Climate Change, Forests, and the Forest Nursery Industry

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Introduction

The devastating consequences of Hurricane Katrina demonstrate how ill-prepared people are when it comes to extreme weather events and potential changes in climate. The hurricane itself cannot be directly ascribed to climate change, but the likelihood of stronger hurricanes can be. The more energy the atmosphere has as it warms because of increasing concentrations of greenhouse gasses, the more energy it needs to shuffle around. Hurricanes are one way of doing just that. The potential risks from just such an event had been described in the region's major daily paper, yet the response to the hurricane seems to indicate that little action had been taken to get ready. The lessons of the event must be taken seriously by all sectors of society because climate change is a certainty, is now well underway, and will impact us all (Fischlin and others 2007).

The fourth series of reports issued in 2007 by the Intergovernmental Panel on Climate Change (IPCC IV), in what is a conservative account of climate change and its impacts, warns us clearly that major effects on forests must be expected (Fischlin and others 2007; Nabuurs and others 2007). In northwestern North America, the climate has already changed and is continuing to change, and those changes are having serious impacts on regional forests. Furthermore, in one of the IPCC IV reports, Fischlin and others

(2007) identify northwest North American forests as especially likely to be impacted by climate change. The devastating mountain pine beetle (*Dendroctonus ponderosae*) outbreak in the interior of British Columbia and adjacent regions has single-handedly altered the character of forests over a huge area in less than decade (Carroll and others 2006). Increases in Dothistroma needle blight on lodgepole pines (*Pinus contorta*) are also attributed to changes in climate (Woods and others 2005). In the coastal temperate rainforests of British Columbia, western redcedars (*Thuja plicata*) are showing excessive autumn branchlet drop and top die-back, likely as a result of increased summer moisture deficits (Hebda 2006).

Lessons on Climate Change from the Past

Studies of sub-fossil pollen and other plant remains from lake and wetland sediments provide insight into what the region might be like under warmer than present climates. Between 10,000 and 7000 years ago, the earth received slightly more solar energy than it does today because of normal variations in the earth's orbit and angle of spin. In southern British Columbia, the climate was warmer than today by about 2 to 4 °C (3.5 to 7 °F), and summers were drier (Hebda 1995). On the coast, dry conifer forests dominated by Douglas-fir (*Pseudotsuga menziesii*) extended well into the zone occupied by moist western hemlock (*Tsuga heterophylla*) and western redcedar forests. In the dry rain shadow of Vancouver Island, open meadows and, later, Garry oak (*Quercus garryana*) savannah or possibly forest predominated where Douglas-fir forests occur now (Pellatt and others 2001). East of the Coast and Cascade mountains, grassland occupied a much greater area than today in the place of mid-slope and valley-bottom conifer forests of Douglas-fir and pine (Hebda 2007). In the southern part of the province, today's montane and high elevation spruce-fir forests were home to pine forests where fires were more active than today (Hebda 1995). Inland rainforests of cedar and hemlock were absent (Hebda 1995; Rosenberg and others 2003) and, to the north, pine forests occupied regions where spruce-dominated Cordilleran boreal forest occur today (Hebda 1995).

Today's geographic pattern of forest ecosystems and forest composition is only 4000 or so years old. It arose as a result of the development of relatively moist mild climate at this time. Major features included: widespread expansion of the range of western redcedar and moist conifer forests; shrinking of interior grasslands; spread of dry interior conifer forests down-slope; and development and expansion of high elevation spruce forests, especially in the south (Hebda 1995; Heinrichs and others 2002). With cooling and moistening climate, fire activity declined and wetlands, especially bogs, spread. The tree ring sequence from fossil Douglas-fir logs recovered from Heal Lake sediments, near Victoria, suggest that the climatic change at this time may have occurred rather rapidly, ushering in 4000 years of relative climatic stability (Zhang and Hebda 2005).

Considering what the fossil record reveals and the trends already evident, we can expect climate change now underway to be of large amplitude, to take place rapidly, and to include extreme events. Unlike many past natural major climatic changes, the effects will be felt world-wide, and unfold upon a landscape much disturbed by human activity. The net effect will be widespread ecological change, which obviously poses a challenge to forest managers and those working to sustain forest values.

