British Columbia's Seed Orchard Program: Multi Species Management With Integration To The End User

By

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British Columbia is Canada's most western and third largest province with an area of 950,000 square kilometres, ranges in latitude from 49 to 60 degrees, and 95% of the land is owned by the province. It is also Canada most ecologically diverse province. B.C. is divided into 14 unique ecosystem zones. It uses what is called a Biogeoclimatic Ecosystem Classification system to provide resource professionals with detailed information about the climate, soils, growing conditions and characteristic vegetation in each zone so they can be sure management decisions about forests, rangeland and wildlife reflect the special needs of each area.

The province has 49 tree species (25 conifer and 24 deciduous) of which 20 are considered commercially useable. Seed is very important in British Columbia. In the last 14 years, over 200 million seedlings were planted annually. In the last three years over 250 million seedlings were planted while 2007 saw 275 million seedlings of 23 different species planted on over 150,000 hectares. The 2007 sowing was comprised of 3,300 sowing requests from 1,341 seedlots that used 2,493 kilograms of seed.

British Columbia's tree improvement program started in 1951 with Dr Alan Orr-Ewing conducting studies with "in-breeding". Plus tree selection began in the late 1950's in coastal Douglas-fir. The first seed orchard was built in 1963 while other species were started in the early 1970's. There are two Branches of the Ministry of Forests and Range (MFR) that are involved with tree improvement in B.C. Research Branch has nine scientists and many technicians responsible for breeding, testing, and selection, while Tree Improvement Branch is responsible for seed production on six production sites, extraction & storage at a centralized Tree Seed Centre, and policy and planning. Today there are 11 species of conifers and 1 deciduous species that are in BC's tree improvement program (see Table 1)

Table 1: Tree Species of the British Columbia Tree Improvement Program

Species	Common Name	# ramets	# orchards
1. Pinus contorta var. latifolia	Lodgepole Pine	63,260	27
2. Picea glauca	White Spruce	26,280	26
3. Pseudotsuga menziesii var menziesii	Coastal Douglas-fir	12,775	14
4. Pseudotsuga menziesii var glauca	Rocky Mountain Douglas-fir	10,760	9
5. Larix occidentalis	Western Larch	4,080	4
6. Pinus monticola	Western White Pine	5,440	6
7. Pinus ponderosa	Ponderosa pine	1,775	2
8. Tsuga heterophylla	Western Hemlock	3,145	9
9. Thuja plicata	Western Redcedar	1,405	6
10. Picea sitchensis	Sitka spruce	1,440	4
11. Chamaecyparis nootkatensis	Yellow cedar (hedges)	22,090	4
12. Betula papyrifera	Paper birch	150	2
		152,600	113

Every parent in every seed orchard has a breeding value calculated from progeny tests and BC's seed orchards have an average of 57 parents in them. Additional progeny test results will reduce this number in the future; however seedlots must have an effective population size of 10 before they can be used in reforesting BC's public land base, so most orchards will probably maintain an average of 25 to 30 parents.

The contribution of the parental breeding values to a seedlot results in the calculation of a genetic worth for that seedlot. Genetic worth (GW) can be calculated for volume gain, wood quality, or pest resistance. GW's for volume gain range from 5 to 34.

While most of the seed orchards listed in Table 1 have been developed for volume gain, some orchards have also been selected for pest resistance against pests such as the White Pine Blister rust, Sitka Spruce leader weevil, and various rust diseases. Research is finding resistance against other pests such as the Mountain Pine Beetle, deer browsing, and root rot all of which will one day be incorporated into new seed orchards.

BC has 14 major seed orchard sites, six are on the coast and eight are in the interior. Seed production is also a shared responsibility among the private sector and the MFR. The MFR has six sites and the private sector has eight. These sites are located in three main areas of B.C.; on the south-east coast of Vancouver Island, the north Okanagan area of the southern interior, and near Prince George in the central interior of the province. The coast and southern interior sites get over 2000 hours of sunshine per year; the coastal orchards receive around 85 cm of precipitation per year, while the interior orchards receive around 45 cm per year. The most northerly orchard is located at 54 degrees latitude near Prince George.

