owlland

SELES Spatial Timber Supply Model (STSM)

Assessing Timber Supply Risk

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Executive Summary

Various elements of a forested landscape that contribute to timber supply over time have differing levels of associated uncertainty or risk. Here, *timber supply risk* is defined as the likelihood that a given level of timber supply at one or more time periods will not be achieved in reality. Information on timber supply risk may be useful to better understand timber supply projections, and make decisions that anticipate and mitigate risk. This report documents a method of structured sensitivity analysis to explore timber supply risk. The approach does not require any specific timber supply modelling tools.

The Morice Timber Supply Area (TSA) is used to exemplify the process.

1 Introduction

One primary goal of timber supply analysis is to identify the most likely maximum level that can be sustainably harvested over time, based on the best available data and knowledge of the forest system, and subject to meeting the biophysical, economic and social objectives and constraints defined for a given scenario. The main scenario of focus, often called the "base case", is a representation of current management (e.g. current land-use objectives, current inventory, etc.).

There are multiple sources of uncertainty inherent to timber supply analysis, including:

- Data uncertainty: accuracy and completeness of forest inventory and other required spatial and non-spatial inputs.
- Natural process uncertainty: understanding of variable stand and landscape scale natural processes, such as tree growth, natural disturbance, and climate change.
- Operational uncertainty: variability of economic drivers of timber harvesting (including external effects such as markets, as well as aspects of decisions for which data is unavailable such as information from pre-harvest timber cruising) and access costs (including complex factors applied to develop multi-year access plans).

Much of this uncertainty cannot be significantly reduced in the foreseeable future (if ever). Hence, uncertainty should be accepted and addressed explicitly as a significant aspect of timber supply analysis.

One way that uncertainty has been addressed in previous timber supply analyses is via use of “sensitivity analyses”, which are sets of experiments in which one or more key parameters are varied (e.g. increase or decrease managed stand growth by 10%). These provide useful information to understand the stability (resilience) of the base case projection relative to potential changes in inputs. However, sensitivity analyses are typically applied as independent scenarios (that is, only one variable is changed at a time), each with a separate timber supply outcome.

We developed a method of structured analysis based on the financial concept of *risk tranches*. In complex financial investments, such as mortgage-backed securities, large collections of investments are stratified by risk class (from lower risk to higher risk), called *tranches* (“slices” in French), each of which contributes differently to expected levels of return (e.g. the nominal interest on “junk” bonds is higher than class A bonds, offsetting the higher levels of uncertainty of default).

We adapted this concept to timber supply assessment, in which inputs related to components of a timber supply landscape system can be partitioned according to expected levels of risk due to their respective uncertainty. These components may be defined as elements of the state of the forest (e.g. existing mature volume, future managed yields) and/or elements of forest processes (e.g. potential increases in landscape scale disturbance or decreases in stand growth due to climate change).

A low-risk tranche represents the portion of the timber supply projection with high certainty of being achievable, while a high-risk tranche represents the portion of timber supply with lower certainty.

For example, low-risk timber supply might be associated with low-susceptibility stands in the existing inventory, base regeneration, stands in lower disturbance areas, stands in climate refugia (areas with lower expectations of impacts from climate change). High risk timber supply might consist of stands with high-susceptibility to bark beetles or fire, long-term growth improvements (e.g. anticipated future genetic gains in growth rate), stands in high disturbance areas (especially where disturbance can affect pre-merchantable stands) and stands in areas with high expected impacts from climate change.

By defining a set of risk classes, or *timber supply risk tranches*, that range from lower risk categories to higher risk categories, the resulting additive timber supply assessments can be expressed in terms of the contribution of each risk class to timber supply. This provides a tool to help interpret the degree of risk associated with a timber supply projection, and in particular how risk changes over time.

This document describes steps to apply this approach to assessing timber supply risk, using Morice TSA as an example.

2 Step 1: Define risk classes

The first step is to define aspects of a timber supply system that have different levels of uncertainty or risk. This is dependent on the management unit, and may include one or more of the following:

- Geographic areas (e.g. high productivity, low elevation forests with good road access vs. lower productivity, high elevation forests that requires heli access or expensive road constructions)
- Forest type (e.g. cedar vs. hemlock; old-growth vs. second growth)
- Regeneration assumptions (e.g. unmanaged natural regeneration vs. heavily managed regeneration with thinning, genetic improvements and fertilization)
- Natural disturbance (e.g. assumptions of low vs. high recovery of salvage)
- Climate change (e.g. historic wildfire levels vs. increased wildfire, climate refugia)

The approach can be applied using multiple factors, either by doing separate risk assessments for different sets of risk tranches, or by combining factors into a single assessment.

