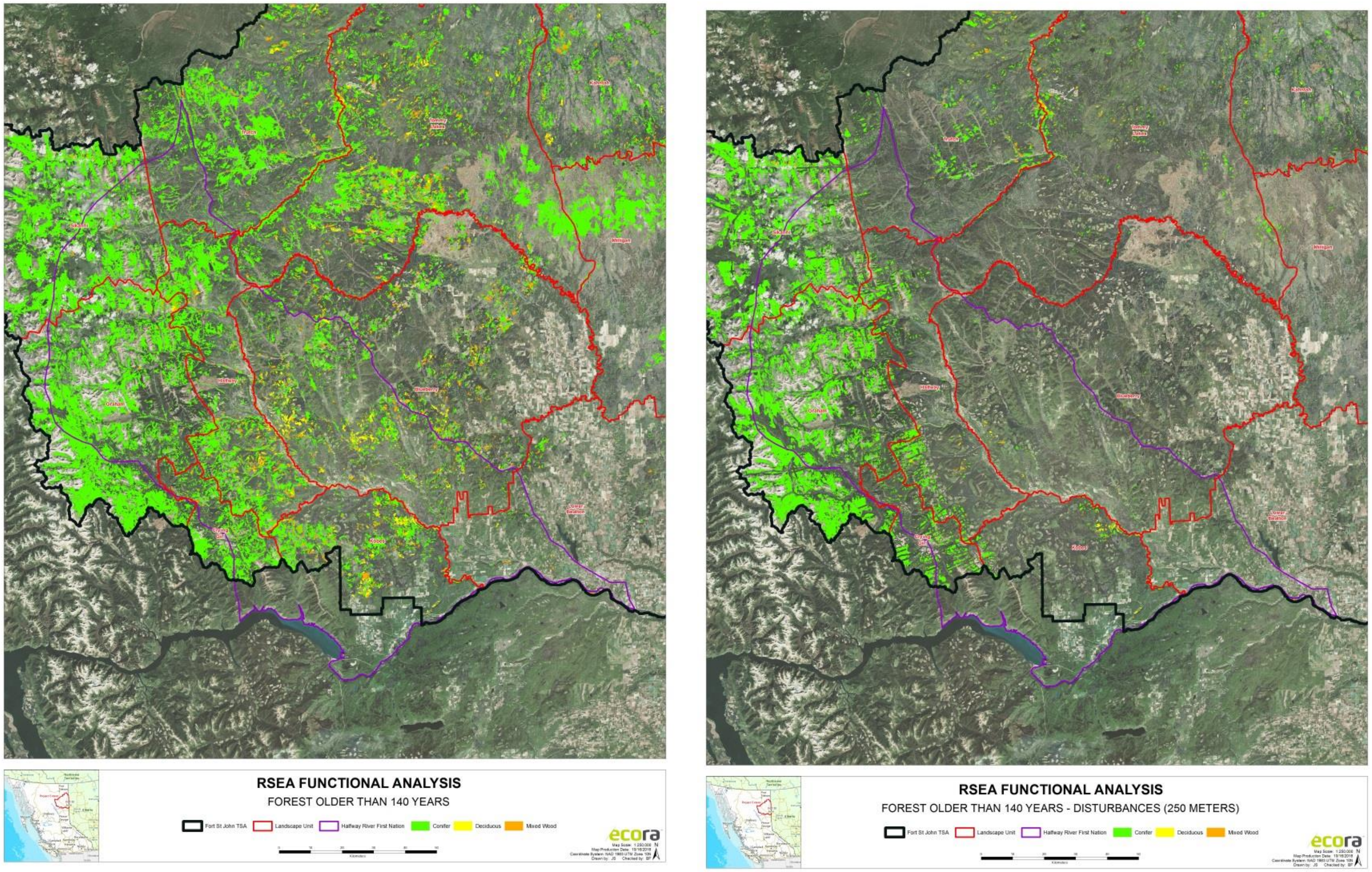


Figure 17. Zoom in on the southern part of the RSEA study area. Left - mapped forest from VRI >140 years, and Right – mapped forest from VRI with disturbances buffered 250m on both sides.

Discussion

Risk Levels

Throughout this report, the condition of NDUs and Landscape Units has been presented in relation to the predicted natural levels of old forest expected for different areas within the study area. This is the same approach used by the Province as the basis of old forest management as outlined first in the Biodiversity Guidebook of the Forest Practices Code (Province of BC 1995; Figure 18), and subsequently in many provincial management frameworks, and in the Great Bear Rainforest Land Use Order (2014).

