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MEMORANDUM

File: 312-20/TR067

April 05/2012

To: Whom it may concern

Re: Errata – author order

Errata for Technical Report 067 - A landscape-level species strategy for forest management in British Columbia: exploration of development and implementation issues.

The title page author listing should say:

Shirley Mah, Kevin Astridge, Craig DeLong, Craig Wickland, Melissa Todd, Leslie McAuley, Phil LePage, Dave Coates, Ben Heemskerk, Allen Banner, and Erin Hall

The Citation on the CIP page should say:

Citation
Shirley Mah, Kevin Astridge, Craig DeLong, Craig Wickland, Melissa Todd, Leslie McAuley, Phil LePage, Dave Coates, Ben Heemskerk, Allen Banner, and Erin Hall. 2012. A landscape-level species strategy for forest management in British Columbia: exploration of development and implementation issues. Prov. B.C., Victoria, B.C. Tech. Rep. 067.
www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr067.htm

Province of British Columbia
851 Yates Street
Victoria, BC V8W 9C2

TECHNICAL REPORT 067

A Landscape-level Species Strategy for Forest Management in British Columbia

Exploration of Development and Implementation Issues

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Shirley Mah, Kevin Astridge, Craig DeLong,
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COLUMBIA

Library and Archives Canada Cataloguing in Publication

A landscape-level species strategy for forest management in British Columbia : exploration of development and implementation issues / Shirley Mah ... [et al.].

(Technical report ; 067)
Includes bibliographical references.
Available also on the Internet.
ISBN 978-0-7726-6556-0

1. Forest landscape management--British Columbia--Planning. 2. Climatic changes--Environmental aspects--British Columbia. 3. Sustainable forestry--British Columbia. I. Mah, Shirley II. British Columbia.

SD414 C3 L36 2012 634.9'209711 C2012-980047-3

(Technical report ; 067)
Includes bibliographical references.
Electronic monograph in PDF format.
Issued also in printed form.
ISBN 978-0-7726-6557-7

SD414 C3 L36 2012 634.9'209711 C2012-980048-1

Citation

Mah, S., K. Astridge, C. DeLong, C. Wickland, M. Todd, L. McAuley, B. Heemskerk, E. Hall, A. Banner, D. Coates, and P. LePage. 2012. A landscape-level species strategy for forest management in British Columbia: exploration of development and implementation issues. Prov. B.C., Victoria, B.C. Tech. Rep. 067.
www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr067.htm

Authors' affiliation

Ministry of Forests, Lands and Natural Resource Operations

Resource Practices Branch
Shirley Mah - Research Ecologist
Kevin Astridge - Silviculture Operations Specialist

Omineca Region
Craig DeLong - Research Ecologist
Melissa Todd - Research Wildlife Ecologist

West Coast Region
Craig Wickland - Silviculture Forester

Tree Improvement Branch
Leslie McAuley - Decision Support Officer

Skeena Region
Ben Heemskerk - Assistant Research Ecologist
Erin Hall - Assistant Research Silviculturist
Allen Banner - Research Ecologist
Dave Coates - Research Silviculturist
Phil LePage - Research Silviculturist

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Crown Publications, Queen's Printer
PO Box 9452 Stn Prov Govt
Victoria, BC V8W 9V7
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EXECUTIVE SUMMARY

The landscape-level species strategy project was initiated in 2009 in support of the Chief Forester's Future Forest Ecosystems Initiative. This scoping report explores the issues related to developing and implementing a landscape-level tree species strategy for forest management in British Columbia. It specifically aims to:

- identify the key elements of a landscape-level tree species strategy
- assess the implementation considerations for a landscape-level species strategy within the existing management framework
- develop an analysis methodology for portraying the landscape-level species composition and distribution for natural and managed stands

The main findings of this report are as follows:

- A landscape-level tree species strategy requires an understanding of the species biology and ecology baseline and processes; the interaction between species, climate change, and natural disturbances; the vulnerability of species and species complexes to changes in disturbance patterns and climate; and the influence of past management actions on landscape-level species patterns.
- The high level of uncertainty associated with how the climate will change and how forest ecosystems will respond over the next few decades requires a broadening of approaches to managing species at both the stand and landscape levels.
- An adaptive management framework for applying new species management approaches is required so that there is a feedback mechanism for evaluating how well the landscape-level species targets are being met or how they need to be adjusted.
- An analysis methodology for portraying tree species composition and density at a landscape-level scale was developed, and it indicated that the existing provincial data sets for mature natural stands and harvested stands provide results that are comparable with similar data sets at the regional scale.
- Effective approaches need to be developed to facilitate the successful implementation of landscape-level species strategies within our current management framework.

The report proposes that the logical extension of the analysis methodology pilot is to undertake an exploration of methodology for developing specific targets for species composition and density variability at the landscape level.

ACKNOWLEDGEMENTS

The Tree Species Selection Project working group members and participants in the March 2009 landscape species strategy scoping workshop provided insightful discussions on defining a conceptual framework and the issues in developing and implementing a landscape-level species strategy. Archie MacDonald, Bernie Peschke, Tim Ebata, and Christine Fletcher provided valuable input in developing the draft report. Allen Banner, Dave Coates, and Phil LePage magnanimously offered to take on the analysis methodology pilot. Alan Vyse and Suzanne Simard significantly improved the early drafts of this report with their editing, suggestions, and comments. Greg O'Neill, Annette Van Niejenhuis, Allan Powelson, and Alvin Yanchuk kindly reviewed drafts of the report and provided helpful suggestions.

In addition to the methodology project team (Phil LePage, Dave Coates, Ben Heemskerk, Allen Banner, and Erin Hall), the pilot involved a number of individuals that made significant contributions towards its completion. Tim Salkeld and Mei-Ching Tsoi undertook the initial ICHmc2 data extraction process from the VRIMS and RESULTS databases, respectively. Dave Weaver provided invaluable help in deciphering the data fields in RESULTS and provided help with understanding the survey process that produced the original data. Russell Klassen developed the Microsoft Access data manipulation and summary tools for RESULTS and VRIMS and Peter Ott provided statistical advice and support throughout the project.

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1 INTRODUCTION

Sustainable management is the overarching goal of forest management policies in British Columbia, and investment in forest renewal activities following natural and human-related disturbances is one of the main routes to achieving this goal. Thirty years ago, the failure to renew forest stocking on logged lands, and thus to achieve sustainable management, was a major public forest policy issue in the province. Since then, substantial public investments have been made to improve the effectiveness and efficiency of forest renewal activities. A recent independent review of these activities indicated that forest licensees, government, and forestry professionals have done an excellent job of ensuring that most trees planted across the province are growing into healthy forests (Forest Practices Board of BC 2003). The generally accepted key to this success has been a series of ecologically based stocking standards that define desirable outcomes for forest renewal activities across the province. These standards describe the tree species that may be used and the stocking levels and minimum tree height that must be reached within specified time windows (British Columbia Ministry of Forests 2009). These standards are accompanied by additional seed transfer standards that limit the movement of tree seed in relation to its provenance to ensure that planted trees are adapted to the climate in which they are established (British Columbia Ministry of Forests 2008).

Climate change is expected to provide a significant challenge to maintaining successful forest renewal programs in the future (Hamann and Wang 2006). A variety of changes have been forecast for the next seven decades (to 2080), including drier summers in the Southern Interior and wetter winters in the coastal and Columbian mountain regions (Spittlehouse 2008). These changes are expected to have a major effect on forest ecosystems, although there is considerable uncertainty about the precise nature of the changes and their effects. Climate change is expected to alter forest and range productivity in certain areas, cause adjustments in watershed hydrology, change vegetation composition, and increase the frequency and severity of disturbance events such as wildfires, ice storms, floods, and droughts (Kurz et al. 2008). Overall forest condition is also expected to decline as climate change contributes to conditions that foster insect and disease outbreaks and enhance the ability of nuisance species to invade forest ecosystems (Logan et al. 2003; Dukes et al. 2009).

There is increasing scientific consensus that climate change is occurring, and recent investigations in British Columbia have shown that the effects of climate change are occurring on the landscape. The devastating effects of the mountain pine beetle on stands of lodgepole pine (Westfall and Ebata 2007), drought in the Southern Interior (Spittlehouse 2008), and the outbreak of Dothistroma needle cast in northwestern British Columbia (Woods et al. 2005) have all, at least in part, been attributed to climate change. Additional studies have detected potential forest health issues in lodgepole pine stands in the Southern Interior (Woods and Bergerud 2008; Heineman et al. 2010; Mather et al. 2010). Declines in forest ecosystems have been noted throughout the world (Allen et al. 2009; van Mantgem et al. 2009), and, in Oregon, widespread problems in Douglas-fir plantations and mature forests have been detected (Rosso and Hansen 2003; Black et al. 2010).

The prospect that tree species may become increasingly maladapted to their environment, less productive, and increasingly susceptible to insects and disease (Aitken et al. 2008) over the next century suggests that major changes in the way forest renewal is conducted in the province are required (Campbell et al. 2009). It is managing to reduce the potential negative impacts that concern us most in this analysis, especially large-scale unexpected mortality events. Climate change may benefit tree productivity, for example, by increasing soil temperature at higher elevations or increasing growing season precipitation levels; however, as observed by Woods et al. (2005), indirect effects of climate change (higher pest incidence) can far outweigh the potential direct benefits. The Future Forest Ecosystems Initiative set out to explore issues related to the effects of climate change on British Columbia's forests, and to explore appropriate short- and long-term actions to reduce risk (Campbell et al. 2009). One component of this initiative involves scoping out what is needed to develop and implement landscape-level tree species strategies for the provincial forests that would guide stand-level species selection decisions. These strategies must facilitate conservation of species and forest landscapes, not only by facilitating the dynamic shifting of species distributions but also by conserving species and ecosystems that are the most vulnerable to climate change effects.

2 A LANDSCAPE-LEVEL TREE SPECIES STRATEGY FOR BRITISH COLUMBIA

The goal of the landscape-level tree species strategy is to promote the adaptability of forests across landscapes in a changing climate by providing a diversity of ecologically suitable tree species that fulfills the need for ecosystem goods and services for future generations. Development of this strategy must take into consideration existing and future landscape-level management values and objectives, and present-day tenure arrangements and legislation.

A landscape-level species strategy would:

- manage species vulnerability to climate change and minimize the effects of climate change on species and forests
- apply a systems approach to species selection and density that measures success at the landscape scale rather than the current stand scale
- set specific targets for species composition and density variability at the landscape scale
- select and manage for species in the context of sustainable forest management objectives (timber and non-timber values)
- adopt an explicit adaptive management approach to deal with the uncertainties associated with climate change and its effects on provincial forests
- co-ordinate access to and analysis of relevant species-related data across multiple databases
- monitor the landscape using a system of permanent plots

3 KEY ELEMENTS OF A SUCCESSFUL LANDSCAPE-LEVEL SPECIES STRATEGY

The following sections describe each of the key elements of a landscape-level species strategy:

- Species biology and ecology baseline and processes
- Natural disturbances
- Species vulnerability
- Management framework

3.1 Species Biology and Ecology Baseline and Processes

Species vulnerability to climate change is based on exposure to climatic shifts and the sensitivity of species to those shifts. An understanding of tree species vulnerabilities to climate change is essential to improving our predictive capacity and to developing a landscape-level species strategy that facilitates sustainable forest management. Species vulnerabilities are influenced by a range of autecological, physiological, and genetic variation. Autecological traits, such as reproductive rates, dispersal ability, or life cycle rates, will be important in determining species resilience to, or recovery from, climate-induced disturbances. Physiological plasticity refers to the ability of individuals to tolerate a range of climates and edaphic conditions, whereas the genetic diversity among individuals in a population determines the rate at which populations adapt to selection pressures such as changes in climate or pests. Less understood but of paramount importance are ecological responses of species to climate change, including interactions of tree species with other elements of the biotic community (e.g., other tree species, plants, insects, fungi, bacteria). Genetic variation and adaptation to climate change will be more difficult to monitor than physiological or ecological changes. Adaptation has already occurred in a variety of species, and is more evident in those with short life-cycles, such as insects, but will be more difficult to monitor in long-lived species, such as trees. Compared with physiological and ecological plasticity, adaptation will be of lesser importance to tree species vulnerability to climate change because it involves multiple generations.

Tree species possess a variety of important physiological, ecological, and genetic traits that determine the establishment, productivity, and persistence of a particular tree species in a particular ecological space. Some traits will be more important to consider than others when developing a landscape-level species strategy. For example, thermal tolerance will be important in a species' ability to adapt to temperature regime changes, whereas reproductive output will be important in a species' resilience to climate-induced disturbance regime changes. A large body of physiology literature, which examines how tree species respond (e.g., breaking dormancy, seed production, shoot and root growth) to their environment (e.g., temperature, light, moisture, nutrients), either through controlled greenhouse experiments or field studies, contributes to our understanding of species traits. Traits of widespread or commercially valuable species are better studied than traits of other species.

Field observations of which tree species have established naturally on sites with a known set of environmental conditions (e.g., Klinka et al. 2000) are also extremely valuable in predicting species responses to climate change. By using the Biogeoclimatic Ecosystem Classification (BEC) framework (Meidinger and Pojar 1991), knowledge of tree species distributions derived from mapping and field work, and data on species traits, we can determine the climatic (e.g., precipitation, temperature) and site (e.g., moisture and nutrient availability) requirements of a particular tree species (Hamann and Wang 2006; McKenney et al. 2007a, 2007b; Nitschke and Innes 2008).