Climate Impacts from Models

Clearly, a business-as-usual approach to managing and sustaining forests is risky when climatic conditions within the next few decades are uncertain. Growing and planting nursery stock depends on matching sites, seedlings, and treatment strategies. Global, and now regional, climate model output can be used to gain insight into what future forest conditions may be (Hamann and Wang 2006), and what changes in reforestation, including seedling stock choices, might be appropriate.

For British Columbia, on average, widespread warming of about 5 °C (9 °F) in the mean daily minimum and maximum temperatures must be expected by about 2080; in the extreme, as much as 10 °C (18 °F) warming is not outside the range of possibility (PCIC 2007b). Climate models do not represent future precipitation as reliably as temperature, but a trend to a generally wetter climate is likely. However, summers in parts of the region will effectively be drier because of the increased temperatures.

Using a Canadian climate model, Hamman and Wang (2006) showed that future climatic conditions will lead to dramatic changes for the potential distribution of forest ecosystems in the region, with obvious consequences to tree growth and forest management. For example, the climate of the Ponderosa Pine Biogeoclimatic zone in British Columbia (see Meidinger and Pojar 1991 for description of modern forest zones) that is representative of the dry climates of the Okanagan valley of southern interior British Columbia might occur in the Peace River region of northeast British Columbia and reach into the Northwest Territories by 2080. A climate change impact model for western redcedar, on exhibit at the Royal British Columbia Museum (Victoria, British Columbia), shows suitable climate for this species disappearing in lowlands of southern British Columbia, but spreading into northern British Columbia by 2080 (PCIC 2007a). Western redcedar is a good indicator for the productive rainforests of northwest North America. The likelihood of changes in cedar distribution signal major changes in the character and distribution of this globally important biome in the near future. As mentioned earlier, declining cedar health is evident now, so we must take these projected changes seriously indeed. Replanting schemes involving this species need careful reconsideration.

Whereas we must be cautious about the way we use and replant moisture-needing tree species in our forests, the situation for warm climate, drought-tolerant species is less acute. For example, the climatically suitable zone for warmth-loving Garry oak will expand greatly. Areas of suitable climate could even appear on islands of the Alaska panhandle and on the adjacent mainland coast by mid century. The enormous increase in area of climate suitable for oak by 2080 east of coastal mountain ranges (PCIC 2007c) poses critical questions about what the nature of future forests in that zone might be. The results of climate impact models are consistent with some observed trends and with past forest ecosystem responses to warmer-than-present climates, a clear indication that models realistically portray the direction and nature of change.

Impacts models for ecosystems, however, have limitations, because they only address the question of where suitable climate may occur. At the predicted rate of change, loss of some tree species, such as cedar, will considerably exceed range expansion into newly suitable regions. Long-lived species, such as dominant trees, often have limited dispersal rates, long intergeneration times, and require centuries to occupy suitable climatic zones. This "big squeeze" of the geographic range means that natural ecological equilibrium will not be achieved in our forest ecosystems for centuries. Furthermore, stable forest ecosystems require the development of appropriate soils, with characteristic organic matter—also a lengthy process.

Whatever way we look at the future character of forest ecosystems in our region and around the world, major changes must be expected. For that reason alone, forestry management and practices will have to change. Along with this, we need to consider that the role of forests, based on the values we want from them (and even for them), will shift, too. The objectives of timber and fiber production may be replaced by carbon accumulation and water yield. In general, the cut and re-grow cycle typical of forest stewardship until recently will likely have to move to one of continuous growth and maintenance of resilience (the ability

