Nadina Climate Change Vulnerability Assessment:

Summary of Technical Workshop 2. Impacts on trees and timber

Workshop held, Nov 22, 2010, Smithers, BC.
Summary prepared by Dave Daust, Nov 23, 2010.

Participants

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Introduction

The purpose of this workshop was to develop a high-level conceptual model describing how trees and timber supply will be affected by climate change. The model will support a vulnerability assessment of the Nadina forest management regime. Timber supply was identified as a valued ecosystem service in an earlier workshop[1].

Dave Daust presented current conditions and expected climate change in the Nadina. Then participants discussed a conceptual model describing potential impacts on timber supply and estimated changes in disturbance rates and productivity.

Timber supply

Timber supply depends on the sum across the landscape of the likely harvestable volume of each stand, where likely harvestable volume accounts for potential volume growth in a stand (productivity) and the chance that the stand will not reach rotation age (or will have reduced productivity) due to various disturbance agents (Figure 1). Productivity and the susceptibility of the stand to mortality can be influenced by management, particularly planting climatically-suited tree species and genotypes (“facilitated migration”) and by increasing diversity at stand and landscape scales (e.g., species and age class diversity). Available timber will depend also on reserves set aside for conservation and on the age class structure of the forest. There is considerable uncertainty about how severely timber supply will be impacted by climate change, as demonstrated by differing perspectives at the workshop.

[1] Daust, D., D. Morgan and K. Zielke. 2010. Summary Nadina climate change vulnerability workshop. Held April 20th 2010, Burns Lake, BC. Access from http://bvcentre.ca/research/project/a_multi-scale_trans-disciplinary_vulnerability_assessment/

Expected high variability in disturbance timing will increase the variability of harvestable forest over time. Some periods may have abundant harvestable timber and some periods may have little. Large disturbances of mature forest may or may not be salvaged depending on decay rates, the ability to make different products from decayed wood and on demand.

