Fort St. John Pilot Project

Sustainable Forest Management Plan

Submitted for approval to the

Regional Manager, Ministry of Forests

and the

Regional Director, Ministry of Water, Land and Air Protection

March 15, 2004

Part 2 of 2 - Appendices

APPENDICES

Please see Part 1 for the main sections of this document

Appendix 1: Sustainable Forest Management Policies

Sustainable Forest Management Policies

BC Timber Sales

In June 2001, the Ministry of Forests was directed by government to develop a plan to make the Small Business Forest Enterprise Program (small business program) more effective and put it on a commercial footing. Since then, significant work has been undertaken to achieve these outcomes. A new program and organization – BC Timber Sales – has replaced the small business program. The transformation of the small business program is part of widespread policy and organizational change across the Ministry of Forests targeted at revitalizing British Columbia's forest industry. BC Timber Sales was fully implemented on April 1, 2003.

High quality stewardship will be an important aspect of achieving success with BCTS and the organization is committed to certification. The foundation of the ISO 14001 certification is the Environmental Management System (EMS) we will pursue. BCTS will continue with the original goal of the small business program originally announced in November 2000 to develop an Environmental Management System. The BCTS program has developed and implemented an EMS in two regions and achieved ISO certification in two forest districts. As a result of reorganizing the program and the results of the latest management review, the current EMS will be revised to match the new organizational structure and to streamline business processes and reporting requirements. After this redefinition is completed, the EMS will be implemented more widely across BCTS. Each Timber Sales Office will pursue registration under ISO or other certification frameworks, as required by their markets and customer needs. Each TSO is currently developing it's own timelines in achieving EMS certification.

In July 1999 the Fort St. John small business program formally announced its commitment to participate in a pilot project within this timber supply area along with several other major licensees in an effort to develop a more streamlined forest management approach. This commitment included its full participation as an equal partner in the development of a sustainable forest management plan to the Canadian Standards Association Sustainable Forest Management Plan (SFM) standard. The SFMP presented here confirms BCTS (Fort St. John Field Team) intentions to achieve and maintain that commitment. As stated earlier each Timber Sales Office will be pursuing EMS certification and it is proposed that the Peace-Liard Business Area will be seeking a registration audit by November 2004, this will include the Fort St. John Field Team. In the interim we will be committed to live up to the expectations of the most current version of our EMS system and the attached Environmental Policy.

The attached vision and mission of the Ministry of Forests and BC Timber Sales along with the Strategic Context of the Ministry of Forests provides the background and guidance in our involvement in the development of this unique consolidated SFMP for the Fort St. John DFA. The Ministry of Forests has shown itself as a leader that models the principles underlying continuous improvement as an essential ingredient for success.

BCTS will ensure that our actions and decisions contribute to an equitable, safe, healthy and satisfying work environment and that our operations are conducted in a manner that will not jeopardize human health and safety and commit to maintaining an excellent safety record.

BCTS will liaise closely with the Ministry of Forests Forest Sciences Program in its efforts to seek and provide innovative solutions to high priority forest resources management problems in BC and to seek opportunities to advance resource stewardship based on sound scientific principles in our efforts to fulfill our forest management responsibilities.

Ministry of Forests Vision and Mission

The Forest Service as the agency responsible for protecting and managing the forest and range resources of the province will focus on ensuring that the health and productivity of these resources are maintained now and in the future. Healthy forests include a diversity of ecosystems that support a full range of forest products, businesses and other opportunities

To protect and manage our public forests for the sustained benefit of all British Columbians by:

- Protecting and managing the province's forest and range resources;
- Providing the basis for a globally competitive forest industry with high environmental standards;
- Maximizing net revenues to the Crown;
- In carrying out our mission and day to day activities the people of the Forest Service share the following core ethics;
- Our Sustainable Use ethic is to manage forest development to meet the current needs of British Columbians without prejudice to the needs of future generations;
- Our Stewardship ethic is to care for the health and sustain the beauty and natural functioning of the province's ecosystems by managing forest and range lands to maintain the natural diversity across the landscape;
- Our Public Service ethic is to provide a continuous flow of benefits from forest and rangelands for the physical, cultural and spiritual well being of British Columbians.

BC Timber Sales Vision and Mission

We will be an effective timber marketer generating wealth through sustainable forest management.

We will market Crown timber to establish market price and to capture the value of the asset for the public.