Using climate models (e.g., Climate BC v.3, ClimateWNA), we can then predict changes in key biological, ecological, and genetic variables that control tree establishment and productivity at relevant spatial scales. If site-level mapping (i.e., ecosystem mapping) is available, we can map the potential suitability of a tree species across landscapes relative to the current climate or a future predicted climate. About 25 tree species are suitable for reforestation in British Columbia, and their projected distributions in our changing climate could form the basis of a landscape-level species strategy.

Species will respond individualistically to climate change, which will result in new configurations of forest ecosystems. Species distributions will shift: some species will become vulnerable to (local) extinction (e.g., whitebark pine, limber pine, alpine larch, yellow cedar in the Interior) in British Columbia; other species will expand their range, including non-native species that migrate from southern regions. Current forest ecosystems will change and novel ones will likely emerge. The current landscape provides the context for change. Not only does it provide the gene pool for migration and adaptation of species, it provides stability and ecosystem functions at the site level for species to assemble. Moreover, the current forested landscape of long-lived trees will be critically important as a buffer against chaotic changes, catastrophic disturbances, and rapid releases of carbon to the atmosphere. The current mature age class structure will cause lag effects by inhibiting new tree species from migrating due to the competitive or transiently inhospitable environment, and by inhibiting the rapid invasion of nuisance plants and novel pests (Aitken et al. 2008; Pringle et al. 2009).

Natural regeneration will form the basis of species distribution shifts in our changing climate. However, site limitations that restrict the natural establishment of a tree species (e.g., lack of mineral soil exposure) can be overcome by particular forest management practices (e.g., planting); therefore, we have the ability to modify species distributions. For example, in many of the biogeoclimatic units within the Interior Cedar-Hemlock (ICH) zone, lodgepole pine has been planted extensively, even though it was naturally uncommon in these stands. Early survival has generally been good, but lodgepole pine is very susceptible to a number of foliar diseases and hard pine stem rusts. An outbreak of Dothistroma needle blight has caused significant mortality of pine in the ICH moist cold subzone (Woods et al. 2005). A recent study suggests that the risk of damage by forest health agents to lodgepole pine plantations is likely to increase with predicted warmer winters and higher frequency of extreme climatic events (Heineman et al. 2010).

More than one species is capable of establishing on many sites, and most plantations are augmented by natural regeneration; therefore, it is important to know how different species interact with one another. Basic ecology will determine this. For instance, where two tree species are similar in shade tolerance but one species has a faster growth rate, the species may be incompatible since the one with the faster growth rate will shade out the other. However, other species traits, such as differences in nutrient acquisition or water uptake, may compensate for shading effects and allow these species to co-exist in certain climates. Observations of species combinations in older naturally regenerated stands provide a good starting point for determining species compatibility. It is important to try to monitor micro-evolutionary processes, however, to understand how species interactions change with climate change. Mixtures of tree species on a site are beneficial because different tree species respond differentially to mortality agents such as fire, wind, and pests; therefore, mortality risks are reduced. Species mixtures have also been shown to increase ecosystem functioning (e.g., increased productivity or reduced mortality) through niche complementarity or facilitation (Tilman et al. 1997; Kelty 2006; Schaberg et al. 2008).

In addition to species diversity, within-species (i.e., genetic) diversity is an essential component of forest resilience. Genetic diversity within stands distributes the risk associated with catastrophic events among trees in the stand, increasing the probability that a proportion of the trees will remain healthy and productive in an uncertain future. Genetic diversity within stands can be most effectively influenced by the number and origin of seed sources planted. Forest management practices can deplete genetic resources; for example, through selective logging (Schaberg et al. 2008) or tree breeding. The latter is a concern where trees are bred for a single specific trait, such as timber yield. It is increasingly being recognized that for new or changing environments, selection for a multivariate grouping of traits (e.g., resistance to insects, diseases, or drought; diversity in response to temperature extremes) is important (Fornara and Tilman 2009). Maintaining or even enhancing genetic diversity, particularly of rare alleles that code for multiple traits, in planting stock and silviculture practices will be particularly important in bolstering adaptability to rapidly evolving species interactions and host–pest dynamics associated with climate change (Schaberg et al. 2008).

One of the key processes affecting landscape-level species distribution is succession. Depending on growth rate and longevity, different tree species will dominate the main canopy of a stand at different points in time. For instance, in a mixed stand of lodgepole pine, hybrid spruce, and western redcedar, the pine may dominate the canopy for the first 150 years, the spruce for the next 150 years, and the redcedar thereafter. A landscape strategy for tree species distribution must take such dynamic processes into account, especially in the unmanaged portions of the landscape.

Carbon sequestration in living and dead biomass, including forest and grassland soils, is increasingly important in forest management and to international climate change treaties. Preservation of native forests and planting of new forests for their carbon stocks is already occurring in underdeveloped countries through benefits from carbon credit trading with developed countries. Across Canada, broadleaf forests have been shown to store greater aboveground biomass more rapidly than have conifer forests (Margolis et al. 2006), but mixtures of conifers and broadleaves experience lower soil carbon losses than broadleaf stands due to harvesting because carbon storage is greater in mineral soil than in the forest floor (Nave et al. 2010). Certain tree species store more carbon belowground because they have a deep rooting architecture. Managing specific species mixes for long-term carbon storage and resistance to rapid carbon loss from damage or disturbance (Kurz et al. 2008; Allen et al. 2009) may need to be considered.

3.2 Natural Disturbances

Disturbance is an important driver of ecosystem change, and can be initiated by a wide variety of physical and biological events, including wind, fire, insects, disease, and the introduction of novel species. Disturbance is essential to maintaining biodiversity because it creates a range of habitat diversity at multiple scales (Franklin and Forman 1987; White and Pickett 1986). Biological legacies of natural disturbance, such as old, large-diameter trees, snags, and woody debris, play a fundamental role in maintaining the long-term ecological functioning of an ecosystem (Hansen et al. 1991; Amaranthus and Perry 1994). It is presumed that forest biota are adapted to the conditions created by natural disturbances, and thus should cope more easily with the ecological changes associated with forest management activities if the pattern and structure created resemble those of natural disturbance (Angelstam 1998; Bunnell et al. 1999; Hunter 1999).

Some of the more important attributes to manage for within a landscape-level species strategy, which can be derived from natural disturbance patterns, are seral stage distribution, patch size distribution, patch shape, biogeographic connectivity, and amount and distribution of legacies (White and Pickett 1986). Creating irregularly shaped openings in order to increase edge environment and leaving legacies of the previous stand for their wildlife or ecosystem function values is relevant with or without climate change, and will likely affect tree species selection and composition. Leaving legacies and microclimatic refugia, such as shelter under rotten logs, can buffer species against changes in regional climate. A common characteristic of natural disturbance is that it creates variability at multiple scales, and this variability results in a diversity of available habitats and enhances landscape resistance to mortality agents (e.g., bark beetles, wildfire). Maintaining biogeographic connectivity to climatic refugia will likely become increasingly important with climate change, however, because it allows species or populations to reach suitable habitat soon enough to allow natural selection to occur.

The current, historically unprecedented outbreaks of mountain pine beetle and Dothistroma needle blight in British Columbia are strong indicators that the amount and pattern of disturbance, including relationships between pests, hosts, and climate, are being altered as climate changes (Woods et al. 2005). Numerous recent pest epidemics elsewhere in North America provide further strong evidence of the impact of changing climate on forest ecosystems (Allen et al. 2009; van Mantgem et al. 2009).

The interactions between pests, hosts, and climate are complex, have co-evolved over centuries, and, in many instances, are not well understood. This, together with the uncertainty about how regional climates will change, makes it difficult to predict the responses of specific pests to climate change. However, as climate changes, the environmental parameters under which present forests were established will change. When these changes result in increasingly suboptimal conditions, trees will become physiologically stressed. Changes in thermal and moisture environments, combined with changes in host plant conditions, will interact synergistically, and thus may facilitate the development of insect and pathogen outbreaks. The incidence of forest decline syndromes is also likely to increase as a result of general reductions in forest health.

3.3 Species Vulnerability

The vulnerability of species to changes in climate and disturbance regimes will depend on the degree and pace of regional climate change. Predicting the implications and developing outcome scenarios for species distributions will be key to developing a flexible, dynamic landscape species strategy. This is becoming increasingly sophisticated as we combine higher-resolution regional climate models with a greater range of species traits, greater spatial resolution, and even soil and microhabitat characteristics.

Because BEC subzones/variants comprise the current ecological framework for supporting forest management decisions (e.g., species selection), projecting how BEC subzones/variants (or climate envelopes) and species ranges will shift under a changing climate will be of fundamental importance. The projections are most applicable to the BEC subzone/variant zonal sites. It is anticipated that the BEC site classification will remain relatively stable due to the enduring features of the site component (i.e., soil, terrain, and site properties) and will continue to be useful in assessing growing conditions, even if vegetation changes.

Model accuracy will be improved if a greater range of species traits that determine species vulnerability to climate change, such as physiological tolerances and ecological responses, is included. Importantly, the climate models must include variables that reflect conditions that organisms directly experience at finer spatial scales (e.g., frost, drought). Models that have greater spatial resolution will also be useful in identifying the locations most vulnerable to change in the landscape, such as BEC transition areas, or species at the periphery of their distribution ranges.

Feedbacks between climate exposure and species vulnerabilities will lead to the assembly of new plant communities, losses of genetic diversity, and changes in interspecific interactions (e.g., host–pest or host–mutualist interactions). Feedbacks will cascade through trophic levels in ways that cannot be predicted by climate envelope models. Because of these feedbacks, novel ecosystems—new plant community assemblages that establish in response to a significant change in the regional climate variables—will emerge (Seastedt et al. 2008). Equivalent ecosystems may or may not be found in jurisdictions south of British Columbia. New species will migrate, including species that are highly invasive because climate change may create habitat conditions that are amenable to invasive species (insect pests, pathogens, plants, and animals). The functional role of species within ecosystems may also change: species that were once incidental may become foundational species. This will affect ecosystem processes such as primary productivity, nutrient or water cycling, and disturbance regimes.

The success of facilitated and natural migrations will also be strongly affected by feedbacks between climate and species vulnerabilities at different life stages; that is, establishment versus maturity. The complexity of the feedbacks will make migrations difficult to predict. Because of our inability to foresee feedbacks, it is imperative that the landscape species strategy remains flexible and dynamic, which can be done only through research, modelling, monitoring, and adaptive management.

3.4 Management Framework

A landscape-level species strategy will, by necessity, consider the existing management framework with which it will integrate. It will also be necessary to look ahead to a shifting and changing management framework that is responsive to new adaptation strategies developed for other management values (e.g., wildlife, water) and objectives based on vulnerability.

Tree species selection at a range of scales will be driven by the guiding principles of forest resilience, adaptability, diversity, and complexity in the context of timber and non-timber values and objectives. Consideration will be given to, among other things:

- current and future economic returns based on timber productivity and market demands
- conservation concerns for fish, wildlife, biodiversity, soil, and hydrology values; and
- social/cultural interests, including First Nations and cultural heritage values, recreational features, and visual quality objectives

In addition, landscape-level tree species strategies should integrate with current management objectives for individual landscapes, as outlined in a range of provincial and federal legislation, and with land use planning at the regional, landscape, and operational levels. However, the current forest management framework often compartmentalizes values, which interferes with effective co-ordination when strategies for multiple value management objectives are being implemented within individual landscapes. Efforts are being made to better integrate management objectives and strategies through initiatives at the District level in order to facilitate Forest Stewardship Planning by licensees.

The following are implementation considerations for landscape-level species strategies:

1. The current legislative framework (Appendix 1) does not specifically address species diversity (numbers or proportions of species) in either the objectives set by government for the values identified under the *Forest and Range Practices Act* (FRPA) or within the requirements for specifying stocking standards at the stand or landscape level. Stocking decisions are most often made at the block or standards unit level, and stand-level decisions are not currently required to consider the cumulative results at the landscape level.
2. To date, where a novel or innovative stocking standard is proposed, to date, very little guidance or information on managing forests for resilience and adaptability in the face of climate change is readily available. This may limit innovation with respect to trying new species if a significant amount of time is required to locate and synthesize information to support such a proposal.
3. Where licensees have undertaken different practices aimed at increasing species diversity, resilience, or adaptability, these alternative strategies can be more expensive. This may reduce the incentive for increasing species diversity or promoting species that may be more adaptable to climate change.
4. Under the current legislative framework, the licensee assumes most of the risk from stand establishment until free growing. Once a stand achieves free growing, the Crown then assumes the risk through to rotation. New and innovative practices that promote species diversity through the use of strategies such as the assisted migration of species may come with increased risks, particularly in the early establishment phase.

Successful implementation of landscape-level species strategies will require effective approaches to address these considerations.

4 LEARNING FROM DOING… AN ADAPTIVE MANAGEMENT FRAMEWORK

Both the physical parameters of climate change and the response of forest ecosystems over the next several decades are highly uncertain. As a consequence, managers are faced with a situation in which there is no single correct species selection strategy. A range of approaches to managing species at both the stand and landscape levels will likely be necessary. Fortunately, the forest landscape (both ecological and social) of British Columbia provides a sufficiently large canvas on which these approaches can be tested, but the testing will have little value unless it is applied within an adaptive management framework.