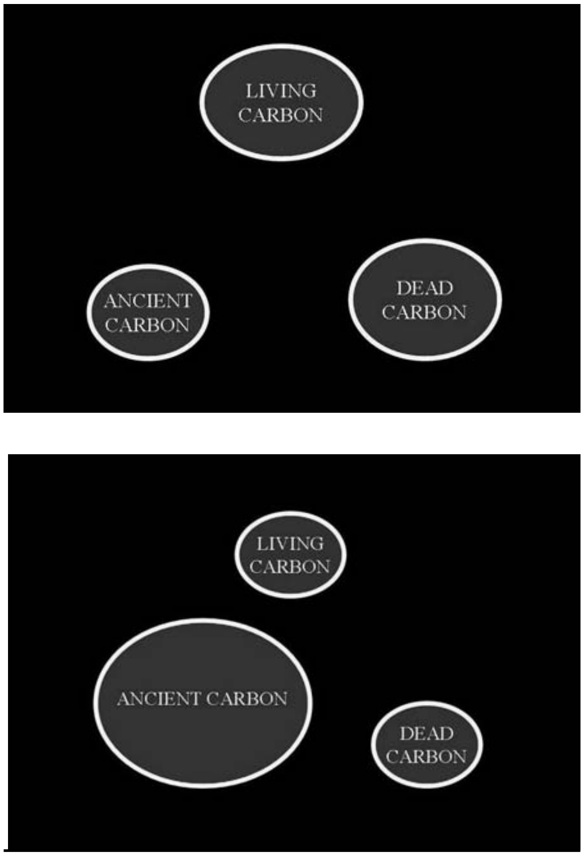

Figure 1. A key role for the forest nursery industry is re-balancing the emphasis in the battle with climate change from one focused on dependence on Ancient Carbon (reducing emissions and use of fossil fuels) (A) to a focus on supporting Living Carbon (ecosystems and species) and the Dead Carbon (organic matter) that supports it (B).

to withstand stress without catastrophic transformation). Indeed, the economic pay back of maintaining healthy carbon-scrubbing forests and avoiding release of carbon into the atmosphere through disturbance may be much greater than widespread removal of forest products.

Carbon stewardship is a new integrated way of looking at the issue of human response to climate change. It combines actions aimed at the reduction of carbon dioxide emissions with those aimed at adapting to the inevitable changes ahead. In so doing, the approach shifts the focus from simply finding alternate sources of energy and reducing energy consumption (dependence on Ancient Carbon) to sustaining and restoring Living Carbon (Figures 1a and b). We cannot exist without the Living Carbon of terrestrial ecosystems, agricultural fields and aquatic environments. Living Carbon feeds us, provides jobs and many other values, and depends on organic matter in the soil or sediments, which I call Dead Carbon. The Living Carbon also plays a central role in removing carbon dioxide through photosynthesis and primary production. Good Carbon Stewardship considers the impacts of activities on all aspects of carbon, not just the reduction of emissions. For example, if production of biofuels, such as converting forest wastes to stove pellets, jeopardizes Living Carbon systems and the Dead Carbon in the soil that supports them, then it may not be as effective a strategy as we may think to deal with climate change.

The forest nursery industry has a particularly important role in supporting Living Carbon by providing the appropriate raw materials for terrestrial ecosystems to return to a healthy condition, either by replanting on non-forested sites or in-planting on sites whose resilience has been jeopardized. This new role was explicitly recognized in the theme and title of this 2007 nursery meeting in Sidney, British Columbia, "Growing and Planting More Trees: A Common Goal and Responsibility." Restoring, rebuilding, or regenerating forest ecosystems around the globe is the most effective mechanism we have at this time for beginning to take carbon dioxide out of the atmosphere today. At this point, it is important to note that the species that will be used for this purpose in the future may not be the same, or be limited to, those that are traditionally supplied to the forest industry for timber or fiber production.

Strategies for the Future

Climate change poses many challenges and provides opportunities for the forest nursery industry. Wide-scale ecological and, likely, economic change is certain to occur; however, the degree of change and the path that change will take is not well understood yet. For sure, there will be alterations in the structure and composition of forests, and, in some places, forest ecosystems will simply not be supported by future climatic conditions. In northern and high elevation portions of our region, forests are likely to expand their range (Hamann and Wang 2006) and trees will grow more rapidly and to a larger size than today. Considering the enormous and likely impacts of the climate change challenge ahead, we must begin taking action now, both at the strategic and practical levels.