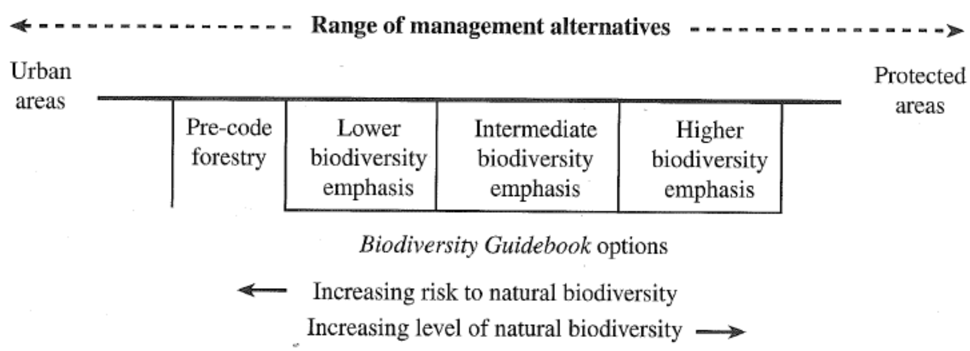


Figure 18. Conceptual approach linking deviation from natural conditions to risk to natural biodiversity. Province of BC. Biodiversity Guidebook 1995.

Old forest is the primary indicator used by the Province of BC, and many others, both to manage, and to assess the condition of forested ecosystems. Old forest is both a 'coarse filter' management tool, and old forest itself has unique values and characteristics. Loss of old forest, in relation to natural levels, increases the 'risk' to natural biodiversity – species, populations and functions. Risk in this context is a combination of the probability and the potential extent of change in relation to biodiversity being impacted or lost. In this RSEA context, this is also a risk to the ability to exercise treaty rights on the landscape.

Figure 19 shows a generalised relationship between change in natural conditions (% reduction in old forest from natural range) in relation to levels of risk to old forest dependent species. This curve was developed for the Coast Information Team (GBR) and shows the general relationship between risk and change from natural. It also hypotheses that at the ends of the relationship - close to natural, and very far from natural – there is less uncertainty around the relationship (or shape of the curve) than in the middle of the range.

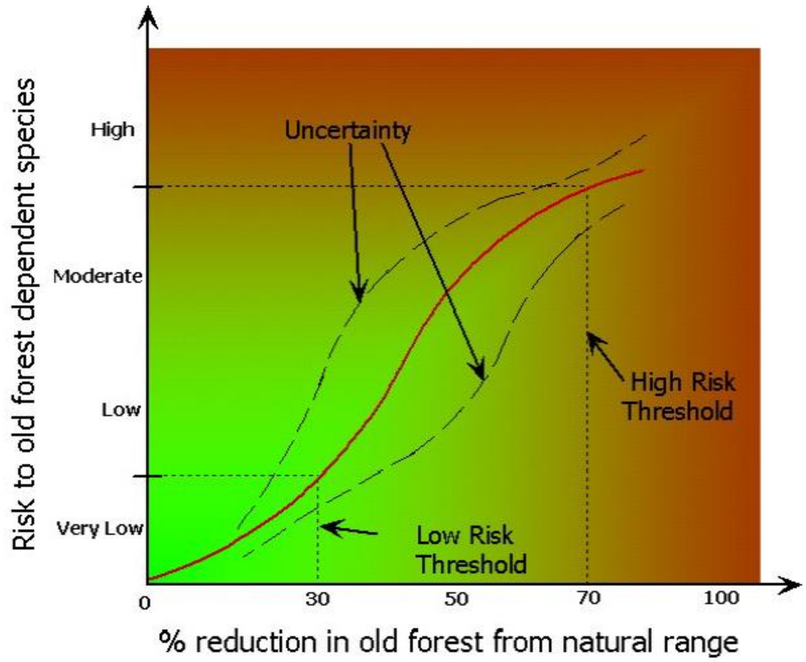


Figure 19. Generalised relationship between deviation from natural conditions and risk to old forest dependent species. Figure derived from meta-analysis of science papers that looked at habitat loss and population changes. Coast Information Team EBM Handbook 2004.

The absolute risk associated with a 'deviation from natural' will be altered by various parameters. This report is not intending to make a statement about the absolute risk associated with change from natural, but some of the relevant parameters are provided for consideration. Absolute risk will vary based on, amongst other things:

- the degree of deviation from natural, however this may or may not be a linear relationship. There may be thresholds beyond which the risk increases at a higher rate (see Figure 19 above);
- The tolerance for changing old forest levels may vary by ecosystem, species, or values of concern;
- The perceived risk may change depending on where the burden of the risk lies. For instance, in many cases, those people who 'take the risk' directly on the ground often perceive the risk to be higher than those at arms-length from the implications;

In development of Ecosystem-Based Management in the Great Bear Rainforest (GBR), the management framework identified a goal of managing the region at low risk for ecological integrity. A series of analyses and workshops led to a report where the team identified thresholds for old forest that would result in high and low risk to ecological integrity (Price et al. 2007);

- 70% of the Natural amount of old forest (or 60% of the total) would equate to low risk for ecological integrity in coastal ecosystems,

- Lower than 30% of the total amount of the ecosystem would equate to high risk for ecological integrity.

These conclusions were drawn for meta-analysis of available science of how individual species respond to changes in habitat, and the approach formed the basis for the Land Use Planning undertaken for the GBR, and resulted in the provincial Land Use Order (2016), which conserves 85% of the forest and 70% of the old forest over time with the goal of achieving a high level of ecological integrity[11].