We envision the process as moving forward from this scoping document to developing a methodology or approach for defining specific species targets within landscape-level species strategies at the management-unit level. Landscape-level species strategies should both be designed following the well-established steps of adaptive management (Taylor et al. 1997). Figure A1 provides a proposed framework of the key elements of developing a successful landscape-level species strategy. These elements correspond to the adaptive management steps:

1. Assess – "What We Have." This involves understanding species ecology baseline distribution and processes, and the drivers that affect their variability in a management unit.
2. Design – "What We Want." In the context of management values and objectives, species (adjusted) targets are set for species composition and density distribution.
3. Implement – "What We Are Doing." Species management is achieved through planting and natural regeneration.
4. Monitor/Evaluate/Adjust – Feedback loops: These involve determining how management values and objectives are being met, evaluating the implementation (through "What We Have"), and then adjusting targets ("What We Want").

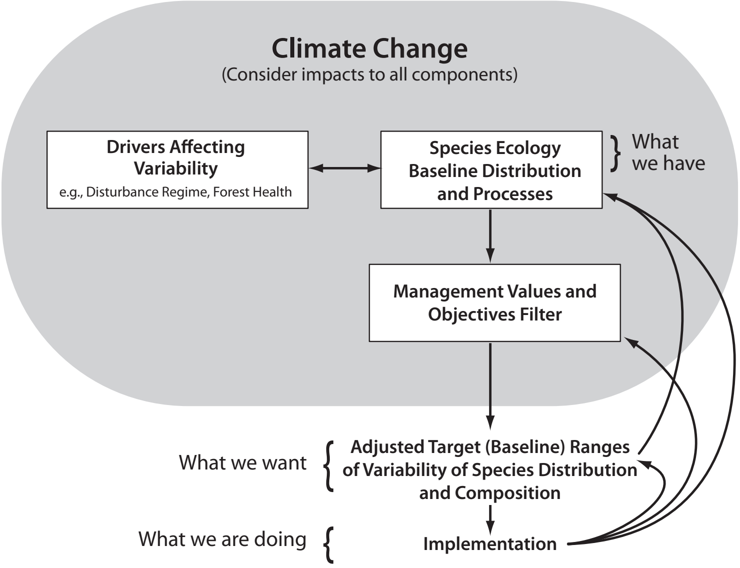

FIGURE 1 *Framework of key elements of landscape-level species strategies.*

4.1 Designing the Landscape-level Species Strategy

The strategy must be designed to work within the current legislative framework, must provide clear guidance to forest professionals and Ministry decision makers, and should detail any additional costs and risks associated with implementing the strategy. Application of the strategy could be considered at several scales from Timber Supply Areas (TSAs) to individual licences, such as woodlots and community forests. However, implementation on an administrative unit, such as a Tree Farm Licence or TSA, would ensure that a linkage is maintained with other planning processes, such as Timber Supply Reviews and silviculture strategies. Several novel approaches already under way in the province (e.g., the Fort St. John Pilot project and Kamloops Future Forest Strategy project) may contribute to the design of the strategy.

There will be some capacity to ameliorate the effects of climate change through targeted management actions, such as conserving canopy cover, climate refugia, and healthy ecological processes, which will decrease species exposure to climate change or increase species resilience. Retaining critical landscape features such as corridors and linkages can facilitate natural or assisted species migrations, and thus increase resilience of the landscape. Additionally, minimizing habitat fragmentation and introduction of exotic pests will be essential in maintaining a resilient landscape.

Dynamic, proactive species conservation planning will be necessary in order to address non-linear changes in climate and shifting species vulnerabilities and distributions. This can involve three types of assisted migration: assisted population migration, assisted range expansion, and introduction of exotic species (S. Aitken, UBC, pers. comm., June 4, 2009). The lowest-risk approach is assisted migration of populations within species. This requires the use of climate modelling, knowledge of BEC unit and species envelopes, climate-based seed zones, and population response curves to climate change. Of greater risk is assisted range expansion (i.e., regional expansion of northern, inland, or upper elevational limits), which requires additional information on species tolerances of climatic extremes, potential effects of species on recipient ecosystems (including social perspectives), and species invasiveness. Of greatest risk is the introduction of exotic species.

A modelling approach that is currently being developed by Gerry Rehfeldt, US Forest Service (G.O'Neill, Min. Forests and Range, pers. comm., Jan. 28, 2009) includes (a) modelling climate envelopes with BEC subzones/variants as surrogates, (b) identifying which species grow in each climate envelope, (c) migrating the climate envelopes to about 1/3 rotation, and (d) selecting species that are suited to the climate envelopes (BEC subzones/variants) anticipated at 1/3 rotation.

Other possible approaches for increasing species selection options (G.O'Neill, Min. Forests and Range, pers. comm., Jan. 28, 2009) include (a) providing a full list of ecologically suitable species for each BEC subzone/variant and their respective site series (as planned for the tree species selection decision support tool), (b) conducting an analysis to address species migration lag, and (c) identifying BEC subzones/variants that are similar climatically but have non-overlapping species compositions. This could identify additional species that are suitable for selection (in the tree species selection decision support tool).

Higher-risk operational trials to expand the range of species (e.g., small in scope for western larch and western white pine) should be encouraged and initiated. There may be opportunity for developing such trials in collaboration with government-funded silviculture investment programs.

Analysis methodology — landscape species composition and spatial variation A detailed pilot study was undertaken in the Hazelton variant of the Interior Cedar-Hemlock, moist cold subzone (ICHmc2) of northwestern British Columbia in order to develop an analytical methodology for portraying tree species composition and density at the landscape scale. The full report is found in Appendix 2. The analysis used existing data sources from the Reporting Silviculture Updates and Land Tracking System (RESULTS), the Biogeoclimatic Ecosystem Classification (BEC) database, the Vegetation Resource Inventory (VRI) database, and ecosystem recovery research plots established in the local area. The ICHmc2 was chosen as the pilot location because it represents one of the more complex forested areas of the province where a large amount of regionally specific and relevant data exist.

The pilot study demonstrates that the existing provincial data sets (RESULTS, VRI, BEC) can be used to assess the current status of managed and natural species composition/diversity at the landscape level, and that the efficacy of this assessment was corroborated by the regionally specific and relevant ecosystem recovery data set. The pilot illustrates a potential tool for portraying and developing landscape species composition/stocking targets throughout the province. The proposed system would allow for the land manager to have considerable flexibility in both the species composition and plantation density in any single unit.

4.2 Implementing the Landscape-level Species Strategy

The successful implementation of a landscape-level species strategy requires a combination of well-defined objectives at the landscape level and flexible planning at the stand level. A variety of management strategies related to species may then be applied concurrently across the landscape to achieve both timber and non-timber objectives. The range of strategies to increase species diversity, resilience, and adaptability at the landscape level may include but is not limited to:

- high-investment, intensive management regimes for short-rotational species such as hardwoods (e.g., alder or cottonwood plantations)
- mixed species/seedlot planting regimes at the stand level
- assisted migration of species to adapt to a changing climate
- introduction of new species on a trial basis

Consideration will also have to be given to developing effective approaches to implementing the strategy within the current forest management framework.

The development of mechanisms to compensate for additional risks associated with managing for species diversity could provide an increased incentive to adapt forest management practices without requiring major regulatory changes. Incentives could be provided for such practices as increasing diversity, or to recognize the increased costs of establishing slower-growing or hard-to-establish species or facilitating the migration of species outside their normal range.

The current legislative framework allows FSPs to have stocking standards that address species diversity at multiple scales. The requirement to address long-term forest health in stocking standards gives planners the ability to use increased species diversity as one strategy for increasing the resilience of managed forests. Multi-block stocking standards could also be used to develop landscape-level stocking standards that address long-term forest health (e.g., Fort St. John Pilot Project approach). If credible climate change information, guidance, and tools are developed, they could be used to inform professionals when developing FSPs and site plans to make greater use of the flexibility already provided in the current framework. Implementation of a landscape-level species strategy will require clear linkages between the strategic landscape-level species targets, stocking standards, and site plans.

4.3 Monitoring the Landscape-level Species Strategy Targets

Once the landscape-level species targets are designed and implemented, monitoring is necessary to measure how management activities affect the composition and spatial distribution of species in stands across a defined land base. Monitoring is a widely used but highly ambiguous term. In this context, we suggest that several monitoring tracks are appropriate:

- Data from the Reporting Silviculture Updates and Land Status Tracking System (RESULTS) could be used to track progress in achieving landscape-level species selection goals. As the strategy progresses and data are collected, the data can be incorporated into timber supply assumptions during timber supply reviews. RESULTS data are used with the ICHmc2 pilot's analysis methodology.
- The Forest and Range Evaluation Program's stand monitoring component of its Resource Stewardship Monitoring program will provide data on post–free-growing regeneration success/failure of stands with regards to their intended regeneration objectives.
- Permanent plots, possibly in partnership with existing long-term research installations across the forested landscape, can be used to monitor the response to climate change of stands that are established under certain species strategy targets.
- Experiments in key locations can be used to provide a range of highly controlled species mixtures against which operational decisions can be compared and evaluated.

4.4 Evaluating the Landscape-level Species Strategy

The successes and failures of the species strategy should be evaluated on a 5-year basis. Several specific evaluation tests, based on the goals of the strategy, should be possible at that time.

The ICHmc2 pilot study's analysis methodology could be tested further in other parts of British Columbia, and could be used in developing a species strategy, evaluating its tree species targets, and revising those targets.

By 2015, it should be possible to review the available data sources and assess whether progress has been made in managing species vulnerability and minimizing the effects of climate change on species and forests. There should be clear evidence of guidance on species composition and density variability within stands and among stands across the landscape of several management units of differing complexity and size. There should be evidence that Registered Professional Foresters and statutory decision makers have selected, or have permitted the selection of, species and species complexes that will contribute to forest resilience in the longer term in the context of sustainable forest management objectives. There should also be evidence of co-ordinated access to and analysis of relevant species-related data across multiple databases. Finally, there should be evidence of an appropriate level of monitoring that will permit evaluation to continue in the future.

5 CONCLUSIONS

To address ongoing climate change and the risk of major changes in ecological conditions across the provincial landscape, adaptation strategies in forest management practices in British Columbia are required. A wide variety of actions is required, many of which are already being implemented. Included among these actions would be the development and implementation of landscape-level species strategies.

Tree species management decisions must be guided by a landscape-level strategy that works within the existing forest management framework. A successful strategy will require a detailed understanding of the interactions between species, climate, disturbances, and management, and an adaptive approach to developing future forest structures and species composition that support the health and productivity of future stands at all stages of their development within a management unit. Evaluation of the strategy will depend upon the establishment of an effective monitoring system that is based on existing data networks but could also incorporate permanent sample plots and experiments that record the response of stands and species to climate change.

6 NEXT STEPS

1. Explore the development of specific targets for tree species composition and density variability at the landscape level for a management unit.
2. Develop a methodology for developing landscape-level species strategies based on the findings of that exploration.

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The current regulatory framework requires licensees to prepare Forest Stewardship Plans (FSPs). A key content requirement of these plans is the specification of stocking standards for areas in which the licensee has an obligation to establish a free-growing stand. Currently, there is no requirement for licensees to prepare a landscape species strategy, nor anything preventing them from preparing such a strategy.

i) Stocking Standards
   Stocking standards may be developed and applied to individual cutblocks (Forest Planning and Practices Regulation (FPPR) Section 44) or collectively across cutblocks (FPPR Section 45). The Minister must approve these standards if they:
   i. specify ecologically suitable species;
   ii. address short- and long-term forest health;
   iii. are consistent with maintaining or enhancing an economically valuable supply of timber;
   iv. are consistent with timber supply analysis and forest management assumptions, and
   v. specify free-growing heights that are sufficient to demonstrate the trees are adapted to the site and growing well and can reasonably be expected to continue to do so (FPPR 26).

ii) Seed Use
   For areas where a free-growing stand must be established, the seed that can be used is regulated in FPPR s 43 and further specified as standards by the Chief Forester under the *Chief Forester Standards for Seed Use*. The purpose of the seed use standards is to maintain the identity, adaptability, diversity, and productivity of the Province's (forest) tree genetic resources.

   Alternative seed use standards, including, but not limited to, seed selection and transfer, can be proposed but are subject to approval by the Chief Forester (FPPR 43). Amendments and new information regarding the standards are made available at: http://www.for.gov.bc.ca/code/cfstandards/.

iii) Cost Estimates
   Through the appraisal system, the basic silviculture cost estimates, the costs for reforesting harvested areas, and all the necessary treatments to achieve the free-growing obligation are used to determine stumpage rates. These cost estimates vary by biogeoclimatic subzone and variant, and are based on reported costs, based on past practices, from licensees and are regularly updated (IAM 4.9; CAM 5.6). The appraisal system is based on the least cost appraisal principle where the reported costs are used to determine the costs for the average efficient operator.

iv) Relief
   Where a regenerated area has been damaged, government has limited ability to grant additional funding or to relieve the person of the obligation to establish a free-growing stand. This relief is dependent on the person not having contributed to the damage and having exercised due diligence (FRPA 108). The damaging agents eligible for relief are fire, landslide, flood, and Dothistroma outbreaks in lodgepole pine plantations established prior to July 31, 2006 (FPPR 96).

In addition to providing relief pursuant to Section 108 of FRPA, provisions exist within the FPPR to exempt a person from silviculture obligations (s. 91) or to allow for a declaration that a free-growing stand has been established to the extent practicable (s. 97.1).