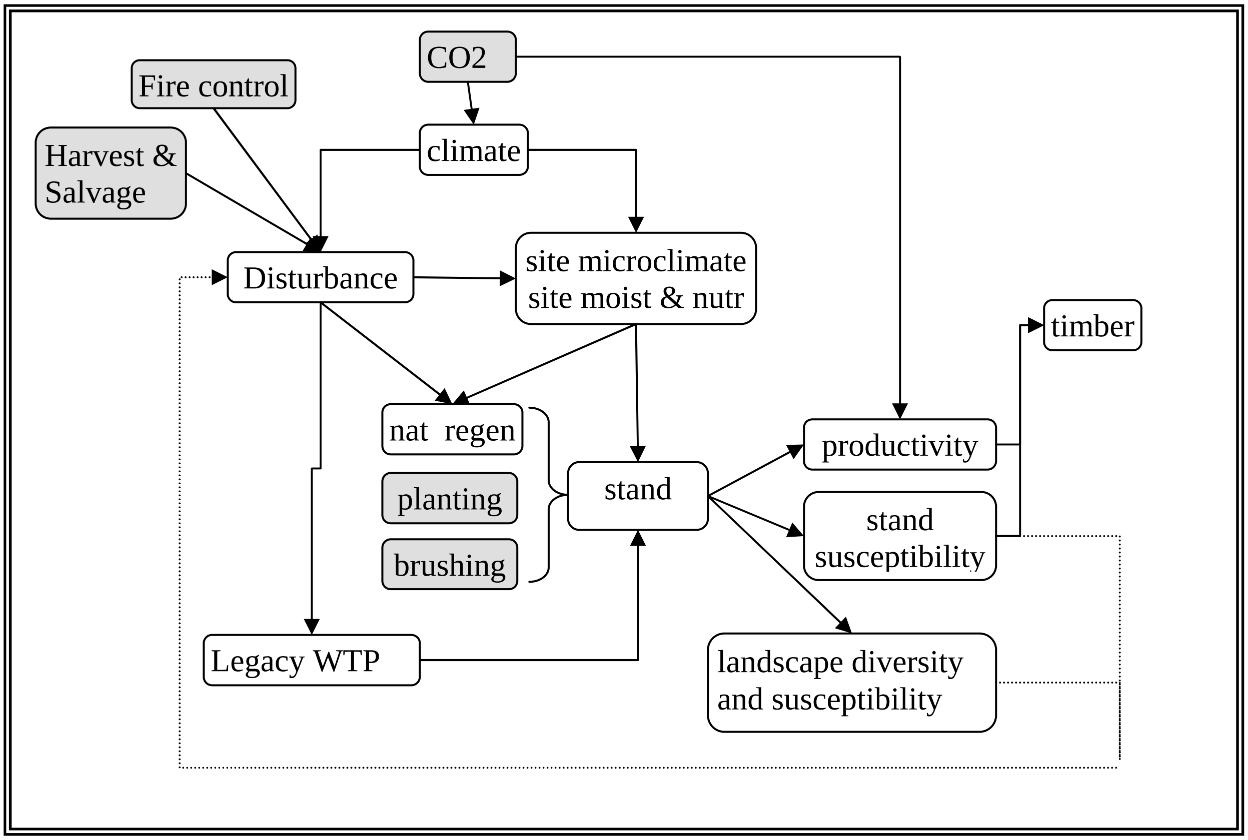

Figure 1. Rough conceptual model of factors influencing timber supply. Boxes show ecological components and processes. Grey boxes show management interventions. Arrows show chains of influence.

Disturbance

Disturbance agents include abiotic ones such as fire, windstorms, ice/snow storms and extreme drought, and biotic ones such as insects and disease.

Storms and droughts

Climate change is expected to increase the variability in regional climatic conditions. For example, summer temperatures may increase only a couple of degrees on average but summers may follow trends of very cool and then very hot. Such variation will increase abiotic disturbances that affect trees.

We discuss changes in site moisture regimes under the stand productivity section below. That section does not account for mortality from extreme droughts associated with increased climatic variability.

Fire

Area burned by fire is expected to approximately double, without fire control. Better estimates should be available from Phil Burton over the next year.

Fire affects stands of all ages and species, but some stand types may be somewhat resistant to fire. At the landscape scale, strips of deciduous trees and of old coniferous forest may serve as fire breaks, but their efficacy is uncertain.

Late seral insects

In addition to fire and severe weather (e.g., wind and ice storms), late seral stands are mainly disturbed by bark beetles in the Nadina. The probability of beetle disturbance depends on the virulence of the beetle population and the amount and contiguity of suitable hosts. Virulence is expected to increase due to longer, warmer summers that favour population growth and a reduced frequency of extreme cold periods that cause high mortality. Spruce bark beetle is expected to shift from a two year to a one year maturation cycle before 2050, substantially increasing population growth rate when suitable hosts exist. Balsam bark beetle may do the same. Based on observed changes to date, the probability of beetle-induced stand-replacing disturbance has probably doubled for a given landscape.

The severity of the current mountain pine beetle outbreak in lodgepole pine forests in the Nadina reflects increased beetle virulence and a large, dense host population. Warmer temperatures have also allowed mountain pine beetle to move to higher elevations and infest whitebark pine.

Complexes of beetles that formerly existed at endemic levels and caused minor damage are likely to cause increased mortality as the climate warms.

Early seral disease

In addition to fire and severe weather (e.g., drought, frost pockets), early seral stands are mainly disturbed by disease, not insects, although the relative proportion of insect damage could increase under climate change. Diseases are most prevalent on lodgepole pine in the Nadina (e.g., Commandra stem rust; Dothestroma needle blight). Pine have evolved to densely colonize fire-disturbed sites and disease agents have evolved to take advantage of this homogenously-distributed host.

Within a stand, disease-caused mortality can range from low (< 1/3 of trees; similar to a thinning) to high (> 2/3 of trees; stand destroying from a timber supply perspective). Based on recent history in plantations, only a small percentage of stands (e.g., 10%) face stand-replacing disturbance or reduced timber productivity (e.g., 20%) due to early-seral disease (e.g., Figure 2). Most stand mortality would be relatively minor.