Boreal and mountain forest ecosystems are different than coastal ecosystems, but the general concepts used throughout BC and on the coast also apply. The specific numbers, in terms of natural forest amounts are different – and those differences are captured in this work as the Province undertook detailed NDU descriptions which are used here (Delong 2011). The shape of the relationship between amount of old forest and the natural range is unknown for this ecosystem (e.g. Figure 19), i.e. whether there is a straight line or whether there are thresholds where a small change in old forest causes a larger than expected change in a value. Species, ecosystem and functional relationships are beyond the scope of a coarse filter analysis and it is reasonable as a starting point, unless there is evidence to the contrary, to assume a simple straight line relationship (as in the Biodiversity Guidebook) that risk to biodiversity (species, ecosystems and functions) will increase the further the condition is from the natural range.

The amount of old forest in individual ecosystems in this study area (represented in this analysis by LU / NDU combinations) varies considerably in terms of how much old forest and how much potentially functional forest is present in relation to natural levels. The graphed results point to how to interpret landscape condition for forest biodiversity –

- Where an individual LU within an NDU is below natural levels of old, this points to potential risk in this LU. If the level of old forest is far below natural levels, risk is likely to be high or very high. An absolute low level of forest (irrespective of natural levels) can further escalate risk because additional factors such as connectivity also become affected.

- Where multiple LUs within an NDU are below the natural levels of old, this points to a significant risk to biodiversity in that broad ecosystem because of the spatial extent affected.

- Where there is high variability in the individual LU pattern (some high, some lower), this points to potential flexibility within that ecosystem and may or may not be cause for concern at the local or regional level.

- Where the base old forest risk levels are significantly increased in the Functional Forest analysis, this points to a strong need to examine both the amount of old forest and its condition and pattern on the landscape.

Limitations and Uncertainties

Age of and Values of Old Forests

Understanding patterns for different age classes of old forest in different ecosystems. The results for two age-class cut-offs are provided in this report for all broad ecosystem types, irrespective of natural

[11] https://www2.gov.bc.ca/gov/content/industry/natural-resource-use/land-use/land-use-plans-objectives/west-coast-region/great-bear-rainforest

disturbance regime. In the management context, age of old is lower in high disturbance ecosystems, however, the amount of forest >250 is still relevant to the boreal plains, even though relatively little of it is expected. In this context, the forest >250 is less of a coarse filter than forest >140 years, but maintaining this very rare component of the landscape may still be very important. Conversely, for those ecosystems dominated by older forest (e.g. the Wet Mountain NDU), the >140 analysis provides general information about the potential of the landscape to provide true 'old forest' over time (i.e. the recruitment potential on the landscape). If there was insufficient >250 AND insufficient >140 that situation would be more difficult to manage over time, than if there is insufficient >250 but lots of >140 forest.

In BC's Northeast, younger deciduous forests are relatively common on this landscape, and in some forest districts deciduous forests 100 years and older have been used to contribute towards the total old forest on the landscape using a mixed age / leading species definition. This may be ecologically reasonable, and potentially may lead to larger contiguous patches of forest able to be retained as OGMAs. However, where this approach is used it is also important to ensure that the retention target is set using the same 'age of old' as the actual ages being used to contribute to the target.

In other parts of the study area, old forest is managed as forest >140 years in age even those that are predicted to have a significant portion of the landscape in forests older than 250 years in age (e.g. Wet Mountain; Province of BC Undated). In a review of issues relating to old forest management in coastal ecosystems, the importance of managing to maintain the full range of old forest types was identified (Coast Information Team Report 2008), and in that case, it was recommended to create a separate system of managing for age class 9a and 9b in order to acknowledge the importance of younger old forests (>250 years) and older old forests (many many hundreds of years of years in age). That direction was relevant for coastal ecosystems, but points out the need to specifically manage for the full age range of forest types present on the landbase, so components of the forest are not lost. In these ecosystems, very old forests are unusual but managing for both standard 'old forests' >140 and in this case very old forests >250 years in age may be required to ensure ecosystem components are not lost from the landscape. This is particularly true because very old forests in boreal systems tend to be found in riparian habitats which have high diversity of additional biodiversity and cultural values, but also are a target for forest harvesting.

Defining Forest Ecosystems

Maintaining 'representative ecosystems' is a primary element of effective management to maintain biodiversity. This analysis uses a very coarse approach to defining ecosystems – it presents analysis only at the level of Landscape Units within NDUs, which is an insufficient level of detail to understand trends for individual ecosystems. Site series are the relevant description of ecosystems but site series mapping is not yet available for the RSEA study area. An attempt to define site series surrogates was made for this analysis (using leading species and productivity groups), but the Working Group determined it more appropriate to wait until higher quality site series surrogate mapping could be generated to understand trends for individual ecosystems.

VRI Age

This analysis is based on age class data from the Provincial Vegetation Resources Inventory layer, where forest stands are assigned an age that can then be summed up into age-classes. VRI is considered a 'strategic level' data set – broadly correct, but not necessarily accurately reflecting the specific values in any location. VRI is used by the province for management and reporting on forest values, but may not reflect real ecological differences observed on the ground.