Landscape Species Selection Pilot Project in the Interior Cedar-Hemlock Zone, moist cold subzone, Hazelton variant (ICHmc2)

Phil LePage, Dave Coates, Ben Heemskerk, Allen Banner, and Erin Hall.

ABSTRACT

We examine the feasibility of determining species selection and stocking standards at the landscape scale rather than the stand scale and we propose a system that allows for greater flexibility in species composition and density at the individual stand scale. We demonstrate these ideas for managed stands with data gathered from the Reporting Silviculture Updates and Land Tracking System (RESULTS), the Biogeoclimatic Ecosystem Classification (BEC) database, and local ecosystem recovery research project plot data for the forested landscape in the Interior Cedar-Hemlock zone, moist cold subzone, Hazelton variant (ICHmc2) of northwestern British Columbia. We also provide a similar analysis for natural stands using the provincial BEC and Vegetation Resource Inventory (VRI) data and older stands in the ecosystem recovery plot data set. The ICHmc2 variant was chosen as the pilot location because it represents one of the more complex forested areas of the province where a large amount of regionally specific and relevant data exist.

Species selection and stocking standards likely need increased flexibility to better deal with ecosystem complexity, variability, and unpredictability, and to increase adaptability in the light of projected climate and global change. We use existing data to illustrate how management success can be measured at the landscape level rather than the current stand-scale system. This requires switching from determining management success based on mean responses in single stands, to setting species composition targets at the landscape scale with a specific desired landscape mean density and density variability. This approach would provide for a wider range of stand conditions, encourage natural regeneration and species mixtures, and reduce management efforts required to bring every single stand up to a single, uniform standard.

The proposed approach would not allow for an “anything goes” attitude to species selection and stocking standards since specific goals for landscape scale species proportions and explicit variability around species-specific landscape mean density must be met within each landscape. Foresters will manage for a specific species composition distribution with a known mean species-specific density and pre-planned variability. We believe that promoting variability among stands within a landscape can be accommodated relatively easily and without major changes to our present system of selecting species and stocking densities. We illustrate a potential tool for portraying and developing landscape species composition/stocking targets throughout the province.

This pilot study has demonstrated that the existing RESULTS, BEC, and VRI provincial data sets can be used to assess the current status of managed and natural species composition/diversity at the landscape level, and that the efficacy of this assessment has been corroborated by regionally specific and relevant data sets.

INTRODUCTION

The landscape species selection pilot project in the Interior Cedar-Hemlock (ICH) forests of northwestern British Columbia is an exploratory analysis to aid decision making in the Tree Species Selection Project, *Scoping Report: Landscape Level Species Strategy for Forest Management in British Columbia*. The broad goal of the Landscape Level Species Strategy is to promote "adaptability of forests across landscapes in a changing climate to provide a diversity of well adapted, healthy, resilient tree species that fulfills the needs for ecosystem goods and services for future generations, in the context of existing and future landscape level management values and objectives."

The purpose of the ICH pilot study is:

- to test the data gathering and analysis process required to determine the current species composition and spatial variation across the managed landscape in the ICHmc2
- to examine the feasibility of determining regeneration success at the landscape scale rather than the stand scale, and to propose a system that allows for greater flexibility in species composition and density at the individual stand scale

The ICH zone in the northern interior region was chosen as the pilot location because it represents one of the more complex forested areas of the province where a large amount of regionally specific and relevant data exist that enable testing the efficacy of using widely available provincial data sets to develop landscape-level targets. Once the data analysis procedures have been developed, completing a similar project in other areas of the province with a less diverse tree species mix should be relatively straightforward.

The ICHmc2 variant in northwestern British Columbia covers approximately 11 210 km^2 (Figure A2.1). Forest management has been active in the region since the 1970s, with clearcutting dominating the harvest prescriptions. Mature and old forests of the region were established after natural disturbances such as wildfire, insect and disease outbreaks, or wind events. Natural ICH forests are typically composed of up to nine tree species, frequently dominated by western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), with variable amounts of western redcedar (*Thuja plicata* [Donn ex D. Don in Lamb]), subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.), lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.), hybrid spruce (the complex of white spruce *Picea glauca* [Moench] Voss), Sitka spruce (*P. sitchensis* [Bong.] Carr.), and occasionally Engelmann spruce (*P. engelmannii* Parry ex Engelm.), paper birch (*Betula papyrifera* Marsh.), trembling aspen (*Populus tremuloides* Michx.), and black cottonwood (*Populus balsamifera* ssp. *trichocarpa* Torr. & Gray). Subalpine fir is typically replaced by amabilis fir (*Abies amabilis* Dougl. ex Forbes) at higher elevations.

As the forests age, species begin to drop out of the mix, starting with aspen, birch, and cottonwood, followed by the shorter lived conifers; spruce and pine. By the time the forests have reached approximately 250 years, they are typically dominated by western hemlock and western redcedar with minor abundances of the other conifer species. Amabilis fir can be common in these older forests at higher elevations.

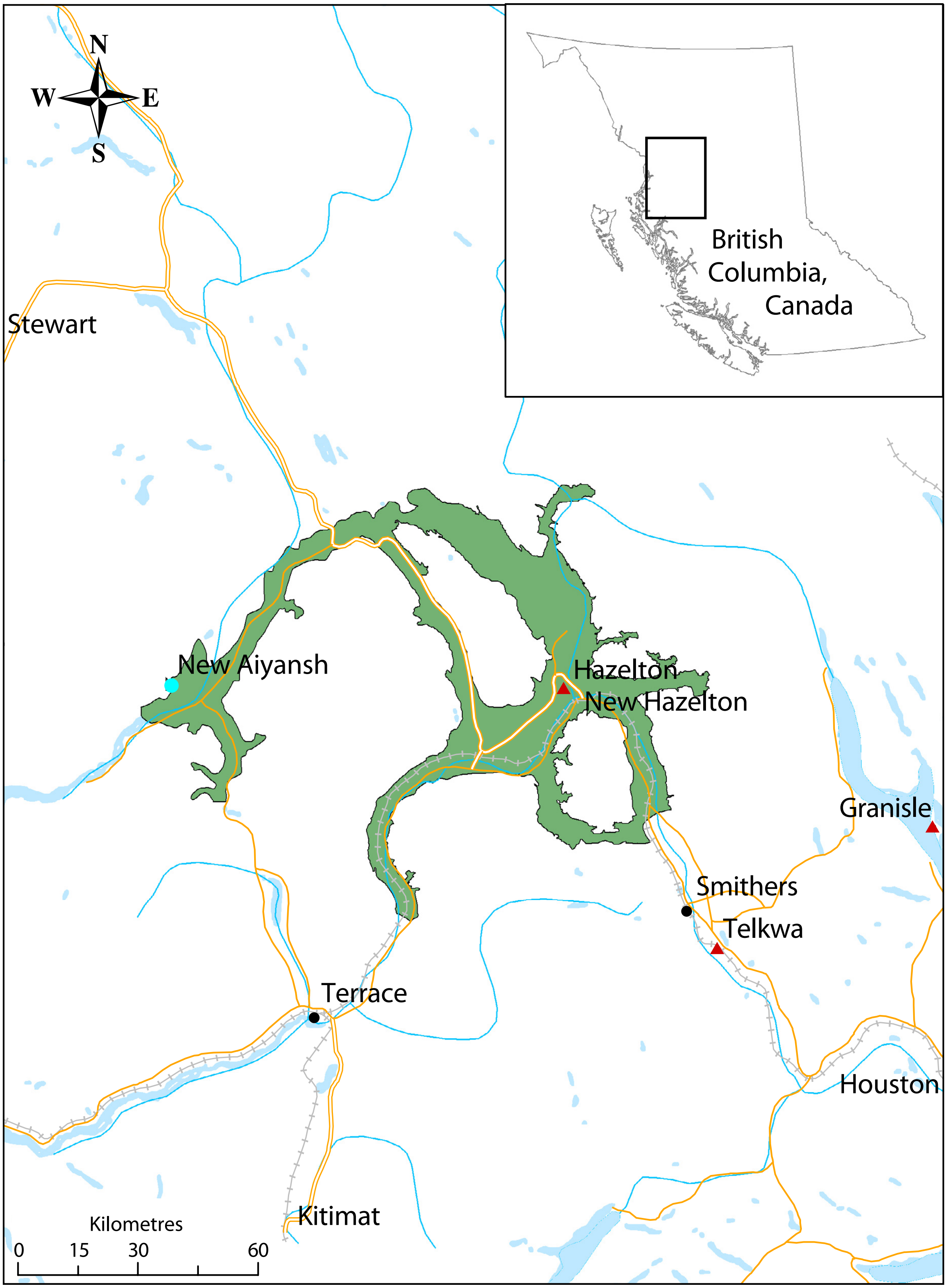


FIGURE A2.1 *Location of the ICHmc2 variant in northwestern British Columbia.*

Since the 1980s, most logged stands in ICH forests have been planted, with two species dominating the planting prescriptions; hybrid spruce and lodgepole pine. Others species such as western redcedar, western hemlock, subalpine fir, and amabilis fir have also been planted, but in considerably smaller numbers. The planting of lodgepole pine has decreased substantially since 2005–07 due to the extensive damage caused by the needle blight *Dothistroma* in many existing pine plantations. Although the use of broadleaved tree species is allowed in the current Ministry of Forests and Range (MFR) default stocking standards, most silvicultural prescriptions have actively discouraged the acceptance and utilization of aspen, birch, and cottonwood.

Natural forests in the ICH landscape support multiple tree species in a diverse array of species mixtures and densities. It is less clear, however, how much species diversity and density variability exists in our managed stands when they are aggregated and considered at the landscape scale. If we use a harvested unit planting prescription as a surrogate for the intended outcome of the silvicultural prescription, the expectation would be that two openings in the same BEC unit with the same prescription would be very similar in species composition and stocking level at all developmental stages. For example, assuming a uniform rate of mortality, every opening planted solely to hybrid spruce would be expected to be dominated by spruce and to have similar spruce densities at the free-growing assessment stage. In reality, this may not be the case, especially for species composition, due to natural ingress of other species. It is this potential variability in species composition and in stocking density within a given management intent that we focus on in our analysis. Are managed stands with the same management intent highly uniform or diverse? If they are diverse, what processes might be driving this diversity and how are they related to management intent? How do openings with the same management intent compare to units with different management intents and to natural stands? How does the analysis inform the debate around managing for resilience and adaptability given assumptions about climate and global change?

Forest management must address concerns about the long-term viability of specific practices and strive to develop those that promote the long-term productivity, biodiversity, and adaptability of managed forest ecosystems. The complexity of forest ecosystems poses significant challenges to management. Managing for adaptability requires a multi-scale perspective that considers stand- and landscape-scale processes as well as an understanding of both the short- and long-term effects of species selection and stocking decisions. British Columbia has a high diversity of forest types and, because of this, our management practices and prescriptions should be equally diverse. Our current regeneration standards, however, allow for fairly limited variation in stocking levels and while different stocking standards can be developed, this in not often done. To illustrate this point, a recent FREP evaluation of FSP stocking standards found that "due to time constraints, uncertainty over the process for supporting the development of new standards, and the uncertainty of what would be acceptable to the delegated decision makers, most FSP holders elected to prepare FSP stocking standards that were similar to those approved under a (previous) forest development plan" and that "most FSP stocking standards are largely similar to the original stocking standards developed by the Ministry of Forests and Range more than 20 years ago" (McWilliams 2009).

The legislative requirement that forest managers achieve the goal of free-growing stands has led many licensees to focus their regeneration efforts on those species that are deemed to be the fastest growing and the most reliable. In many areas of the British Columbia interior, this has led to a predominance of single-species, fixed-density lodgepole pine or spruce plantation prescriptions. At the free growing assessment milestone, however, we frequently find these plantations to have species mixtures and wide density variation. This variation is a result of natural regeneration ingress following planting although the sites are often still dominated by the planted species. This diversity at free growing is, in a way, accidental rather than planned and, as such, cannot be reliably counted on in a planning process. It is a legacy of the remaining mature and old-growth stands adjacent to managed stands—or memory in a complex adaptive system. As the ratio of logged to natural stands continues to increase in managed landscapes over time, managed stands will eventually dominate and the current contribution that the old, unmanaged forests make to the species, density, and size diversity of our managed stands through natural ingress will diminish. Species selection and stocking standards need increased flexibility to better deal with the loss of memory in increasingly managed landscapes, and to promote ecosystem complexity and adaptability. We suggest that part of this process should involve a switch from determining management success based solely on mean responses within individual stands, to a landscape perspective where the mean and variability around the mean are explicitly managed for species composition and density. This report explores one possible way of moving management toward a landscape perspective; however, there are probably many other possible approaches.

Promoting resilient and adaptable forests will require taking a systems view to forest management. For example, how species selection, composition, and density decisions at the stand scale affects overall landscape species distributions, growth and yield, and long-term risks of biotic or abiotic damage agents needs consideration. Understanding the long-term consequences of stand-scale decisions will require linking processes across different scales.

We believe that moving toward a landscape perspective can be accommodated relatively easily and without major changes to our present system of selecting species and stocking densities. In this report, we outline two possible changes: (1) assessing success at the landscape scale across multiple stands instead of at the individual-stand scale, and (2) shifting management intent to setting species composition goals and targeted mean densities for each tree species at the landscape level in combination with stand-level variability around species-specific mean density target objectives. With these changes, species composition and density variability would come about because of explicitly different management prescriptions implemented at the stand scale while keeping the overall landscape objectives in mind.