The Forest Genetics' Council is an advisory body that provides advice to the Province's Chief Forester and has set two major goals:

1. That 75% of all seed used for reforestation in the province is to come from seed orchards by the year 2105. Currently the province plants over 270 million seedlings per year and over 50% comes from orchards, so that means around 135 million seedlings per year are currently produced from orchards and this figure will rise to around 200 million to meet the goal.
2. The average genetic worth (in volume gain) of the seed is to be 20% by 2020. Currently, the average gain of the seed orchard production is 14%.

All of the productive capacity needed to reach these goals has now been established in seed orchards and just need time to mature to the seed production age.

The key to making this program work is a very structured business and strategic plan.
The province is divided into multiple seed planning zones for each species. These zones, when classified elevationally are called seed planning units (SPU). Seed planning units are geographically distinct areas that form the basis for gene resource management, including: tree improvement (breeding, orchard crop production), seed transfer (areas of use), monitoring and gene conservation. SPUs are based on species (see figure 1), ecological zone, elevation, and, in some cases, latitude band. B.C. has 90 SPU's of which 50 have been selected for inclusion into the business plan. There are seed orchards for 37 SPU's while the balance of the zones are included in the plans for genecological or conservation purposes. For some species in some SPU's there are multiple orchards on different sites due to historical development or ownership patterns.

The sites are generally multi- species sites - the largest Ministry site is about 35 hectares and 20,000 ramets (see figure 2) while the largest private site is 85 hectares and 40,000 ramets. In total, the fourteen seed orchard sites cover just over 400 hectares of land.

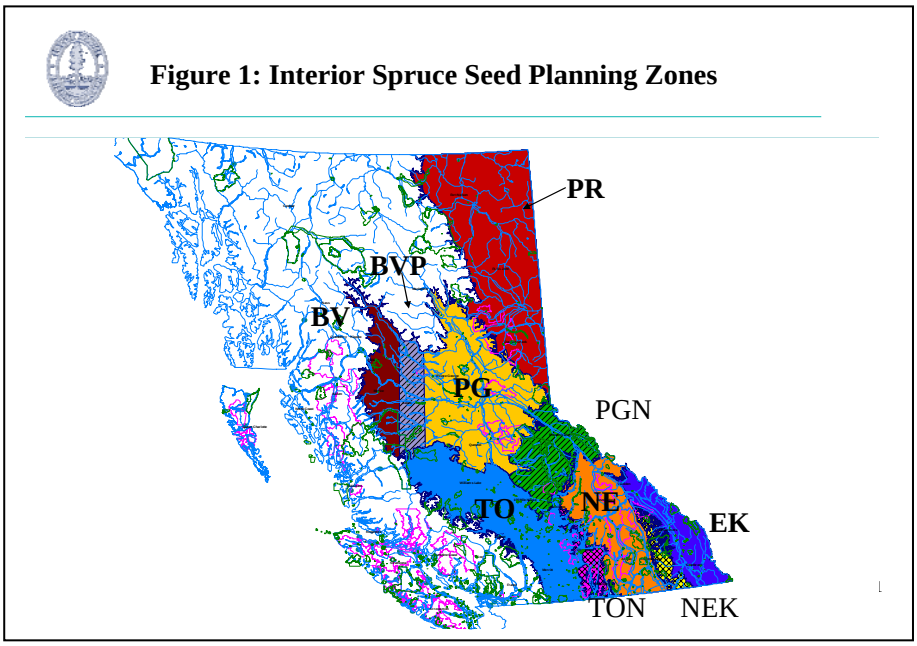
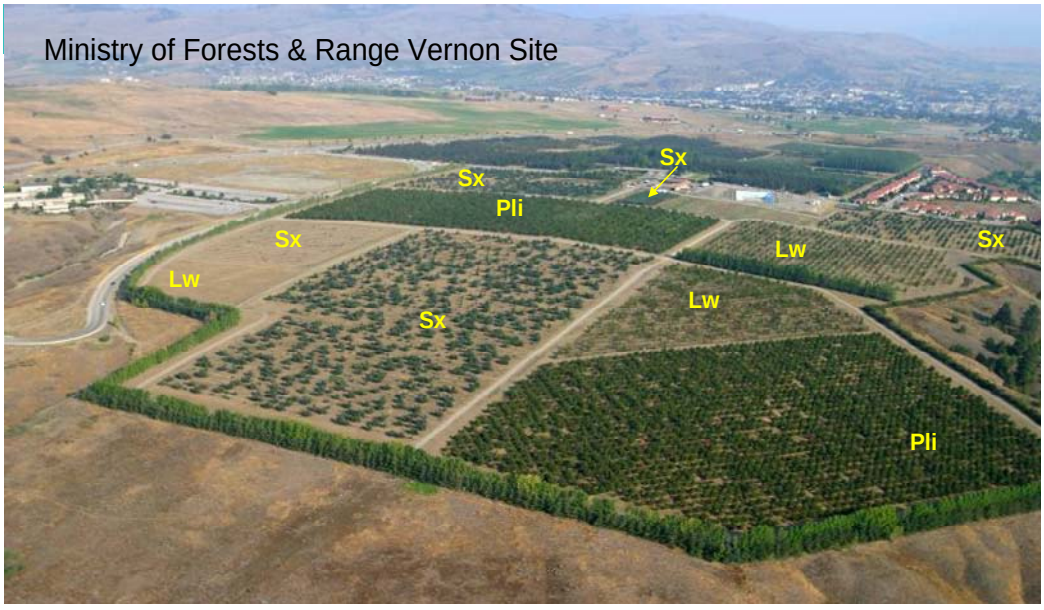