For example, age-class 9 forests (>250 years in age) or age-class 8 forests (>140 years in age) are broadly considered old forests, but can reflect a very diverse set of actual structural and ecological attributes on the ground. Understanding patterns of age, structural stage and value may require a more detailed breakdown of age and forest ecosystem type to provide meaningful input into more future RSEA analyses and planning processes (e.g. Kremsater and Holt, 2019 in preparation).

NEXT STEPS

ADDITIONAL INDICATORS

Old forest and Functional Forest were the first indicators identified by the RSEA Biodiversity Working Group, however, they also identified a draft list of additional indicators, including:

- Natural young forest. This is an important part of the landscape of these ecosystems, particularly in drier ecosystems defined naturally by relatively high proportion of natural fires. Natural early habitat is also linked to many biodiversity and cultural indicators;

- Riparian Forest Condition. Riparian forests contain a significant portion of biodiversity and cultural values.

These two indicators can be developed relatively quickly from the existing data, and additional discussion is needed to determine any other key indicators relevant to this working group.

MANAGEMENT TOOLS AND FUTURE TRENDS?

This analysis presents current condition of old forests in relation to a historic baseline. In order to understand potential future trends, analysis of current management direction is needed. This can be undertaken using modeling exercises of base case management (and this is the intention at the RSEA table); and in addition the coarse level can be evaluated by considering the cumulative effects of policies governing protection of land for different industries. Provincial direction to maintain old forest ecosystems was provided through the Biodiversity Guidebook (1995) and amended in the Landscape Unit Planning Guide (1999). These documents required spatial identification of Old Growth Management Areas (and other approaches for maintaining biodiversity values such as Forest Ecosystem Networks). For most, if not all of the study area, this direction was not implemented, and these policies were replaced by aspatial direction[12] - the Provincial Non-Spatial Old Growth Order, which was 'intended to be temporary until local objectives for old growth could be established' (Dawson Creek MoF Undated). In some areas of the study area (such as Dawson Creek TSA), efforts were made in the early 2000s to establish spatial Old Growth Management Areas, but in other areas (e.g. Fort St John TSA) there are no approved spatial Old Growth Management Areas today, though draft areas have been identified.

[12] Aspatial old growth management refers to using forest cover (VRI) dataset to determine whether sufficient apparent old forest exists to meet the target. It does not determine whether that forest actually exists on the ground, or what types of functional attributes are captured (e.g. is the forest mostly large functional intact patches, versus long corridors of narrow forest adjacent to a highway).

Other land designations (e.g. Provincial Protected Areas, Wildlife Habitat Areas, Ungulate Winter Range) exist on this landscape. The area in protected area differs greatly by BEC zone and NDU – with low elevation forests in the boreal / taiga plains ecoregions (the Boreal Plains-Upland NDU) having less than 1% in protected areas, whereas some of the mountainous areas, such as the Northern Boreal Mountains areas have higher protection levels. Most, if not all, of the other existing tools (e.g. WHAs and UWRs) do not actually prevent loss or disturbance of old forest, and do not provide an effective tool for managing the old forest value (e.g. incursions and harvest can be, and often are, permitted (e.g. Canada-BC 2017)).

Managing fragmentation of landscapes is a well-known problem, identified by the province through various policy tools. For example, the concern about fragmentation effects and the need to avoid them, is highlighted in the Ministry of Forests extension note from 1998 which identifies policies from the FPC that were intended to minimise the effects of fragmentation and edge effects (e.g. Voller 1998). However, no policies exist in the RSEA Project Area to manage or minimise landscape fragmentation at this time.

Cumulative Effects

The need to contemplate cumulative effects in all aspects of land management has been raised many times in the last few decades (e.g. FPB 2011; BC Auditor General 2015). Land management in BC is managed primarily through forest management policies – but many other industries also use the landbase which can lead to uncertain outcomes for individual values such as old forest condition.

As an assessment approach this work is similar in concept to that outlined by the Provincial Cumulative Effects Framework for old forest, but may differ in a number of critical ways[13], including a) using a natural benchmark (rather than provincial policy) to understand the implications of the results, b) considering the potential condition (functionality) of remaining old forest, and c) evaluating the effect of ecosystem conversion on the results of the analysis. These factors are crucial for undertaking meaningful cumulative effects analysis that aim to do more than basic implementation monitoring (are policies being met), but to ask whether those policies are potentially effective in maintaining values and how effectiveness is maintained in the face of a cumulative footprint.

The northeast of BC is on the far end of the spectrum in the BC context for having multiple development sectors that affect forest landscape condition, with different factors affecting different areas of the study area. The Fort St John LRMP identifies 27 resource management zones that cover much of the study area – including agricultural development (12% of the area), enhanced resource development (20%), general resource development (46%), special management (14%), major river corridors (4%) and protected areas (4%[14]). Development activities are allowed in all RMZs, with the exception of protected areas (LRMP 1997). The geographic distribution of these zones affects the biodiversity and cultural values remaining in a particular area into the future.

Forest harvesting is the primary land / forest disturbance agent over much of the study area, with the exception of a number of landscape units in the mountains to the northwest of the study area. The forestry footprint is affected by the land use zones outlined in the LRMP and superseded by the FSJ SFMP. The direct effects of forest management are recognised in this CE analysis.