Early seral stands in the eastern plateau portion of the Nadina District face increased disturbance rates from disease agents as the climate warms (Figure 3). Historically, natural stands faced some small chance of stand-wide mortality (Figure 3, column 1), but such events are relatively uncommon in mixed species stands and dense pine stands of natural origin. In mixed stands, resistant species remain. In dense stands, a small proportion of survivors may still provide adequate stocking.

Recent climate change (approx. 0.75 deg. from 1900 to present) has led to increased rates of stand-wide mortality events in planted stands (Figure 3, column 2). Up until recently, standard reforestation practices ("1990 style") have favoured lightly stocked (1200-1600 stems/ha) pine monocultures. Disease spread is rapid in such stands because few non-host species are present to act as barriers to spread and to stock the site after the outbreak.

Projected climate change could lead to high mortality in ¼ to ½ of early seral stands. This projected increase is based on two general trends and on the observation that 60% of planted pine monocultures were severely impacted in one study. The two main general trends follow. Insect and disease species will become more virulent and will expand their range as temperatures (particularly overnight temperatures) increase. Host trees will become more susceptible due to climate induced stress, the most important of which may be drought stress.

Two strategies in combination, facilitating migration of climatically-suited trees and increasing tree species diversity, can reduce disease-related mortality (Figure 3, column 4). "Facilitated migration" is the practice of planting tree species and genotypes that are expected to be better adapted to future climatic conditions. In theory, these trees should be less stressed by the future climate and therefore less susceptible to disease. Identifying appropriate species and genotypes is challenging for several reasons. First, geneticists have a history of focussing on volume growth rather than on disease resistance and on other traits that confer resilience, such as drought tolerance. New selection criteria will need to be developed. Second, because trees live a long time and the climate is changing rapidly, it will be difficult to ensure trees are well adapted for their lifetime. In particular, trees are susceptible to climate-related stresses during the establishment phase, so it may be difficult to establish species and genotypes originating from further south even though they are expected to be better adapted over their lifetime. Third, future climatic trends are uncertain.

Increasing the diversity of conifer and non-conifer tree species in a stand increases the spacing of host trees, reducing disease transmission, and increases the proportion of the stand that survives, because diseases are species specific.

At the landscape scale, diversity in stand age and leading species (particularly deciduous versus coniferous) should reduce the spread of insects and disease, which prefer specific species and ages of trees. Large strips of deciduous trees and/or of a locally atypical seral stage may serve as barriers.

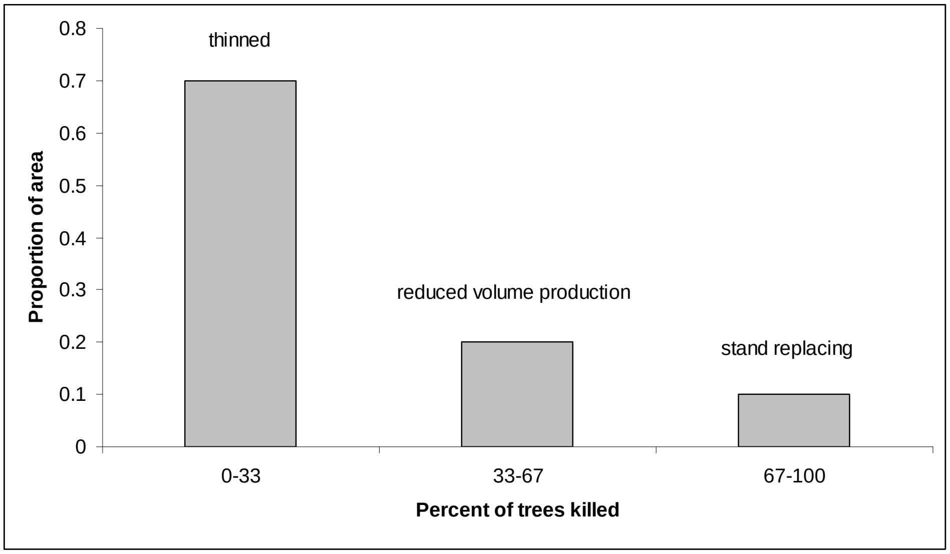

Figure 2. Hypothesized distribution of diseased early seral stands by mortality class.