This approach would be inexpensive to implement, provide for a wider range of managed stand conditions, encourage natural regeneration and species mixtures, and reduce management efforts required to bring every single stand up to a single, uniform standard. This would mean, for example, that moderate seedling mortality will not automatically result in replanting efforts, especially when regeneration of that species in neighbouring stands has been quite successful, or if future stands can be planted to higher densities as compensation to maintain the desired overall landscape mean. Assessing success at the landscape scale does not allow for an “anything goes” approach to forest management since specific goals for mean landscape objectives and explicit variability around the mean must be met. In other words, foresters will manage for a specific distribution with a known mean and pre-planned variability. Accepting stochastic elements as an inherent part of forest ecosystems is also important for management of expectations. Thus, incorporating risk and uncertainty should be interpreted as an opportunity to avoid having to impose a narrow range of stand structures on every single stand. It provides increased flexibility for foresters to use a wider variety of treatments and to carefully weigh responses to unplanned events and disturbances, including simply accepting them as an inherent and therefore valuable part of complex adaptive ecosystems.

METHODS

Species selection and establishment densities at planting, and density, acceptability, and spacing standards at free-growing are based on government guidelines that have remained relatively unchanged for more than 20 years. In this report, we use the term **management intent** to describe the initial planting prescription for an opening, that presumably is the desired composition of the stand throughout development. We examine four management intents—openings that were (1) planted only to lodgepole pine, (2) planted only to hybrid spruce, (3) planted to a mixture of pine and spruce (regardless of the ratio), and (4) planted to some western redcedar (along with any other species).

RESULTS Data

RESULTS (British Columbia Ministry of Forests and Range 2009b) is an application that tracks silviculture information including disturbances, silviculture activities, and FRPA legal obligation declarations for individual openings. It represents the most widely available source of digital silviculture data from managed openings and as such we have used the data to determine the initial planting prescription and the outcome of this prescription at the free-growing assessment milestone in each opening. The database does, however, have limitations in the scale at which the data can be applied and the subsequent analysis of the data.

The data were extracted by selecting openings that were artificially regenerated, declared free growing, and within the ICHmc2 variant (Table A2.1). The information required for the analysis was contained in the Opening Inquiry, Stocking Standards, Activities (including Planting), and Forest Cover tables contained within RESULTS (Table A2.2).

Once the data were extracted, species codes were grouped (Table A2.3). The data were then separated into the four management intents and the averages for each tree species in the individual Standard Unit (SU) were weighted and summed for each opening. This was calculated individually for both the Inventory and Silviculture labels using Equation 1:

$$\text{Weighted Average Cover of Species} = \frac{\Sigma_{j}^{m} = 1^{\text{Silviculture Polygon Area}_j \times \frac{\text{Species} \times \text{Composition}_j}{100}}}{\Sigma_{j}^{m} = 1^{\text{Silviculture Polygon Area}_j}}$$

where m = the number of silviculture polygons for an individual opening.

TABLE A2.1 *Query criteria for data extraction from RESULTS*

Results Data Field	Query Criteria	Explanation of Criteria
BGC_ZONE_CODE	“ICH”	Biogeoclimatic zone
BGC_SUBZONE_CODE	“mc”	Biogeoclimatic subzone
BGC_VARIANT	“2”	Biogeoclimatic variant
ORG_UNIT_CODE	“DSS” or “DKM”	Skeena-Stikine and Kalum Forest Districts
STOCKING_TYPE_CODE	“ART”	Artificially regenerated; Planted
OPENING_STATUS_CODE	“FG”	Declared Free-Growing

TABLE A2.2 *RESULTS data fields used in the analysis*

Results Data Field	Description
OPENING_ID	Unique identifier for each opening
STOCKING_STANDARD_UNIT_ID	Unique identifier for Standard Unit (SU) within an opening
FOREST_COVER_ID	Unique identifier for within an SU
FOREST_COVER_LAYER_CODE	Inventory (I) or Silviculture (S) label
SILV_POLYGON_AREA	Area (ha) of silviculture polygon
NAR	Net Area of opening to be Reforested
TOTAL_STEMS_PER_HA	Total stems per hectare
TOTAL_WELL_SPACED_STEMS_PER_HA	Total well spaced stems per ha
FREE_GROWING_STEMS_PER_HA	Free-growing stems per ha
Spp1 ……. Spp9	Tree species in label; up to nine species can be recorded
Spp1% ……. Spp9%	Tree species composition within label
Tree Species Planted*	Tree species planted
Number of Tree Planted*	Number of trees planted

* Not original field name; changed as part of results data extraction from planting information

TABLE A2.3 *Grouping of tree species codes in RESULTS data*

Tree Species Code	Tree Species Groupings	Tree Species
Act	Ac, Act, Ax	black cottonwood
At	At	trembling aspen
Ba	Ba	amabilis fir
Bl	Bl, B	subalpine fir
Cw	Cw	western redcedar
Ep	Ep, E, Ew	paper birch
Hw	Hw, Hx	western hemlock
Pl	Pl, Plc, Pli, Pr, Pw	lodgepole pine
Sx	Ss, Sw, Sx, Sxe, Sxs, S, Se, Sxl	hybrid spruce

Using the same methodology, weighted averages for total stems per ha, total well spaced stems per ha, and free-growing stems per ha for the Inventory and Silviculture labels were calculated when the data were present for the opening using Equation 2:

$$\textit{Weighted Average SPH} = \frac{\Sigma_{j}^{m} = 1 \, \textit{Silviculture Polygon Area}_j \times SPH_j}{\Sigma_{j}^{m} = 1 \, \textit{Silviculture Polygon Area}_j}$$

where m = the number of silviculture polygons for an individual opening.

A Microsoft Access-based tool called RSSeT (RESULTS Species Selection Tool) was developed to help automate calculating the weighted averages. Although designed for this pilot exercise, this tool could be adapted to complete the calculations for any data set extracted from RESULTS. Appendix 2.1 contains the instructions for using RRSeT.

Limitations of RESULTS data

- When openings are reforested, the data entered into the database include species planted, number of seedlings planted, and the area planted; however, the number and type of seedlings planted are not linked to opening Standard Units (SU), only the opening ID. When multiple species are planted in an opening, this level of data resolution does not provide the ability to determine if individual SUs were planted as monocultures or mixed plantations; however, it is possible at an opening level to determine the distribution of species.
- Inventory labels provide the best indication of the "actual" composition of species in the managed openings; however, they are often the result of ocular estimates of species composition that can be tied to either volume or stem density. Inventory labels were originally created for mature forests and therefore were based on volume. For many decades, silviculture surveyors have been required to collect information by stem density. This would result in a 3 m tall pine plantation at a density of 1000 sph with 3000 sph of hemlock seedlings being labelled as 75% hemlock and 25% pine.
- As with any large data set, errors are typically present and it was noted during this project that RESULTS is no exception. Errors included incorrect species codes, species codes not entered, species composition not adding up to 100 percent, incorrect BEC data, and planted species not recorded (i.e., spruce-only plantation with over 400 sph of pine).
- RESULTS is the latest information system in a long line of programs (History Records, Major Licensee Silviculture Information System [MLSIS], Integrated Silviculture Information System [ISIS]) and as these programs were developed, changes were made both in the fields they contained and the methods used to collect the data. Due to this history, it is difficult, if not impossible, to track long-term changes in our managed stands through time.

Vegetation Resource Inventory Management System (VRIMS) Data

Vegetation Resource Inventory (VRI) data were extracted from the VRIMS database (British Columbia Ministry of Forests and Range 2009c) in March 2009 using query criteria of ICHmc2 in the biogeoclimatic data fields (Table A2.4). The data were then separated into natural and managed stands using the presence/absence of a harvest date. Stands were then separated in young (0–60 years old), mature (61–140 years old), and old (> 140 years old) using the Projected_Age_1 data field (Table A2.4). There were very few managed stands in the two older age classes (Figure A2.2). As these openings are the result of some sort of partial cutting prescription in older stands, we did not include them in our analysis.

A Microsoft Access-based tool called VSSeT (VRI Species Selection Tool) was created to (1) group tree species codes (Table A2.5), (2) reformat tree species data in a more usable format, (3) calculate proportion of area (ha) in polygon occupied by tree species using composition, and (4) summarize area (ha) occupied by each tree species grouping in the study area. Appendix 2.1 contains the instructions for using VSSeT.

TABLE A2.4 *VRIMS data fields used in the Analysis*

VRIMS Data Field	Description
FEATURE_ID	Unique identifier for a special feature
LAYER_ID	Unique identification of a layer, or horizontal stratum in a stand
HARVEST_DATE	Date forest cover information entered into database
POLYGON_AREA	Area of polygon in hectares
BEC_ZONE	Biogeoclimatic Zone
BEC_SUBZONE	Biogeoclimatic Subzone
BEC_VARIANT	Biogeoclimatic Variant
SPECIES_CD_1 ……. SPECIES_CD_6	Code indicating tree species; up to six species can be recorded
SPECIES_PCT_1 ……. SPECIES_PCT_6	Percentage of layer species occupies
PROJECTED_AGE_1	Stand age to adjusted area ground sample date for leading species

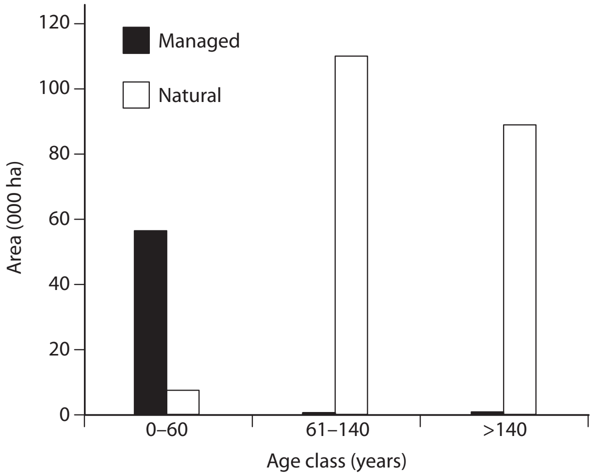


FIGURE A2.2 *Total area (ha) of managed and natural ICHmc2 forests by age class.*

TABLE A2.5 *Grouping of tree species codes in VRI data*

Tree Species Code	Tree Species Groupings	Tree Species
Act	Ac, Act	black cottonwood
At	At	trembling aspen
Ba	Ba	amabilis fir
Bl	Bl, B	subalpine fir
Cw	Cw	western redcedar
Ep	Ep, E	paper birch
Hw	Hw, H	western hemlock
Pl	Pl, Pli	lodgepole pine
Sx	Ss, Sw, Sx, Sxs, S	hybrid spruce

BEC Plot Data

Tree species data from 236 mature and old (> 60 years old) plots in the ICHmc2 were extracted from the provincial biogeoclimatic plot database (British Columbia Ministry of Forests and Range 2009a). These data are a result of intensive and detailed ocular assessments of percent tree cover in field-based ecological plots. For this project, only tree species cover data from the tree layer (A) were used to calculate tree species percentages of the total area of an individual plot.

Ecosystem Recovery Data

Data from 123 ecosystem recovery mensuration plots (Heemskerk et al. 2009) collected using British Columbia Ministry of Forests and Range cruising standards were also used for comparison in this analysis. These plots were collected throughout the ICHmc2 and were sampled in young, mature, and old stands.

RESULTS

Tree species composition

The managed forest area of the ICHmc2 in northwestern British Columbia is 265 874 ha. About 78% of this area is in natural forests, with most being older than 60 years (Figure A2.2). There have been very minor amounts of partial cutting in mature and old stands (611 and 896 ha, respectively). Old natural forests (> 140 years) comprise 42% of the natural forest area. According to the provincial vegetation inventory, old natural forest landscapes of the ICHmc2 are comprised of western hemlock (48%), hybrid spruce (16%), subalpine fir (8%), western redcedar (6%), lodgepole pine (4%), black cottonwood (10%), trembling aspen (4%), and paper birch (2%) (Figure A2.3).

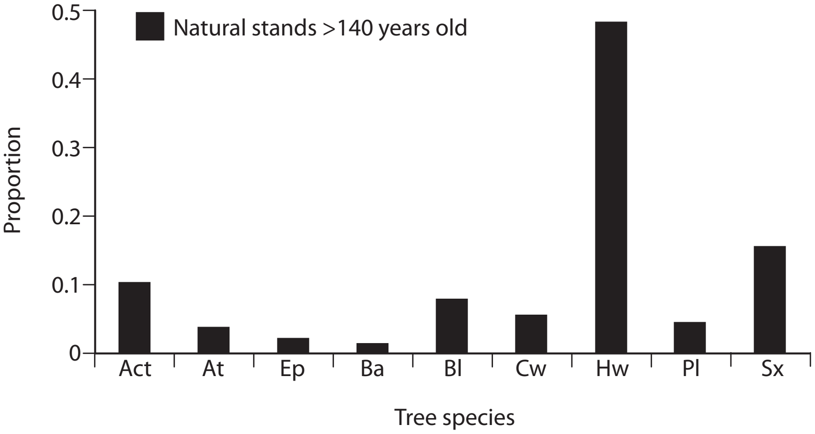


FIGURE A2.3 *Proportion of each tree species in natural ICHmc2 forest stands older than 140 years. Refer to Table A2.3 for species codes.*

We also summarized the more detailed but less extensive tree species percent cover data (236 old-forest ICHmc2 plots) from the provincial BEC database (Figure A2.4). In comparison to the VRI data, the BEC data illustrate a slightly greater dominance of hemlock (53% vs. 48%), over twice the percentage of western redcedar (16% vs. 6%), and roughly half the percentage of hybrid spruce (9% vs. 16%) and broadleaf species (7% vs. 16%) in old stands. These differences arise from the different data collection methods.