At this stage, one needs to define the number of risk classes. A simple assessment may focus on just low vs. high risk, but a more detailed assessment may include a gradient of as many risk classes as desired.

3 Step 2: Structured sensitivity analysis

The basic method involves assessing a set of “nested” sensitivity analysis scenarios. The first scenario to assess is the lowest risk class. In principal, this provides the lowest risk (most certain) timber supply projection.

Subsequent scenarios are then assessed, each incrementally adding the next lowest risk class. The timber supply outcome will normally be the same or higher than the previous outcome across all time periods. That is, because the factors that contribute to timber supply included in a scenario are additional to those for a prior scenario, the resulting timber supply will generally be nested, with the subsequent scenario realizing an increased timber supply in one or more time periods. The final scenario will include the full timber supply for all risk classes.

4 Step 3: Overlay and assess results

Instead of a timber supply “flow” being shown as a single line (volume harvested over time), the structured analysis of scenarios using risk classes allows timber supply to be shown as a surface (volume contributed from each risk class over time).

The resulting timber supply surface can then be examined for how and when each risk class contributes to timber supply. Since uncertainty tends to increase over projected time, the contribution of future timber supply will tend to come from increasingly risky classes. However, one of the main reasons to do formal timber supply analysis is because mid and long term behaviour (e.g., the assumption that a particular component of the inventory will be available for harvest) can sometimes have an effect on short term timber supply. Hence, higher risk timber supply classes may contribute significantly to short term timber supply. That is because risk classes are assessed in terms of how they contribute to resulting timber supply, not to the exact stands harvested. For example, including a higher risk class may result in a significant increase in short term harvest levels. The stands harvested in the short term may be considered lower risk individually, but the timber supply assessment may allow a higher level of such stands to be harvested in the short term because of the assumption that higher risk stands will be available to support the mid and/or long term.

5 Putting it together: example from Morice TSA

5.1 Step 1: Define risk classes

For illustration, in the Morice TSA case study, we assessed two different sets of risk tranches:

(a) Volume type risk classes:

- Tranche 1: includes existing mature volume only with no further growth increment (and regenerated on natural yield curves).
- Tranche 2: includes volume growth increments on existing mature stands.
- Tranche 3: includes existing immature stands (but all still regenerating on natural yield curves).
- Tranche 4: includes regeneration on managed yield curves (i.e. to assess differences between unmanaged and managed yields).

(b) Climate change risk classes:

- Tranche 1: includes timber supply subject to impacts on stand growth (losses increasing linearly from 0% to 25% at and after 100 year) and landscape-scale natural disturbance (increasing linearly up to 50% at and after 100 years), with disturbance in random stand order (i.e. timber supply resilient to climate change impacts).
- Tranche 2: includes supply due to assuming no stand-scale effects of climate change (i.e. the effect of removing the increases in stand growth impacts in Tranche 1).
- Tranche 3: includes supply due to assuming no landscape-scale disturbance effects of climate change (i.e. the effect of removing the increases in landscape-scale impacts in Tranche 1).
- Tranche 4: includes supply due to assuming an oldest-first rather than random order for natural disturbance (i.e. the effect of assuming that natural disturbance affects stands are more likely to contain merchantable salvageable volume, which is closer to assumptions often used to represent non-recovered losses).

5.2 Step 2: Structured sensitivity analysis

Each risk class was assessed for timber supply using standard methods.

5.3 Step 3: Overlay and assess results

5.3.1 Volume type risk classes

The results from applying the volume type risk classes indicates that over the mid to long term, a fairly high proportion (nearly 40%) of timber supply depends on the difference between managed and natural stand yields (Tranche 4 in Figure 1). Nearly 25% depends on existing managed stands (Tranche 3). Only a few percent depends on growth increment to existing natural stands, while over 1/3 depends on existing natural stands (regenerating minimally on natural yield curves; Tranche 1). Short-term timber supply depends heavily on existing natural stands, and to a lesser degree on existing managed stands, until after 10 years.

Note the results can be presented graphically using volume harvested on the y-axes or, as done here, as the percent of the overall harvest contribution by each risk class.