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[13] Although draft reports have been written, a provincial old forest report is yet to be released.

[14] This percent from the 1997 LRMP appears to represent goal 1 and goal 2 Protected Areas – though not sure if all Goal 2 areas were established.

Gas development activities, while accessing a resource located underground, has a significant surface footprint in the northeast. Forest clearing for roads, well sites, pipelines and seismic exploration all affect the potential values to be found in the remaining forested landbase. The potential effects of gas development are recognised in this analysis through the buffered functional forest analysis (20 – 250m buffers), but many indirect effects (water effects, noise, disturbance etc.) are not recognised in this analysis.

Agriculture land conversion is primarily located around the Peace River Valley – in the south of the Boreal Plains-Upland NDU. This conversion affects the amount of forest land that is available to provide biodiversity and cultural values in certain areas of the landscape and in some areas covers a significant portion of the land. The total conversion can affect the apparent percent of old forest remaining in an area, and this conversion is recognised in this CE analysis. Cattle grazing (ranching) also occurs within the Crown Forest Land Base and can affect the biodiversity and cultural values associated with older forest. Effects are cattle and grazing on functional attributes of older forest and water are not recognised in this CE analysis.

Significant coal mine development also occurs within the study area – and is located in the coal belt in the foothills / mountains in the west / south west of the study area. Although relatively compact in footprint, coal development creates disturbance and significant industrial road traffic in certain areas. The actual footprint of mines is recognised in the functional forest analysis, but the many disturbance factors relating to mining development are not reflected in this CE analysis.

Significant tourism and recreational hunting also occurs in this landscape. Although not affecting the forest directly, the use of roads and disturbance from hunters and other users has the potential to affect both biodiversity values and cultural values available from the forested landbase, and these effects are only indirectly reflected in the functional forest analysis.

Different combinations of factors affect different parts of the landbase, and understanding future trends will be dependent on understanding how policies relating to different industries combine to affect the whole landscape. For example, the combined effects of agricultural conversion, grazing, enhanced resource development (high intensity forest management), and gas development all combine in the central part of the study area (Kiskatinaw, Blueberry, Lower Beatton and surrounding Landscape Units), so future trends for old forest will be different here compared with other areas of the study area with only limited subset of the industrial development pressures. Future modeling will be undertaken as part of the RSEA Project process to understand these trends over time and space.

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Appendix 1:

Old Forest Analysis

An old forest analysis comprised of various summary statistics was completed by following a detailed methodology. This involved creating a resultant dataset using ESRI ArcMap software to overlay 19 key datasets. The resultant dataset was input into a customized script which standardized and automated the calculation of numerous old forest parameters, which generated an excel spreadsheet summarizing various old forest characteristics. To compliment these summary statistics, numerous maps were created to illustrate old forest characteristics for the entire study area, first nation areas, and each of the 8 natural disturbance units contained within the area of interest. A complete definition of all datasets and queries used to calculate old forest summary statistics is provided within a manually created data dictionary spreadsheet.

Dataset	Source	Date
Agricultural Land Reserves (ALR)	WHSE_LEGAL_ADMIN_BOUNDARIES.OATS_ALR_POLYS	August 2017
Biogeoclimatic Ecosystem Classification (BEC)	WHSE_FOREST_VEGETATION.BEC_BIOGEOCLIMATIC_POLY	August 2017
Digital Road Atlas (DRA)	WHSE_BASEMAPPING.DRA_DGTL_ROAD_ATLAS_MPAR_SP	August 2017
Fires - Current	WHSE_LAND_AND_NATURAL_RESOURCE.PROT_CURRENT_FIRE_POLYS_SP	August 2017
Fires - Historical	WHSE_LAND_AND_NATURAL_RESOURCE.PROT_HISTORICAL_FIRE_POLYS_SP	August 2017
First Nations	SEA_Study_Areas_19JUL2017 (FROM KML)	July 2017
Forest Tenure Cutblocks	WHSE_FOREST_TENURE.FTEN_CUT_BLOCK_POLY_SVW	August 2017
Forest Vegetation Composite Polygons and Rank1 Layer (VRI)	WHSE_FOREST_VEGETATION.VEG_COMP_LYR_R1_POLY	August 2017
Geophysical Permits (Seismic)	WHSE_MINERAL_TENURE.OG_GEOPHYSICAL_PERMIT_SP	August 2017
Landscape Units (LU)	WHSE_LAND_USE_PLANNING.RMP_LANDSCAPE_UNIT_SVW	August 2017
Natural Disturbance Units (NDU)	REG_LAND_AND_NATURAL_RESOURCE.NATURAL_DIST_UNITS_RPG_POLY	August 2017
Oil and Gas Commission Facility Location Permits	WHSE_MINERAL_TENURE.OG_FACILITY_LOCATNS_PERMIT_SP	August 2017
Oil and Gas Commission Pre-2016 Facility Locations	WHSE_MINERAL_TENURE.OG_FACILITY_LOCATNS_PRE2016_SP	August 2017
Oil and Gas Commission Water Management Basins	WHSE_MINERAL_TENURE.OG_WATER_MANAGEMENT_BASINS_SP	August 2017
Oil and Gas Commission Well/Facility Area Permits	WHSE_MINERAL_TENURE.OG_WELL_FACILITY_PERMIT_SP	August 2017
Pipeline Permits	WHSE_MINERAL_TENURE.OG_PIPELINE_AREA_PERMIT_SP	August 2017
Private Land (ParcelMap BC Parcel Fabric)	WHSE_CADASTRE.PMBC_PARCEL_FABRIC_POLY_SVW	August 2017
RESULTS Openings	WHSE_FOREST_VEGETATION.RSLT_OPENING_SVW	August 2017
Well Surface Hole Event	WHSE_MINERAL_TENURE.OG_SURFACE_HOLE_EVENT_SP	August 2017