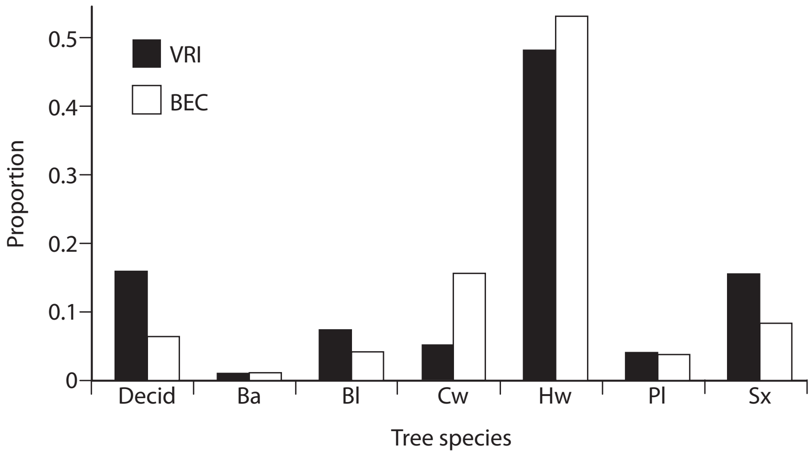


FIGURE A2.4 *Proportion of each tree species in natural ICHmc2 forest stands older than 140 years comparing data from the provincial BEC and VRIMS databases. Refer to Table A2.3 for species codes.*

Mature natural forests (61–140 years old) based on VRI data comprise 53% of the natural forested area. They are comprised of western hemlock (19%), subalpine fir (2%), western redcedar (3%), hybrid spruce (10%), lodgepole pine (15%), black cottonwood (8%), trembling aspen (28%), and paper birch (14%) (Figure A2.5).

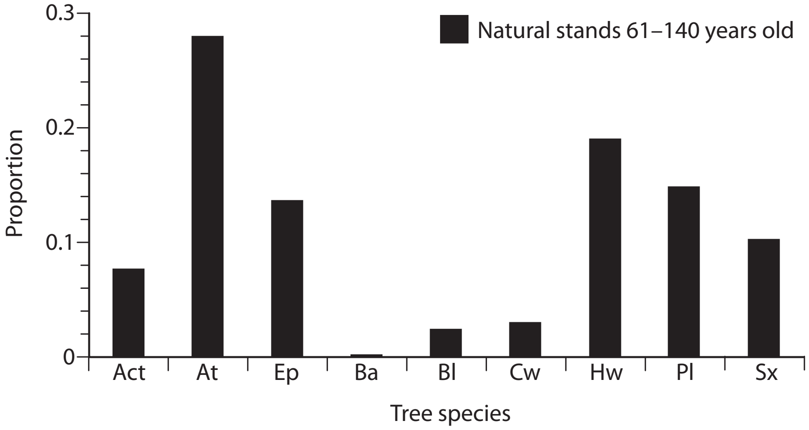


FIGURE A2.5 *Proportion of each tree species in 61- to 140-year-old natural ICHmc2 forest stands. Refer to Table A2.3 for species codes.*

The ecosystem recovery research plots for mature forests indicate greater percentages of hemlock (29%), hybrid spruce (17%), and (especially) western redcedar (27%), broadly similar amounts of subalpine fir (2%) and pine (12%), and significantly less percentages of broadleaf species (12% in total). Comparisons between these two data sources are limited by the sampling emphasis on coniferous stands in the ecosystem recovery study.

Young natural forests (< 60 years) form a minor component of the ICHmc2 landscape (12%) but these forests typically consist of western hemlock (36%), lodgepole pine (16%), hybrid spruce (11%), subalpine fir (2%), western redcedar (2%), black cottonwood (3%), trembling aspen (21%), and paper birch (9%) (Figure A2.6).

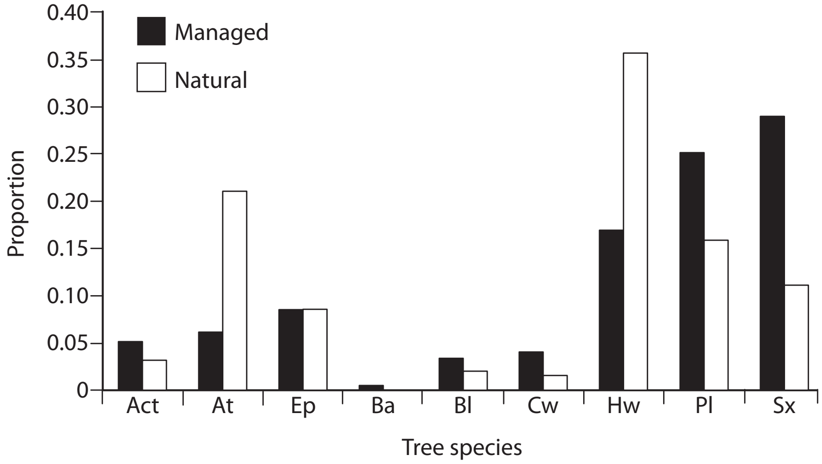


FIGURE A2.6 *Proportion of each tree species in less than 60-year-old managed and natural ICHmc2 forest stands. Refer to Table A2.3 for species codes.*

In contrast to natural forests, managed stands make up 22% of the ICHmc2 landscape (see Figure A2.2) and these stands fall almost exclusively into the young 0–60 age class (most resulting from logging over the past 30–40 years). According to the VRI (derived from RESULTS) database (Figure A2.6), young stands are comprised of hybrid spruce (29%), lodgepole pine (25%), western hemlock (17%), subalpine fir (2%), western redcedar (2%), black cottonwood (5%), trembling aspen (6%), and paper birch (9%).

Our ecosystem recovery data indicates a broadly similar breakdown of tree species composition in young managed stands, the main differences being a slightly higher spruce and deciduous component. Regeneration efforts in the ICHmc2 have focussed on planting hybrid spruce and lodgepole pine, with the remainder of the species regenerating naturally. Young stands resulting from harvesting are spruce- or pine-dominated with lesser and variable amounts of natural ingress by other coniferous (mainly hemlock) and deciduous species.

A NEW LANDSCAPE APPROACH

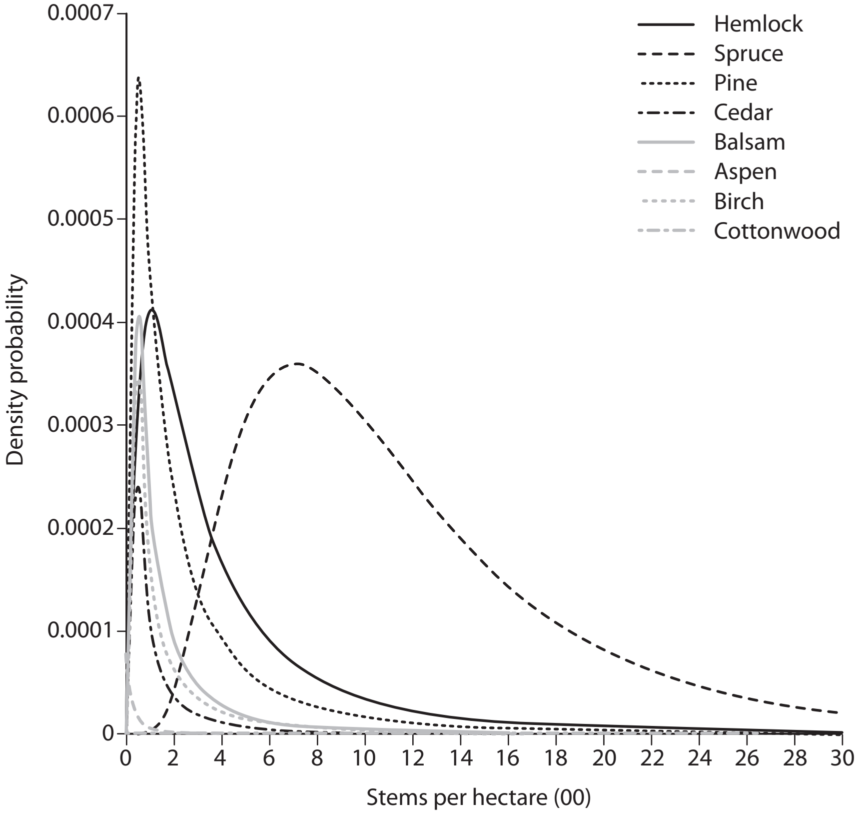
A landscape-based approach to species composition and stocking will require extensive discussion and consultation with provincial ecologists and silviculturists on how to prepare such distributions for a variety of landscapes and ownership objectives. For example, the range of values might be determined in co-operation with disturbance ecologists to match the natural range of variability with adjustments for expected future climate change. The intent is to measure success at the landscape scale rather than the stand scale and to allow for greater flexibility in species composition and density at the stand scale. Silvicultural treatments would aim to maintain as much species, functional, and structural diversity as possible. Given the preliminary and exploratory nature of this pilot project, it would be premature for us to suggest actual guidelines for the ICHmc2; however, we do present some examples of how the proposed approach would work and how the method could be used to track landscape-level changes.

To illustrate our proposed approach, we portray data from the RESULTS database and our ecosystem recovery research plots using a lognormal function to show landscape-scale distribution of tree species composition and density (Figures A2.7–A2.12). The amount of area under the curve for each individual species represents the proportion of that species across the landscape. The shape of the lognormal function (the curve) indicates the density distribution of a species in the landscape. The shape is flexible and can be continually increasing or decreasing, or have a single "hump" with a skew to the left (the most typical shape for natural tree densities). A narrow curve indicates that a species has a limited density range across the landscape while a wider curve indicates a much broader range. The most common density of a species is at the peak of the curve (highest point on y-axis). The higher a point is found on the curve for a species the more likely you are to find that specific density in the landscape. The accompanying table shows the average density and the variability (probability intervals) around the average for each species. The probability intervals indicate the lower and upper densities expected for that species in the landscape at specified endpoints (e.g., 90%). In simple terms, at a 90% probability interval, if the lower and upper densities for a species were 300 and 2500 stems per hectare (sph), respectively, then you would expect the density of that species to fall between these values in 90 out of 100 stands established within the landscape.

Our portrayal of data from RESULTS and the ecosystem recovery plots presents the current conditions for various management intents or natural seral stages in the ICHmc2 landscape (Figures A2.7–A2.12). We do this to illustrate the approach, and the exact same approach can be used to set management objectives for species composition and density variability in a landscape by explicitly choosing the desired species proportions and density variability.

To provide an example, Figure A2.7 shows the tree species proportions and density ranges of up to 40-year-old stands based on our ecosystem recovery data. Hybrid spruce comprises 46% of the landscape at a mean density of 1221 sph with lower and upper 90% probability intervals of 380 and 2737 sph, respectively. The most common density (not the mean value) of spruce found in the landscape is 712 sph (peak of the curve) and because of the shape of the lognormal curve, this value will always be to the left of and lower than the mean value. Lodgepole pine represents 15% of the composition in the less than 40-year-old stands landscape with a mean density of 337 sph (90% probability intervals of 22–1190 sph). Western hemlock represents 18% of the species composition with a mean density of 488 sph (90% probability intervals of 54–1553 sph), and so on.

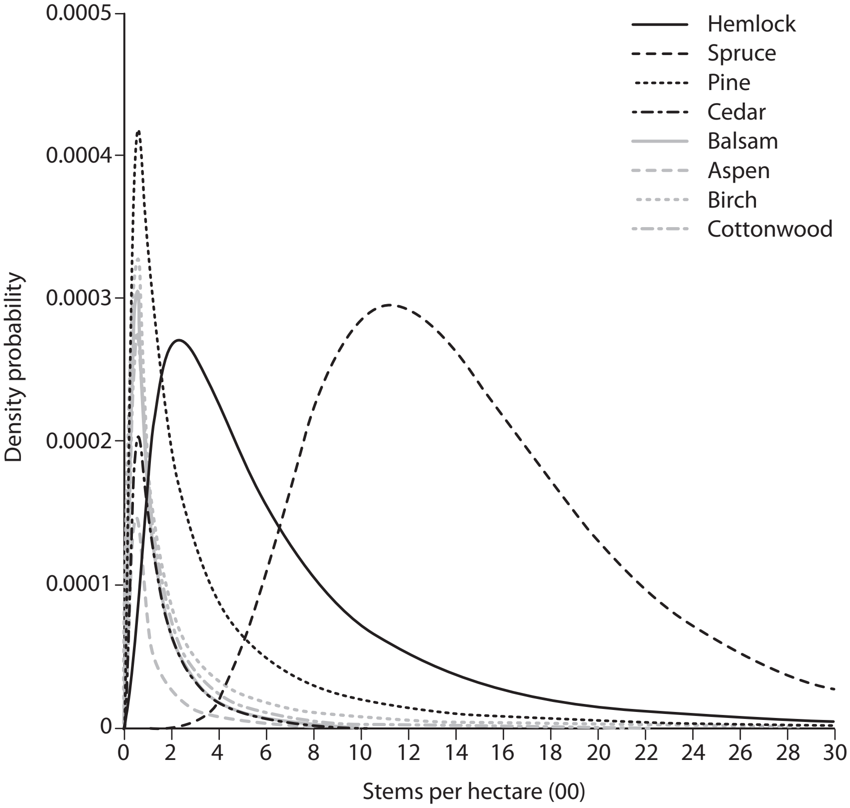
Figures A2.8–A2.10 portray landscape species composition based on the RESULTS database for spruce, pine, and spruce-pine management intent plantations, respectively. For comparison with species-specific plantations and the earlier ecosystem recovery data (Figure A2.7), we present the landscape distribution of tree species based on data from all plantations combined (Figure A2.11). The RESULTS data for all plantations combined are the most comparable to the 0–40 age class ecosystem recovery plots (Figure A2.7).