Figure 2: A 35 hectare site that has ten seed orchards of three species. Each seed orchard produces seed for a different Seed Planning Unit. This site and three others were developed on grasslands while most other sites were derived by clearing forested areas. Tree spacing varies by species: Lw: 5m x 2m, Sx: 5m x 5m, Pli: 5m x 4m and 7m x 3.5m, Fdi: 6m x 3m, Pw: 6m x 4m.



Managing multiple species means that pollination season lasts for 5 months as the individual species have different physiological developmental times. Red cedar pollen season starts in February and White Pine in mid June with the other species in between (Figure 3). Supplemental mass pollination (SMP) is used frequently in young or old orchards where there is an insufficient internal pollen cloud to ensure cones maximize their filled seed potential. SMP is also used to help boost the genetic worth of seedlots by applying high breeding value pollen. Controlled pollination is done operationally in B.C. seed orchards but not on a large scale due to the high labour cost of this technique.

Figure 3: Multi-Species Pollen Management runs from February to June

British Columbia MFR employs three cone and seed entomologists to help control insect problems at the seed orchards and conduct research into new pests that constantly appear and develop integrated pest management programs to help control populations as the ability to use and availability of registered pesticides shrinks. Entire seed crops can be lost if staff are not vigilant.

Cone harvest can start in July for Interior spruce and go into December for Lodgepole pine. Since the first seed orchard cone crop in 1976, and not including the 2007 crop, over 15,240 kilograms of seed have been produced from BC seed orchards. This is enough seed for over two billion seedlings.

Most cones are sent to the Provincial Tree Seed Centre (TSC) (celebrating its 50th anniversary in 2008) for seed extraction, testing and storage; although there are three private extractories in B.C. It is a provincial requirement that all seed to be used in public land reforestation must be tested and stored at the TSC. Approximately 70,000 kilograms of orchard and wild seed are stored at the facility. Selection of seed by the forestry companies for their sowing requests is done through an online computerized catalogue ordering system called the " Seed Planning and Registry" system (SPAR) maintained by the MFR. It is provincial policy that all public land must use seed orchard seed of GW 5 or better first if it is available on SPAR before wild stand seed can be used. The cost of seed orchard seed varies by species. The provincial or domestic price list appears in Table 2 below:

Table 2: British Columbia MFR Domestic Seed Price List

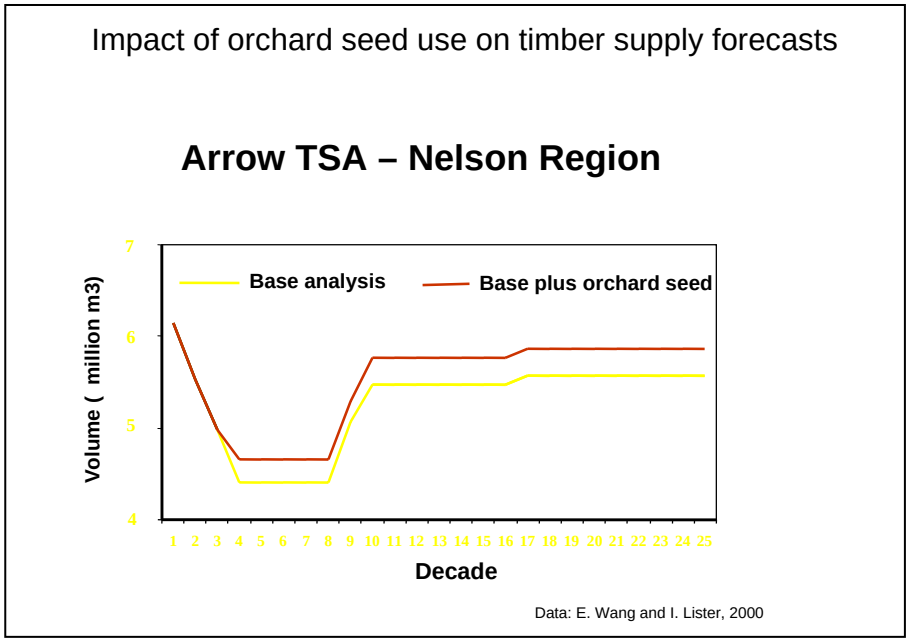
	Species	Cost / Kg ($CAN)
1	Douglas fir	$3,850
2	Red Cedar	$6,500
3	Lodgepole pine	$6,300
4	Spruce	$4,400
5	Western Hemlock	$5,500
6	Western Larch	$3,850
7	Western White Pine	$2,500

While the above prices may seem high to some, the incremental cost of using orchard seed over wild seed translates to approximately $40 per hectare when planting 1,600 seedlings per hectare. There are also many other benefits to using seed orchard seed. In the early years of plantation survival, orchard seed grows faster and thus may eliminate the need for costly brushing and weeding treatments that can cost over $1,000 per hectare per year. Seed orchard plantations will also reach "free growing" sooner which is a regulatory designation that will permit adjacent timber to be harvested. Then, there is the benefit of producing more timber volume faster and reducing rotation ages. This last benefit is where the use of seed orchard seed is a major benefit to the end users in B.C. which are the forest company licensees that operate on the public Timber Harvest Land Base (THLB).

Timber supply in BC is calculated on 71 management units called timber supply areas. The Chief Forester sets the Allowable Annual Cut (AAC) and is reviewed every 5 years. As the source of the seed planted out is tracked in a database, it is a matter of tracking the genetic gain of the seed used and inputting this data into a managed stand growth model.

Data is then run through forest estate models and other considerations to arrive at an AAC determination. The volume gain from using seed orchard seed is represented in Figure 4. A base case is calculated without using improved seed and then run using improved seed. The resulting difference can be seen in the higher line. This is volume that is available for use to the licensees.

Figure 4:



The use of seed orchard seed in this TSA has an impact on the timber flow as early as decade three.

Calculating AAC's in B.C. has been challenging since the Mountain Pine Beetle (MPB) insect infestation has been attacking the Lodgepole pine forest of BC since the mid 1990's. The normal cold climatic conditions that normally control such outbreaks have not occurred. Thus, as of 2007, the outbreak has killed over 50% of the Pli on 10 million hectares (Figure 5) and when the outbreak is expected to finish around 2013, it will have killed over 80% of the Pli over 13 million hectares or an estimated one billion cubic meters of wood. The insect has not behaved according to its normal pattern which is to normally attack mature and over mature timber. Due to its outbreak size it is attacking trees as young as 15 years old. This has

serious long term implications for timber supply in BC. BC's seed orchards were never sized to meet this extra need, so reforestation of beetle killed areas is being done with wild stand seed. Thus volume gains will not be expected in these areas.

Figure 5: An example of the widespread Mountain Pine Beetle infestation killing Lodgepole Pine in British Columbia's forests.

Climate change is a global concern. Studies conducted at the University of British Columbia Centre for Gene Conservation have outlined how temperatures in B.C. will shift over the next 70 years and the impact this may have on the ecosystem zones (see Figure 6). Species will shift also and where some species may increase their potential range, other species range will decrease (see Figures 7 & 8). This presents dilemmas to forest managers who must decide what seed source to plant now that will survive the anticipated upcoming climate change. SPU boundaries will change and seed orchards will have to change as well. B.C. is implementing a new range of multi-species test plantations over 18 locations around the province that will help guide decision makers and indicate a course of direction. However, we may not be able to wait for the data to be analyzed as the trees we plant today must survive for the next 60 to 100 years depending upon location. One course of action that is being considered is what is called "facilitated migration". This is where, for example, instead of using 100% of the seed for a defined SPU, a manager will start to include seed from either lower elevations or more southerly latitudes from other SPU's. As the first ten years of a plantations survival is the most fragile, this course of action is not without its risks. To do

nothing also appears to be risky, so the key question will be “when to implement new strategies and actions?”