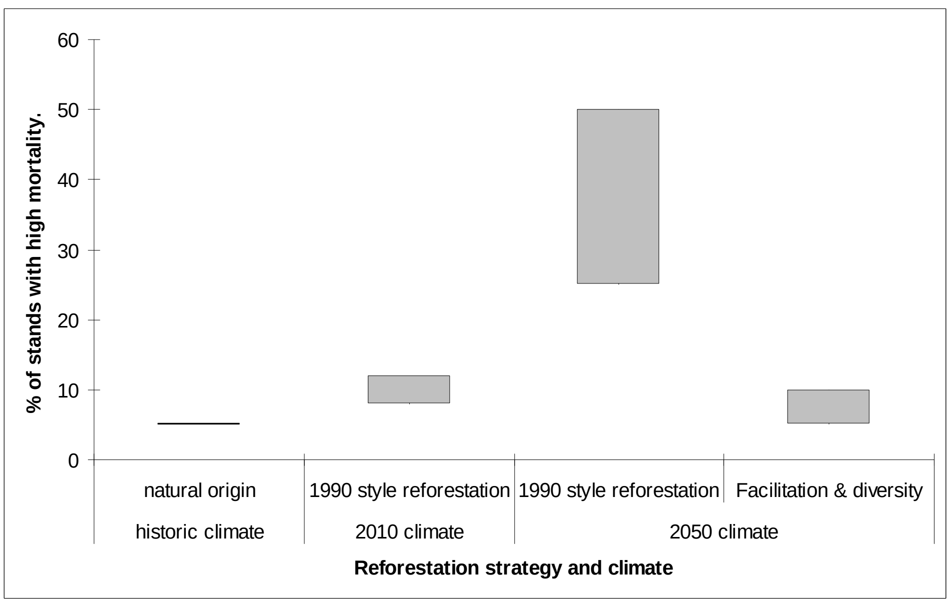

Figure 3. Hypothesized percentage of early seral stands in the eastern plateau portion of the Nadina District that will incur high tree mortality due to insects and disease for different climatic conditions and reforestation strategies. Boxes show range of best estimates. Ideally, boxes should have tails to show uncertainty.

Productivity

Changes in moisture availability of sites

Climate change is expected to increase drought stress on drier sites unless rainfall increases substantially, because warmer temperatures increase evaporation and because increased tree growth (see below) increases transpiration (although moisture lost per unit of respiration decreases as atmospheric CO_2 increases). Conversely, drier conditions may increase productivity on sites where growth is limited by excess moisture. In the eastern plateau portion of the Nadina, drought stress will likely have more impact than in the western mountains. PEM exists for the Nadina, thus, the area of dry sites that face lower productivity and higher mortality and of wet sites where productivity may increase could be calculated (see mock up Figure 4). In the workshop we estimated that the proportion of dry sites with marginal timber production may double from the current level of about 5 to 10%.