	Hemlock	Spruce	Pine	Cedar	Balsam	Aspen	Birch	Cottonwood
Proportion	0.18	0.46	0.15	0.05	0.070	0.010	0.079	0.001
Mean density	488	1221	337	156	195	32	253	18
90% lower	54	380	22	3	13	0	3	3
90% upper	1553	2737	1190	603	684	111	966	48

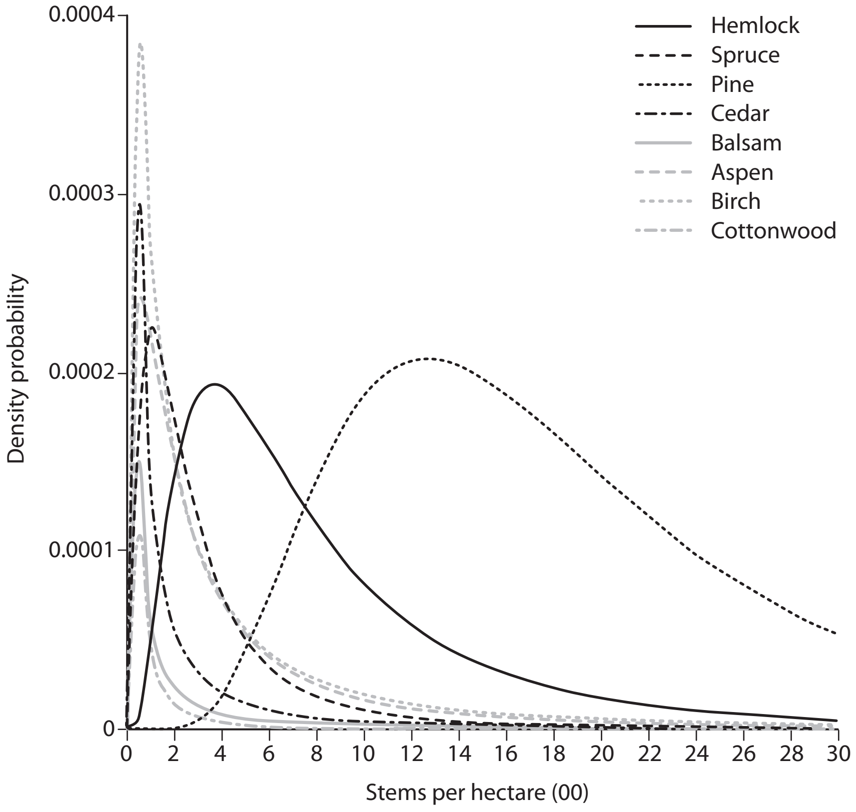
FIGURE A2.7 *Landscape distribution of tree species up to 40 years old in the ICHmc2 subzone based on data from ecosystem recovery research plots.*

Lastly, we present the landscape distribution of tree species in the 61 to 140-year-old age classes based on data from ecosystem recovery plots (Figure A2.12). This represents the species distribution in the landscape based on prior natural disturbance patterns. Of particular note is the difference in western redcedar distribution in natural stands (Figure A2.12) compared to managed stands (Figures A2.7–A2.11). Redcedar composition in the managed landscape is considerably lower than that found in natural stands, suggesting that clearcut environments are less favourable for natural redcedar regeneration than those created by natural disturbances. It is also clear that past planting programs have not included redcedar at levels similar to pre-harvest densities. The overall distribution of western hemlock is also of interest. Given that management intent in the past rarely included this species, it is of note that the proportion of hemlock in the landscape in managed stands (Figures A2.7–A2.11) varied between 13 and 21% and was only slightly lower than the 27% observed in natural stands (Figure A2.12). This suggests that, given the dominance of hemlock in the surrounding old-growth landscape, natural regeneration of hemlock in ICHmc2 stands after logging will be present in virtually all stands.



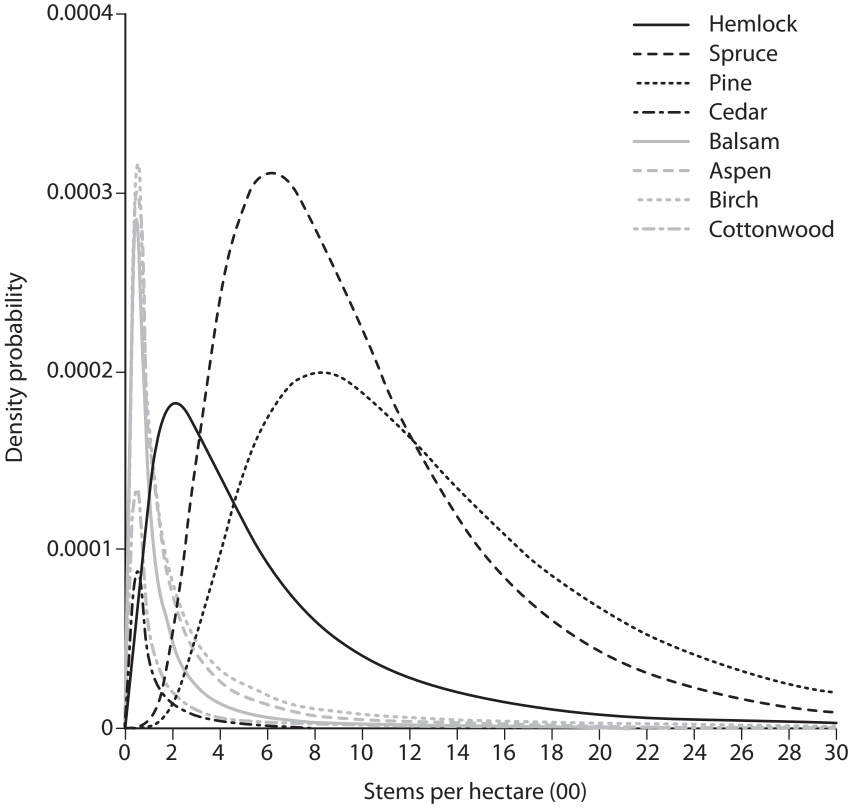
	Hemlock	Spruce	Pine	Cedar	Balsam	Aspen	Birch	Cottonwood
Proportion	0.212	0.416	0.128	0.037	0.052	0.026	0.078	0.051
Mean density	780	1527	512	198	184	160	456	226
90% lower	118	658	26	23	10	6	6	15
90% upper	2285	2893	1867	622	659	600	1756	792

FIGURE A2.8 *Landscape distribution of tree species in the ICHmc2 variant based on hybrid spruce management intent plantations. Data are from the inventory label in the RESULTS database.*



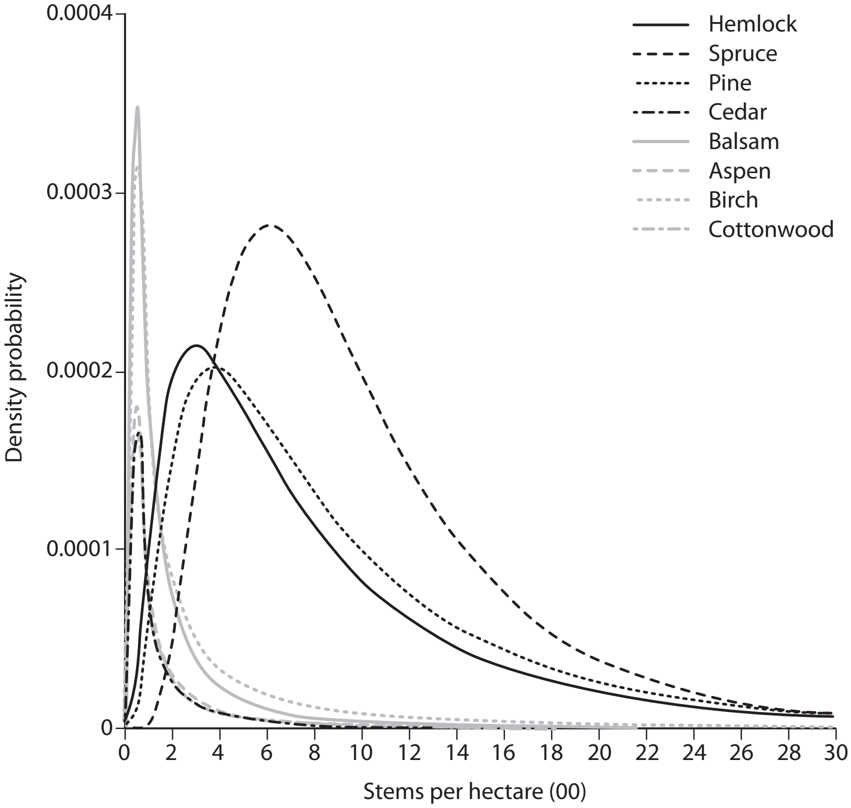
	Hemlock	Spruce	Pine	Cedar	Balsam	Aspen	Birch	Cottonwood
Proportion	0.183	0.081	0.393	0.07	0.043	0.093	0.119	0.018
Mean density	888	360	1906	304	200	534	708	105
90% lower	186	55	708	2	1	36	20	5
90% upper	2342	1055	3916	1138	696	1872	2712	382

FIGURE A2.9 *Landscape distribution of tree species in the ICHmc2 variant based on lodgepole pine management intent plantations. Data are from the inventory label in the RESULTS database.*



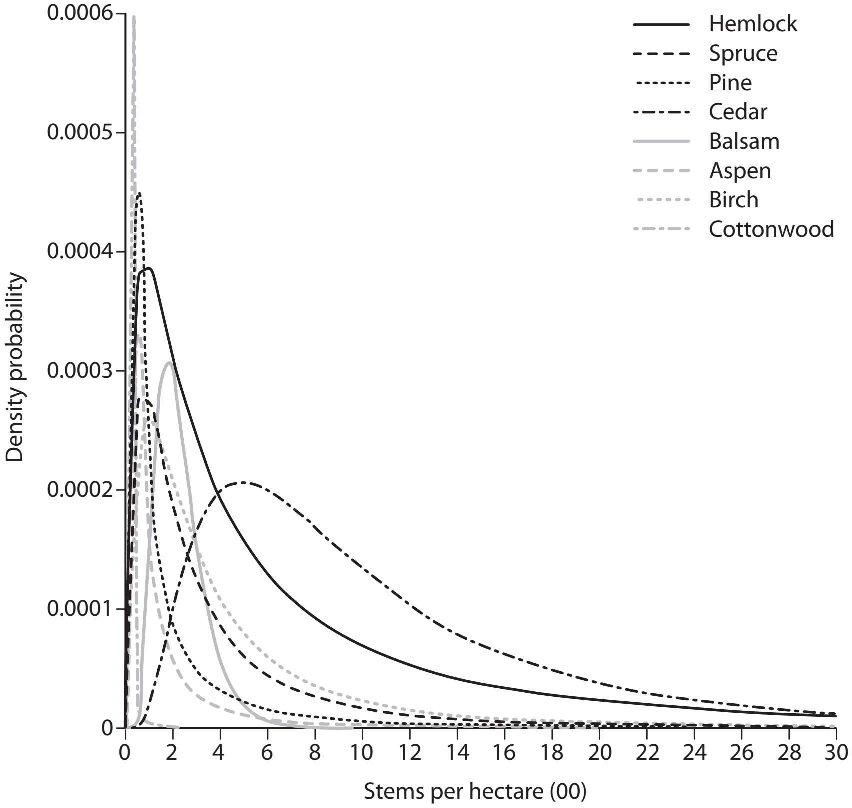
	Hemlock	Spruce	Pine	Cedar	Balsam	Aspen	Birch	Cottonwood
Proportion	0.13	0.338	0.294	0.023	0.049	0.06	0.074	0.032
Mean density	712	1043	1413	167	151	266	467	141
90% lower	108	332	440	1	6	10	7	1
90% upper	2087	2312	3166	618	562	1000	1802	541

FIGURE A2.10 *Landscape distribution of tree species in the ICHmc2 variant based on hybrid spruce–lodgepole pine management intent plantations. Data are from the inventory label in the RESULTS database.*



	Hemlock	Spruce	Pine	Cedar	Balsam	Aspen	Birch	Cottonwood
Proportion	0.207	0.307	0.221	0.042	0.064	0.041	0.075	0.043
Mean density	954	1039	1050	217	213	217	488	187
90% lower	150	324	190	1	8	2	7	1
90% upper	2766	2329	2914	802	800	830	1884	692

FIGURE A2.11 *Landscape distribution of tree species in the ICHmc2 variant based on data from all plantations combined. Data are from the inventory label in the RESULTS database.*



	Hemlock	Spruce	Pine	Cedar	Balsam	Aspen	Birch	Cottonwood
Proportion	0.269	0.104	0.104	0.261	0.068	0.064	0.117	0.013
Mean density	1322	444	293	1180	232	166	521	28
90% lower	53	39	3	247	100	4	53	0
90% upper	4936	1490	1111	3112	440	640	1687	88

FIGURE A2.12 *Landscape distribution of tree species in the 61- to 140-year-old age classes for the ICHmc2 variant based on data from Ecosystem Recovery Plots.*

SETTING LANDSCAPE-LEVEL SPECIES OBJECTIVES

By setting values in an active Excel spreadsheet for species proportion, density, and variability it is possible to develop species selection and density objectives for a landscape. The "desired condition" would be pre-determined on a landscape level (perhaps a BEC unit or Timber Supply Area), and the operators within that landscape would simply enter their own survey data to see how the area they manage fits into the overall landscape-unit species objectives. Regular assessments could be conducted to see if the trend is towards the desired future condition or away from it, and stand-level management objectives could be modified as needed. Although the desire is to manage at a landscape level, individual operators would be responsible for ensuring that the lands they manage meet the overall objectives. The proposed system allows for the land manager to have considerable flexibility in both the species composition and plantation density in any single unit. Individual stands do not all have to meet the same standard as long as the overall managed landscape falls within the pre-determined criteria for species proportions and density variability. Under this approach, single-species stands would still be potential options as long as choosing this option would not result in the landscape condition moving outside the pre-determined objectives.