Table 1 – List of datasets that were overlaid to produce a resultant dataset which was utilized to generate old forest summary statistics

Element	Definition
First Nation	"Name"
Basin Name	"WATER_MANAGEMENT_BASIN_NAME"
NDU	"NDZ_NAME"
NDU - Boreal Foothills (Mountain)	"NDZ_NAME" = 'Boreal Foothills' AND "ZONE" IN ('ESSF', 'SWB', 'BAFA')
NDU - Boreal Foothills (Valley)	"NDZ_NAME" = 'Boreal Foothills' AND "ZONE" IN ('SBS', 'BWBS', 'ICH')
NDU - Boreal Plains (Alluvial)	"NDZ_NAME" = 'Boreal Plains' AND "LANDSCAPE_UNIT_NAME" = 'Nelson Forks'
NDU - Boreal Plains (Upland)	"NDZ_NAME" = 'Boreal Plains' AND "LANDSCAPE_UNIT_NAME" <> 'Nelson Forks'
NDU - McGregor Plateau	"NDZ_NAME" = 'McGregor Plateau'
NDU - Moist Interior (Mountain)	"NDZ_NAME" = 'Moist Interior' AND "ZONE" IN ('ESSF', 'SWB', 'BAFA')
NDU - Moist Interior (Plateau)	"NDZ_NAME" = 'Moist Interior' AND "ZONE" IN ('SBS', 'BWBS', 'ICH')
NDU - Northern Boreal Mountains	"NDZ_NAME" = 'Northern Boreal Mountains'
NDU - Omineca (Mountain)	"NDZ_NAME" = 'Omineca' AND "ZONE" IN ('ESSF', 'SWB', 'BAFA')
NDU - Omineca (Valley)	"NDZ_NAME" = 'Omineca' AND "ZONE" IN ('SBS', 'BWBS', 'ICH')
NDU - Wet Mountain	"NDZ_NAME" = 'Wet Mountain'
NDU - Wet Trench (Mountain)	"NDZ_NAME" = 'Wet Trench' AND "ZONE" IN ('ESSF', 'SWB', 'BAFA', 'IMA')
NDU - Wet Trench (Valley)	"NDZ_NAME" = 'Wet Trench' AND "ZONE" IN ('SBS', 'BWBS', 'ICH')
Landscape Unit	"LANDSCAPE_UNIT_NAME"
BEC Variant	"MAP_LABEL"
SPSI - Site Index (None)	"SITE_INDEX" IS NULL
SPSI - Site Index (Low)	"SITE_INDEX" <= 12
SPSI - Site Index (Med)	"SITE_INDEX" > 12 AND "SITE_INDEX" < 18
SPSI - Site Index (High)	"SITE_INDEX" >= 18
SPSI - Species (Aspen)	"SPECIES_CD_1" = 'AT'
SPSI - Species (Balsam Fir)	"SPECIES_CD_1" IN ['B','BA','BB','BG','BL','BN']
SPSI - Species (Balsam Poplar)	"SPECIES_CD_1" = 'ACB'
SPSI - Species (Birch)	"SPECIES_CD_1" IN ['E','EA','EB','EP','ES','EW','EX']
SPSI - Species (Black Cottonwood)	"SPECIES_CD_1" = 'ACT'
SPSI - Species (Black Spruce)	"SPECIES_CD_1" = 'SB'
SPSI - Species (Cedar)	"SPECIES_CD_1" IN ['C','CW','YC']
SPSI - Species (Douglas Fir)	"SPECIES_CD_1" IN ['F', 'FD', 'FDC', 'FDI']
SPSI - Species (Hemlock)	"SPECIES_CD_1" IN ['H','HM','HW','HX']
SPSI - Species (Pine)	"SPECIES_CD_1" IN ['P','PA','PF','PJ','PL','PLC','PLI','PR','PW','PX','PY']
SPSI - Species (Spruce)	"SPECIES_CD_1" IN ['S','SA','SE','SS','SW','SX','SXW','SXE']