Figure 6: Prediction on how climate change may impact the ecological zones of B.C. from the current zones to a prediction for the year 2085.

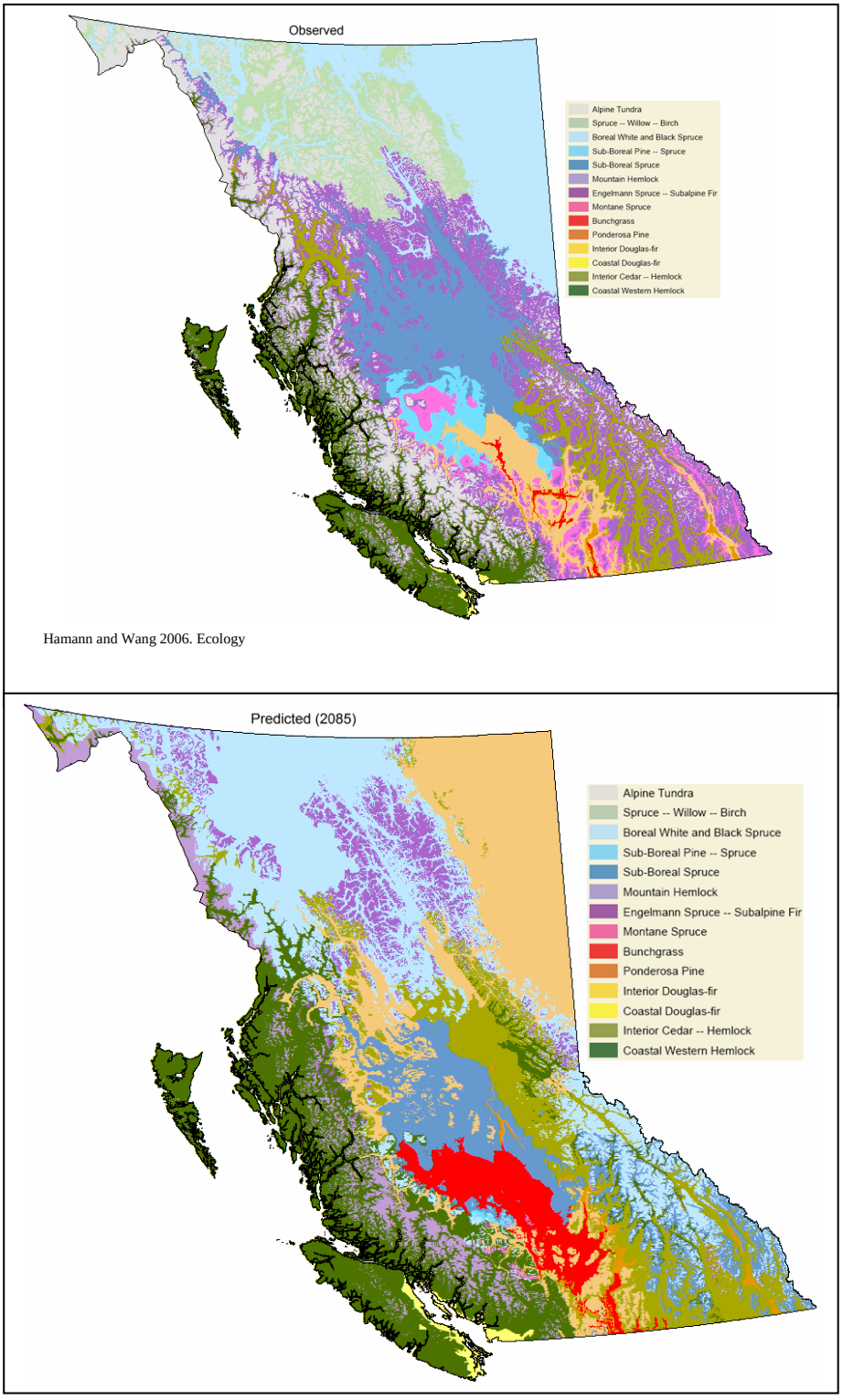
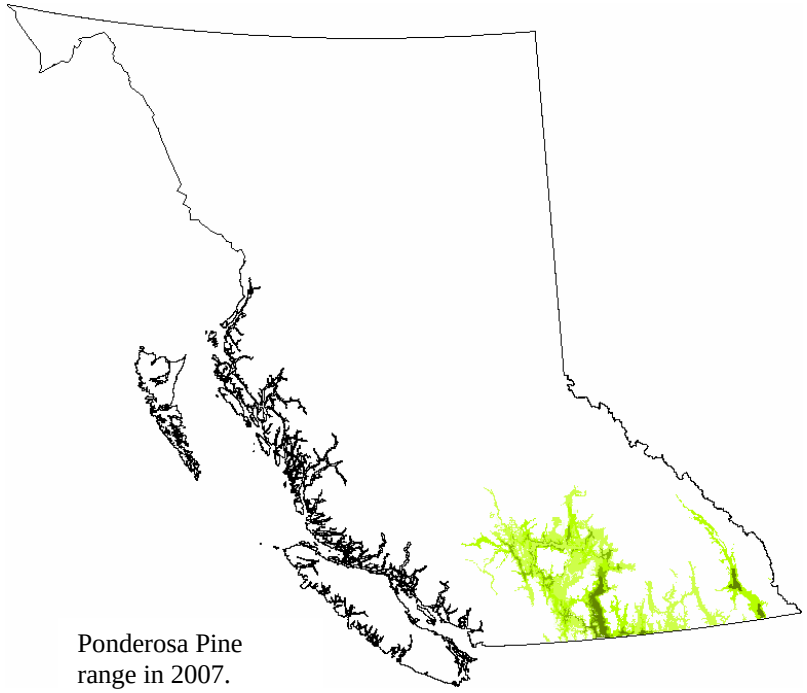
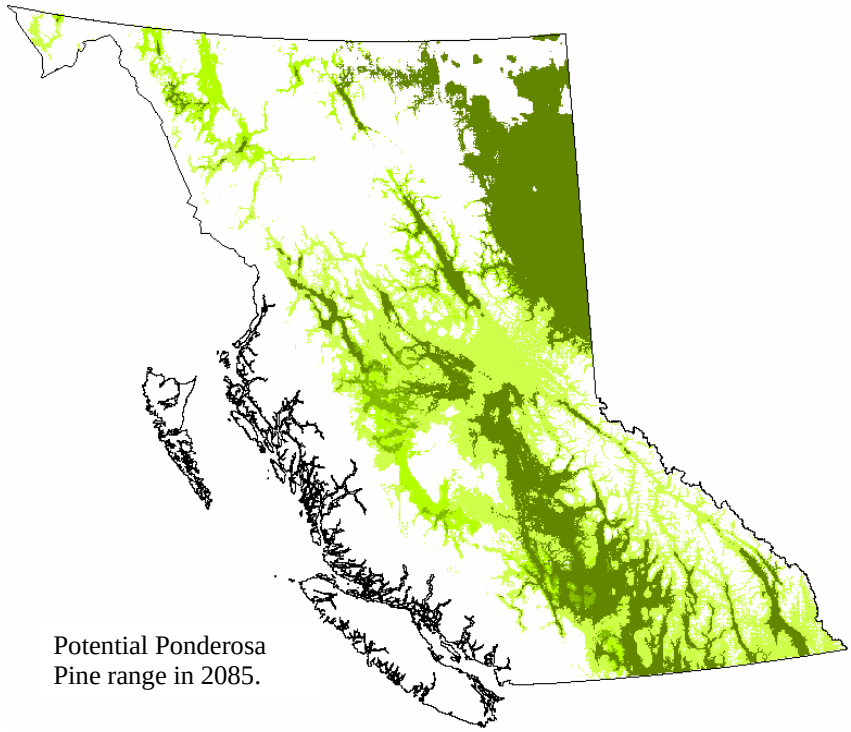


Figure 7: The top diagram indicates the current range of Ponderosa Pine in 2007 while the bottom diagram shows the potential range in 2085.



Ponderosa Pine range in 2007.



Potential Ponderosa Pine range in 2085.

Figure 8: The lower figures are the current and predicted ranges for White Spruce. (from Hamann and Wang 2006, Ecology).