CONCLUSIONS

Management intent, or the initial planting prescription for an opening, has already had a profound influence on species composition in second-growth stands of the ICHmc2. Planted hybrid spruce and lodgepole pine dominate the young, managed second-growth forests that make up about 22% of the forested landscape. While the dominance of these two species contrasts with the hemlock-dominated older forests of the ICHmc2, when compared with the mature forests (60- to 140-years) that make up about 42% of the forested landscape, the contrast is not as stark. These mature natural forests contain a more even mix of hemlock, spruce, and pine and many are dominated by broadleaf tree species.

While most existing managed second-growth forests exhibit high overall tree species diversity, it is unclear whether this diversity is well represented in the main tree canopy of these managed stands—that is to say, those individuals that are most likely to be the dominant part of the next stand by commercial rotation. Even though the understorey species are unlikely to be major players, their diversity is still important, especially in light of the *Dothistroma* needle blight epidemic that has occurred in the ICHmc2 (Woods 2003; Woods et al. 2005). It is these other species established in the understorey of planted pine that will reduce the regeneration delay as the overstorey pine trees die. The *Dothistroma* needle blight epidemic is a compelling story of why concentrating on establishing one tree species on a significant portion of the managed landscape carries risks, especially when the indirect effects of our changing climate on tree productivity are poorly understood (Woods et al. 2005).

The tree species diversity that currently exists in the managed stands of the ICHmc2 is a legacy of natural ingress originating from the surrounding mature and old natural stands that still dominate the ICH landscape. If the narrow management focus on tree species selection continues in the ICHmc2 (mainly two species), then, as the extent of managed stands increases, the seed sources for other species will be affected and the contribution of species ingress from natural stands will decrease. It is also important to note that much of the current managed second growth is located in lower elevations where original (pre-harvest) species composition may have included more spruce, pine, and broadleaf species compared with the remaining old growth, which is hemlock-dominated. As timber harvesting continues to move up and out of the valley bottoms, the opportunities for natural ingress from non-hemlock species will be significantly decreased.

The ICHmc2 has the "ecological advantage" of a relatively high tree species diversity (six coniferous species and three broadleaf species) compared with many BEC subzones. We should be taking full advantage of this native diversity (and possibly adding to it) in order to create adaptable forests that will withstand the direct and indirect effects of climate change. In our opinion, this is more important than concentrating too much on maintaining the current species profiles of the natural stands. What has emerged out of our analysis is an under-emphasis on the active establishment of all species other than lodgepole pine and spruce. These other species are all regenerating naturally to some extent in second-growth stands but because they have not been explicitly part of the management intent (at least to any significant degree), their role in managed stands is relatively minor—especially for redcedar and subalpine fir. This is an issue that needs to be addressed in order to take full advantage of the high species diversity of this variant. The especially high cultural, ecological, and economic value of western redcedar emphasizes the need to more actively manage for a greater component of this species in second-growth stands.

With the current managed second growth in the ICHmc2 occupying only about 22% of the forested landscape, there remains significant opportunity to alter management intent into the future. Past management activities have over-emphasized one or two species. A managed landscape that includes a more balanced distribution of all native ICHmc2 tree species would be an ecologically appropriate target and likely increase adaptability in the face of unexpected disturbance. To further increase forest adaptability and to buffer the future effects of climate change, it may be also reasonable to begin the introduction of off-site tree species such as western larch (*Larix occidentalis*) and interior Douglas-fir (*Pseudotsuga menziesii*) in some parts of the ICHmc2. This can be done by explicitly choosing what proportion of the landscape these species will represent and their desired density distribution (i.e., a narrow or wide curve). Similar to allowable annual cut determinations, landscape-level species choices should be re-visited and revised at fixed intervals.

This pilot study has demonstrated that the existing VRI and RESULTS provincial data sets can be used to assess the current status of managed and natural species composition and density variability at the landscape scale, and that the efficacy of this assessment has been corroborated by regionally specific and relevant data sets.

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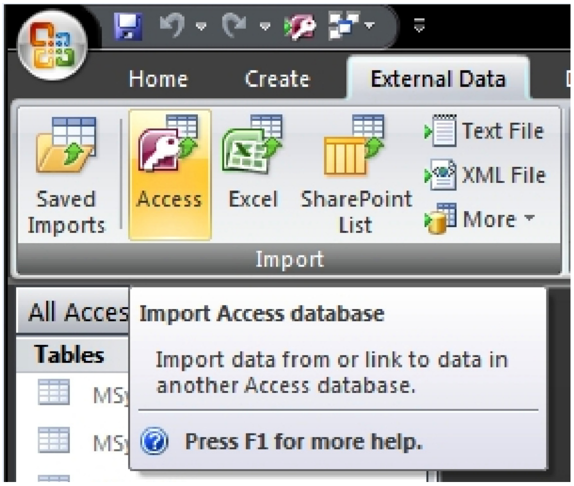
Woods A.J. 2003. Species diversity and forest health in northwest British Columbia. For. Chron. 79(5): 892–897.

These summaries are generated in Microsoft Access using a step method that employs the use of both VBA, for the creation of custom functions and modifying table structure, and SQL, for transforming and displaying data. The main requirement for the input data is that it must be in a consistent format. The only Microsoft Access-based skill required is the ability to import tables.

Importing Tables

Access contains a wizard to make importing data from another database painless. Two clicks will get you started: External Data/Access.

Once the desired table(s) is imported, you can turn your attention to the floating form that opened when you started the tool.



Import Access database

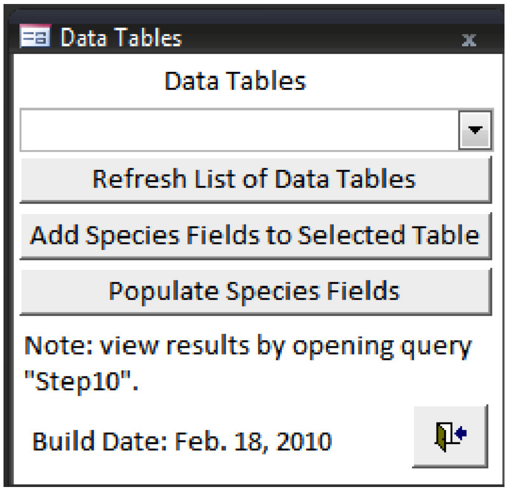
Import data from or link to data in another Access database.

Press F1 for more help.

Modifying/ Summarizing the Data

Select the table you wish to work with using the drop-down box. If you do not see your table, click the button labeled "Refresh List of Data Tables" and try again. Once your table has been selected, click the button "Add Species Fields to Selected Table." No mystery as to what that button did. Finally, click the button "Populate Species Fields" and the newly added fields will be populated with the summarized data. A note below this button informs you of where to look for the output.

If you are unable to see the database objects, press "F11" to show the database components on the left side of the screen and select the object(s) indicated at the bottom of the form.



Note: view results by opening query "Step10".

Build Date: Feb. 18, 2010

How It Works – RSSeT

Selecting a data table using the floating form triggers an event that causes the query named "qryRawData" to be rebuilt based on the selected table. The rest of the steps are based on this query and the table "tblSppGroups."

Step 1 – is a union query that transforms the data view into a single column containing all nine species columns from the raw data. Note that there is not a query grid option for this type of query; it must be written manually using SQL.

Step 2 – this crosstab query groups and sums the cover data from Step1 using the table "tblSpeciesGroups." Note that this query uses fixed column headings that must be changed if the groups are changed in the table "tblSpecies-Groups."

Step 3 – generates a table from Step2 named "tblStep2". The need for this table is because ultimately Step2 is dependent on the original query "qryRawData" and Access will not normally allow a table to be updated using a live derivative of itself.

Step 4 – uses the values in the table "tblStep2" to update the data in the query "qryRawData," which is directly connected to the original data.

Step 5 – based on the query "qryRawData," groups the data by OPENING_ID and FOREST_COVER_LAYER _CODE, sums the SILV_POLYGON_AREA, and generates the fields errTSPH, errTWSSPH, and errFGSPH.

Step 6 – uses Step1 and Step5 to generate the weighted cover.

Step 7 – is another crosstab query that transforms the data from Step6 using OPENING_ID, FOREST_COVER_LAYER _CODE, and SumOfSILV_POLYGON_AREA for row headings, Spp as column headings, and WeightedCover as the values. This crosstab query also uses fixed column headings.

Step 8 – brings the data from Step5 together with the data from qryRawData by joining the fields OPENING_ID and FOREST_COVER_LAYER _CODE.

Step 9 – contains some additional row labels generated from qryRawData for the final data presentation.

Step 10 – this is the final step and it combines the data from steps 7, 8, and 9.

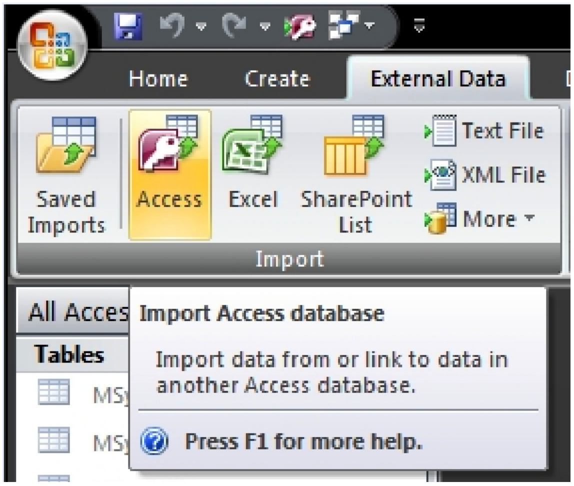
Summarizing VRIMS Data Using VSSeT

These summaries are generated in Microsoft Access using a step method that employs the use of both VBA, for the creation of custom functions and modifying table structure, and SQL, for transforming and displaying data. The main requirement for the input data is that it must be in a consistent format. The only Microsoft Access-based skill required is the ability to import tables.

Importing Tables

Access contains a wizard to make importing data from another database painless. Two clicks will get you started: External Data/Access.

Once the desired table(s) is imported, you can turn your attention to the floating form that opened when you started the tool.



Import Access database

Import data from or link to data in another Access database.

Press F1 for more help.

Modifying/ Summarizing the Data

Select the table you wish to work with using the drop-down box. If you do not see your table, click the button labeled "Refresh List of Data Tables" and try again. Once your table has been selected, click the button "Add Species Fields to Selected Table." No mystery as to what that button did. Finally, click the button "Populate Species Fields" and the newly added fields will be populated with the summarized data. A note below this button informs you of where to look for the output.

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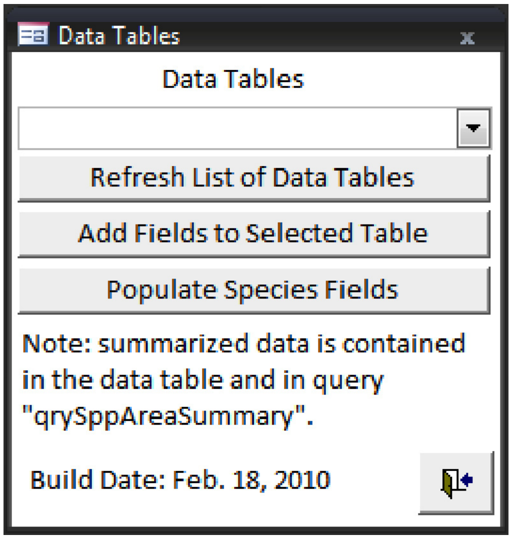

Note: summarized data is contained in the data table and in query "qrySppAreaSummary".

Build Date: Feb. 18, 2010

How It Works – VSSeT

Selecting a data table using the floating form triggers an event that causes the query named “qryRawData” to be rebuilt based on the selected table. The rest of the steps are based on this query and the table “tblSppGroups.”

Step 1 – is a union query that transforms the data view into a single column containing all nine species columns from the raw data. Note that there is not a query grid option for this type of query; it must be written manually using SQL.

Step 1b – filters out null cover values.

Step2 – is a crosstab query that arranges the data so that Feature_ID is the row headings and species groups are the column headings. This query uses the table “tblSppGroups” to group the species and the values are the sum of the cover values for those groups.

Step 3 – creates a table named “tblStep2” from the data in Step2.

Step 4 – updates the new percent fields in the original data table.

Step 5 – updates the new area fields in the original data table.

qrySppAreaSummary – the sum of polygon area for each species group.