Element	Definition
SPSI - Species (Other)	"SPECIES_CD_1" NOT IN [Aspen, Balsam Fir, Balsam Poplar, Birch, Black Cottonwood, Black Spruce, Cedar, Douglas Fir, Hemlock, Pine, Spruce]
Old Coniferous	"BCLCS_LEVEL_4" == 'TC' AND "PROJ_AGE_1" > 140
Old Deciduous	"BCLCS_LEVEL_4" == 'TB' AND "PROJ_AGE_1" > 100
Old Mixed Wood	"BCLCS_LEVEL_4" == 'TM' AND "PROJ_AGE_1" > 120
Young Forest	("BCLCS_LEVEL_4" == 'TC' AND "PROJ_AGE_1" <= 140) OR ("BCLCS_LEVEL_4" == 'TB' AND "PROJ_AGE_1" <= 100) OR ("BCLCS_LEVEL_4" == 'TM' AND "PROJ_AGE_1" <= 120)
Total Forest	Old Coniferous + Old Deciduous + Old Mixed Wood + Young Forest
Non-Forest	"BCLCS_LEVEL_4" != 'TC' AND "BCLCS_LEVEL_4" != 'TB' AND "BCLCS_LEVEL_4" != 'TM' AND "STATUS" != 'ALR' AND "OWNER_TYPE" != 'PRIVATE'
ALR	"STATUS" == 'ALR' AND "BCLCS_LEVEL_4" != 'TC' AND "BCLCS_LEVEL_4" != 'TB' AND "BCLCS_LEVEL_4" != 'TM'
Private Land (non ALR)	"OWNER_TYPE" == 'PRIVATE' AND "STATUS" != 'ALR' AND "BCLCS_LEVEL_4" != 'TC' AND "BCLCS_LEVEL_4" != 'TB' AND "BCLCS_LEVEL_4" != 'TM'
Total	Total Forest + Non-Forest + ALR + Private Land (non ALR)
Old Coniferous Wetland	"BCLCS_LEVEL_4" == 'TC' AND "PROJ_AGE_1" > 140 AND "BCLCS_LEVEL_3" == 'W'
Old Coniferous Upland	"BCLCS_LEVEL_4" == 'TC' AND "PROJ_AGE_1" > 140 AND "BCLCS_LEVEL_3" == 'U'
Coniferous (older than 250 years)	"BCLCS_LEVEL_4" == 'TC' AND "PROJ_AGE_1" > 250
Forest (older than 100 years)	"BCLCS_LEVEL_2" == 'T' AND "PROJ_AGE_1" > 100
Forest (140 years and older)	"BCLCS_LEVEL_2" == 'T' AND "PROJ_AGE_1" >= 140
Forest (older than 250 years)	"BCLCS_LEVEL_2" == 'T' AND "PROJ_AGE_1" > 250
Forest (less than 40 years)	"BCLCS_LEVEL_2" == 'T' AND "PROJ_AGE_1" < 40
Old Coniferous Percentage	(Old Coniferous / (Total Forest + ALR + Private Land (non ALR))
Old Deciduous Percentage	(Old Deciduous / (Total Forest + ALR + Private Land (non ALR))
Old Mixed Wood Percentage	(Old Mixed Wood / (Total Forest + ALR + Private Land (non ALR))
Forest (older than 100 years) Percentage	(Forest (older than 100 years)) / (Total Forest + ALR + Private Land (non ALR))
Forest (140 years and older) Percentage	(Forest (140 years and older)) / (Total Forest + ALR + Private Land (non ALR))
Forest (older than 250 years) Percentage	(Forest (older than 250 years)) / (Total Forest + ALR + Private Land (non ALR))
Forest (less than 40 years) Percentage	(Forest (less than 40 years)) / (Total Forest + ALR + Private Land (non ALR))
Risk (Forest older than 100 years) - Below Range of Natural Variation (RONV)	Forest (older than 100 years) Percentage <= Min
Risk (Forest older than 100 years) - Bottom half of Range of Natural Variation (RONV)	Forest (older than 100 years) Percentage > Min AND Forest (older than 100 years) Percentage <= Mid
Risk (Forest older than 100 years) - Top half of Range of Natural Variation (RONV)	Forest (older than 100 years) Percentage > Mid AND Forest (older than 100 years) Percentage <= Max
Risk (Forest older than 100 years) -	Forest (older than 100 years) Percentage > Max

Element	Definition
Above Range of Natural Variation (RONV)	
Risk (Forest 140 years and older) - Below Range of Natural Variation (RONV)	Forest (140 years and older) Percentage <= Min
Risk (Forest 140 years and older) - Bottom half of Range of Natural Variation (RONV)	Forest (140 years and older) Percentage > Min AND Forest (140 years and older) Percentage <= Mid
Risk (Forest 140 years and older) - Top half of Range of Natural Variation (RONV)	Forest (140 years and older) Percentage > Mid AND Forest (140 years and older) Percentage <= Max
Risk (Forest 140 years and older) - Above Range of Natural Variation (RONV)	Forest (140 years and older) Percentage > Max
Risk (Forest older than 250 years) - Below Range of Natural Variation (RONV)	Forest (older than 250 years) Percentage <= Min
Risk (Forest older than 250 years) - Bottom half of Range of Natural Variation (RONV)	Forest (older than 250 years) Percentage > Min AND Forest (older than 250 years) Percentage <= Mid
Risk (Forest older than 250 years) - Top half of Range of Natural Variation (RONV)	Forest (older than 250 years) Percentage > Mid AND Forest (older than 250 years) Percentage <= Max
Risk (Forest older than 250 years) - Above Range of Natural Variation (RONV)	Forest (older than 250 years) Percentage > Max
Risk (Forest less than 40 years) - Below Range of Natural Variation (RONV)	Forest (less than 40 years) Percentage <= Min
Risk (Forest less than 40 years) - Bottom half of Range of Natural Variation (RONV)	Forest (less than 40 years) Percentage > Min AND Forest (less than 40 years) Percentage <= Mid
Risk (Forest less than 40 years) - Top half of Range of Natural Variation (RONV)	Forest (less than 40 years) Percentage > Mid AND Forest (less than 40 years) Percentage <= Max
Risk (Forest less than 40 years) - Above Range of Natural Variation (RONV)	Forest (less than 40 years) Percentage > Max