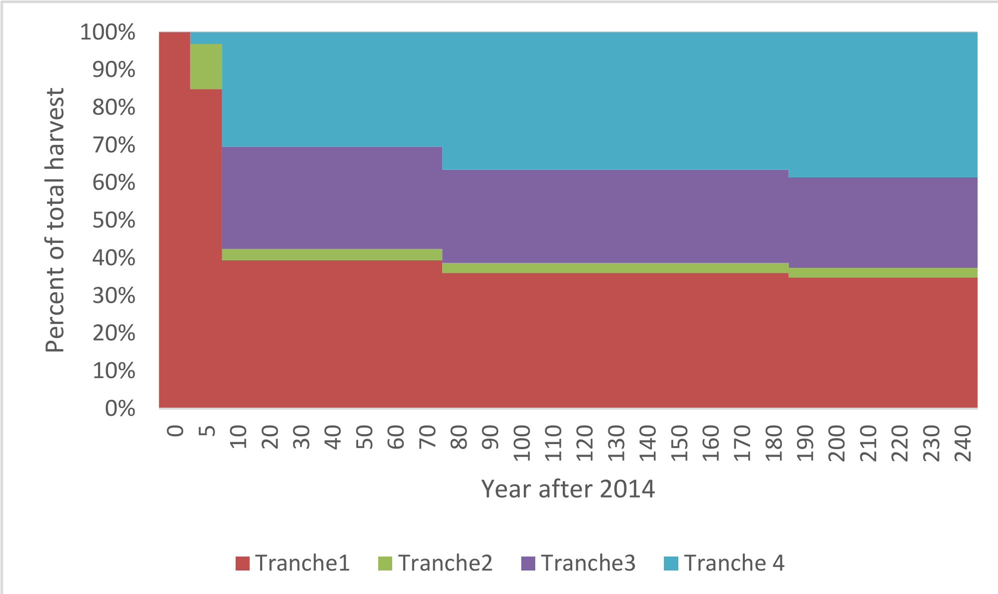

Figure 1. Harvest tranches for the set of risk classes based on volume type. Tranche 1 is existing merchantable volume plus future "unmanaged" volume (i.e. stands are regenerated on natural yield curves). Tranche 2 also includes volume increments on existing mature stands. Tranche 3 additionally includes existing immature stands (but all still regenerating on natural yield curves). Tranche 4 includes regeneration on managed yield curves.

5.3.2 Climate change risk classes

The results from the climate change risk classes indicate that about 60% of the timber supply over the mid to long-term appears to be resilient to fairly high levels of climate change impacts on both stand growth and natural disturbance (Figure 2; Tranche 1). About ¼ of supply after 10 years depends on stand growth remaining robust (Tranche 2). Between 13 and 18% depends on natural disturbance levels not increasing (Tranches 3 and 4).

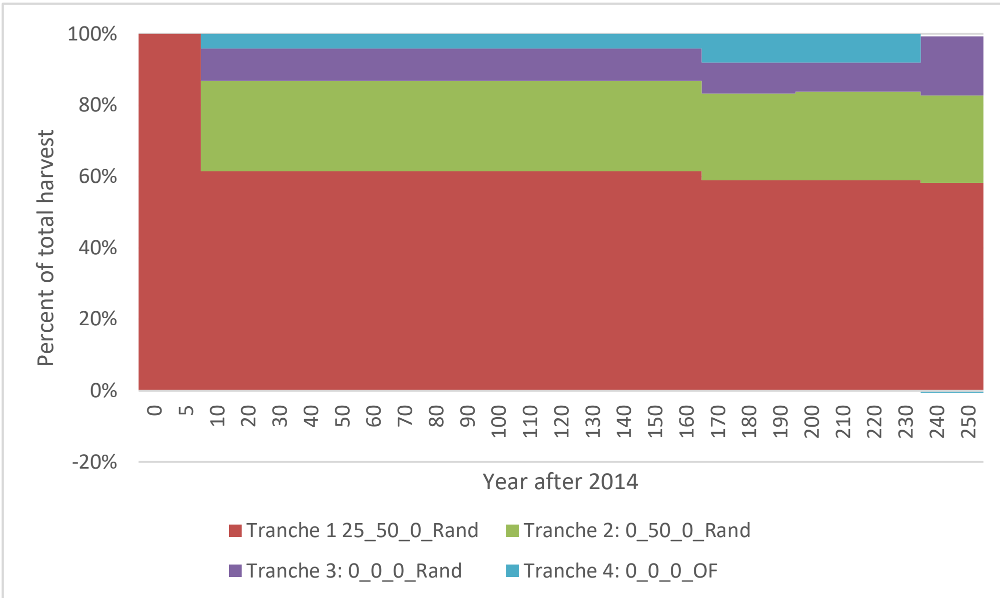

Figure 2. Harvest tranches for the set of risk classes based on potential climate change impacts. Tranche 1 is supply even under climate change impact on stand growth (linear up to 25% at and after 100 year) and landscape-scale natural disturbance (linear up to 50% increase at and after 100 years), with disturbance in random stand order. Tranche 2 also includes supply with no stand-scale effects of climate change. Tranche 3 additionally includes supply with no increase in landscape-scale disturbance. Tranche 4 includes supply from applying an oldest-first rather than random order for natural disturbance.