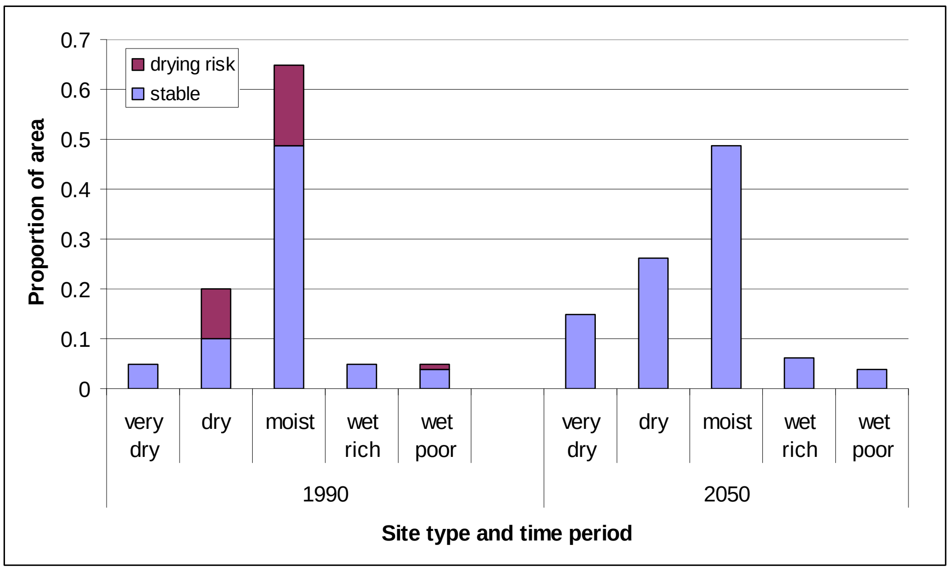

Figure 4. Mock up: distribution of site moisture classes in the SBSdk in 1990 (based on PEM) and projected for 2050. The 2050 distribution is created by shifting the sites facing "drying risk" in 1990 to the next driest class. To create this graph, we need to estimate the distribution of sites and the proportion of each site that faces drying risk. PEM is available, but not used for this mock up.

Sites with sufficient moisture

Climate change is expected to create warmer and longer growing seasons. Coupled with increased atmospheric CO_2, these conditions should increase growth where moisture or other nutrients are not limiting (Figure 5). Climate change alone should increase productivity by 10 to 25%. Planting of climatically-suited species and genotypes (i.e., facilitated migration), will further increase productivity.

The benefits of facilitating migration should be separated from those of improving genetic stock. From within climatically-suited genotypes, it should be possible to select genetic stock that both increases productivity and increases resistance to disease. These benefits have not been explicitly shown in Figure 5.

This section has considered potential changes in growth without accounting for disturbance agents that reduce growth rates or stocking measurably (see disturbance above).

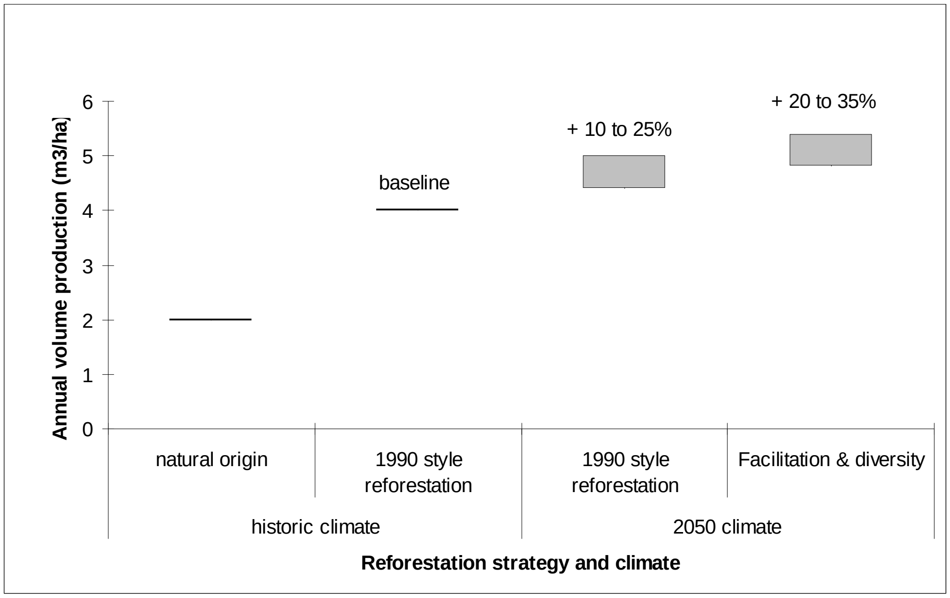

Figure 5. Annual volume production for different reforestation practices, under different climatic conditions.

Salvage

Naturally-disturbed stands, particularly those with high structural retention, provide different habitats than managed stands and should not be eliminated from the landscape. Conversely, salvage provides the opportunity to facilitate tree species migration and to increase stand diversity.