Table 2 – Summary of query parameters utilized to generate Old Forest Summary Statistics

* As a note, ‘Min’, ‘Mid’, ‘Max’ values within the above table refer to Natural Disturbance values from Craig Delong, 2011; Land units and benchmarks for developing natural disturbance-based forest management guidance for Northeastern British Columbia

Appendix 2. Table of natural disturbance characteristics for NDUs- copied from Delong 2011

TABLE 3 *Estimates of statistics relatin*

Natural Disturbance Unit	Stand replacement disturbance cycle[a]	Time since disturbance distribution[b] (% of total forest area)				Patch size (ha) (% of total disturbance area)[c]				Disturbance type (% of disturbance area)[d]	
		>250 yr	>140 yr	>100 yr	<40 yr	>1000	101–1000	51–100	<50	Stand replacement	Gap replacement[e]
Boreal Foothills–Mountain	150	15–25	33–49	43–62	19–36	40	30	10	20	80	20
Boreal Foothills–Valley	120	8–17	23–40	33–55	19–45	40	30	10	20	90	10
Boreal Plains–Alluvial	200[d]	23–37	41–61	52–72	12–33	0	0	40[d]	60[d]	80	20
Boreal Plains–Upland	100	6–12	17–33	28–49	25–50	70	20	5	5	98	2
Cariboo Mountain Foothills	400	47–59	65–74	71–81	8–18	40	30	15	15	80	20
McGregor Plateau	220	26–39	43–61	54–72	13–31	40	45	5	10	90	10
Moist Interior–Mountain	200	23–37	41–61	52–72	12–33	40	30	10	20	70	30
Moist Interior–Plateau	100	6–12	17–33	28–49	25–50	70	20	5	5	98	2
Moist Trench–Mountain	300	39–50	58–69	66–77	10–22	60	30	5	5	70	30
Moist Trench–Valley	150	15–25	33–49	43–62	19–36	70	20	5	5	90	10
Northern Boreal Mountains	180[d]	20–35	37–60	48–70	12–34	60[d]	30[d]	5[d]	5[d]	70	30
Omineca–Mountain	300	39–50	58–69	66–77	10–22	40	30	10	20	70	30
Omineca–Valley	120	8–17	23–40	33–55	19–45	60	30	5	5	95	5
Wet Mountain	900	74–80	84–89	88–93	3–7	10	60	10	20	40	60
Wet Trench–Mountain	800	70–77	80–88	83–92	4–11	10[d]	60[d]	10[d]	20[d]	40	60
Wet Trench–Valley	600	63–72	76–84	81–90	4–11	10[d]	60[d]	10[d]	20[d]	60	40

a Disturbance cycles are the inverse of disturbance rate (% of total forested area/yr) × 100. Unless noted in the text, disturbance rates were derived using methodology outlined in DeLong (1998) and generalized for the NDU.

b This is the range in percent of the total forested area within the NDU that has not had a stand replacement event for the specified time period, estimated to be present at any one time. See Section 2 for details on how the estimate was determined.

c Patch size distributions were estimated using methodology outlined in DeLong (1998) except where noted in the table.

d Based on expert opinion. Methods in DeLong (1998) could not be used since much of the area has been burned by prescribed fire so natural pattern is obscured.

e Disturbance openings caused by death of individual trees or small groups of trees. Gaps are generally < 1 ha and remove < 40% of the basal area of a stand.

Appendix 3. Summary of Range of Natural Variability for old forest in different age categories. Table shows the minimum, midpoint and upper bound (from Delong 2011), that were used in this analysis.

NDU	>140-min	>140- mid	>140- max	>250 min	>250- mid	>250- max
Boreal Foothills-Mountain	33	41	49	15	20	25
Boreal Foothills-Valley	23	31.5	40	8	12.5	17
Boreal Plains-Alluvial	41	51	61	23	30	37
Boreal Plains-Upland	17	25	33	6	9	12
McGregor Plateau	43	52	61	26	32.5	39
Moist Interior-Mountain	41	51	61	23	30	37
Moist Interior-Plateau	17	25	33	6	9	12
Northern Boreal Mountains	37	48.5	60	20	27.5	35
Omineca-Mountain	58	63.5	69	39	44.5	50
Omineca-Valley	23	31.5	40	8	12.5	17
Wet Mountain	84	86.5	89	74	77	80
Wet Trench-Mountain	80	84	88	70	73.5	77
Wet Trench-Valley	76	80	84	63	67.5	72