General Strategies

At the strategic level, the focus needs to shift from growing trees to growing and sustaining forests. These two are certainly mutually compatible goals, but they are not the same. Society will almost certainly expect many roles from our forest ecosystems, especially those related to mitigating carbon dioxide levels in the atmosphere and providing a reliable supply of water.

We also need to prepare for extremes and surprises. The mountain pine beetle outbreak in central British Columbia has come as an unpleasant surprise (Carroll and others 2006). The blowdown of many large trees during an intense windstorm in Vancouver's Stanley Park was another surprise. Exceptional weather events are almost certain as climate moves toward a new set of norms.

Bold forest and landscape management experiments will prove valuable as an adaptation strategy for the future. Following a status quo approach brings with it high risks of failure, especially because decisions made now commit us to outcomes many decades down the line. We need to establish practices that broaden our options and spread the responsibility for risk of failure in the future. Diversified replanting schemes involving several species is one mechanism to reducing overall risk.

The uncertainty in terms of the character and location of future forest ecosystems and the expectation of multiple values requires landscape-level planning of forest ecosystems and, especially, forest management and use. Establishing the sensitivity of geographic regions, species, and genetic stocks to climate change will be part of the landscape approach. There is little point in planting standard species or stocks in regions highly sensitive to climate change. In British Columbia, most biogeoclimatic zones (macro-ecosystems) are expected to change by at least one type (to a warmer one) (Hebda 1994).

Our knowledge of the ecology of species and ecosystems remains poor. We have an excellent descriptive knowledge of the distribution and character of our forests but we have only a rudimentary understanding of the processes that shape them (mycorrizhae for example). An understanding of the climatic controls on species distributions and key processes (bio-climate profiles) is especially needed for planning future forests. With a sound knowledge of species-climate relations, and especially of the responses of pests to climatic change, decision tables could be constructed to assist in forest management at specific sites.

Operational Strategies

With respect to timber and fiber production, it may be necessary to develop intensively managed ecological plantations for high value yield. In such plantations, comprehensive monitoring of growth, pests, and diseases might allow risks to be minimized or avoided through practices such as pest control and moisture management. Under such conditions, there might also be interest in species and stocks with short rotation times to reduce exposure of the stand to unacceptable climate variability.

Other on-ground adaptive approaches might include:

- Minimizing soil disturbance when replanting to limit sites for invasive species, and to limit exposure of organic matter to decomposition;
- Use of plantings of mixed species and genetic composition, perhaps at high initial densities to optimize survival rates;

:: Regular monitoring for impacts and immediate repeat planting where poor growth or seedling and sapling death is noted;
:: Saving and propagating genetic stocks from hot and dry extremes of a species range, because growing trees for survival may become as important as growing perfectly formed trees quickly.

One caution, at least for the time being, is to avoid the inclination to propagate and use species foreign to the region just because they grow well. Invasion of native ecosystems by alien species will almost certainly be a major battle for decades to come. The use of species that might naturally migrate into a region is acceptable. But introducing exotic species from other continents or across major natural barriers is not recommended at this time. These species have the capacity to weaken the natural resilience of the forest landscape at a time when it needs to be as strong as possible.

As far as the forest nursery industry is concerned, it will be hard to anticipate when the demand for a diversity of seedlings will arise. Nurseries should be prepared, however, for the potential demand by broadening their capacity, by increasing expertise, and beginning experimentation with different species. Opportunities to do this may arise through experimental trials in collaboration with a range of land tenure holders, such as watershed agencies, land trusts, First Nations, and various levels of government. Such experiments might well be supported through grants, providing an opportunity for pre-adaptive development by the industry.

In general, the rate of climate change is going to increase; the longer we wait to return ecological integrity to our forest ecosystems, the more difficult it will be to do so. Widespread replanting and in-planting to establish healthy stands now is vital to prepare our forested landscape before major changes really set in. It would seem that the forest nursery industry is likely to have bright future ahead. And the knowledge and skills gained here in the Northwest may have broad application around the globe.

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