Our reputation will be built upon:

- Employing and developing skilled and motivated employees;
- Ensuring responsible forest stewardship on those forest lands we manage;
- Ensuring fair and prompt client services;
- Utilizing efficient, effective and innovative business practices;
- Ensuring open, honest and ethical behaviour on all people we encounter.

BC Timber Sales Environmental Policy

We are committed to responsible forest stewardship on Crown forest land throughout British Columbia where small business timber harvesting and related forest management activities will be occurring.

It is the policy of BCTS to:

- Comply with all relevant environmental legislation and regulations.
- Strive for excellence in forest management by continually improving the performance of resource management activities and practices.
- Maintain a framework for setting and reviewing environmental objectives and targets.
- Monitor and evaluate key BCTS forestry operations.
- Endeavour to prevent or mitigate undesired environmental impacts associated with BCTS forestry operations.
- Communicate BCTS business activities and policies to all staff and make them available to the public.

Ministry of Forests Strategic Context

The Ministry of Forests pursues its goals for sustainable forest resources and benefits in a consultative manner with the public, industry, and other Crown agencies, while recognizing the unique interests of aboriginal people.

- The protection of forest and range assets and infrastructure and the assistance given to rural communities to combat wildland fire requires a co-coordinated and consultative approach by the ministry with a great many stakeholders. These include the oil and gas community, First Nations, guide outfitters, cattle and range associations, local and regional governments as well as the forest industry and the general public.
- The ministry works with thousands of license tenure holders each year, ranging from small area or volume based holdings (e.g., woodlots or timber sale licences) to large major licences (e.g., forest licences or Tree Farm Licences). In addition there are over 2,500 individuals and corporations registered as BC Timber Sales Enterprises (formerly known as Small Business Forest Enterprises).
- More than 1,800 range licence and permit holders for grazing and hay cutting held by members of the ranching industry, guide outfitters and commercial recreation operators are involved with the ministry in Crown range management.
- The ministry consults with First Nations regarding forest management activities on Crown land. In addition MOF supports government's objectives of establishing working relationships with First Nations by negotiating interim measures and economic measures agreements with First Nations and supporting the Treaty Negotiations Office.
- The ministry maintains key partnerships with the Ministry of Sustainable Resources Management, for co-operation on land-use planning and land and resource information gathering, and with Ministry of Water, Land and Air Protection, for co-coordinating resource protection and management of habitat and riparian areas.
- Partnerships with local governments, recreation groups, First Nations, forest companies and others are also expanding as the ministry pursues partnership agreements for the management of over 1,800 Forest Service Recreation sites and trails.

This consultative and partnership approach to forest management, seeks to earn the public's trust as our staff protect and manage the province's forest and range resources, to ensure that all British Columbians can look forward to healthy forests and a strong forest economy now and in the future.

Canfor

In July of 1999 Canfor formally announced its commitment to seek sustainable forest management certification of the company's forestry operations under the Canadian Standards Association Sustainable Forest Management (SFM) standard. The Sustainable Forest Management Plan presented here and its implementation is intended to fulfill that commitment for Canfor's Fort St John operation.

As a preparatory step to sustainable forest management certification, Canfor developed an environmental management system (EMS) for the company's woodlands operations. In December 1999 this environmental management system was certified to the ISO 14001 standard developed by the International Organization for Standardization. The Company EMS provides a platform on which to build the sustainable forest management elements required to meet the CSA SFM standard.

The management of Canfor has set out a number of commitments which define the mission, vision, policies and guiding principles for the company. These include the Canfor Mission, Environment Policy and Forestry Principles. These commitments have been used to enable and guide the development of this Sustainable Forest Management Plan, and also commit us to the continual improvement of our performance in implementing the plan under the principle of adaptive management.

Canfor's Environment Policy includes a commitment to "create opportunities for interested parties to have input to our forest planning activities". The CSA SFM standard requires that sustainable forest management planning be carried out in consultation with those directly affected by or interested in forest management on the defined forest area (DFA). Our Environment Policy commitment has been interpreted and extended to include the involvement of the public in the setting of local values, objectives, indicators and targets for the purpose of developing a plan to achieve and maintain sustainable forest management on the DFA. The Environment Policy and Canfor's Forestry Principles also include the opportunity for participation by Aboriginal peoples with respect to their rights and interests in SFM on the DFA. The Fort St John Results Based Pilot Project Public Advisory Group is the body that has provided this input.

Additionally Canfor, acting on behalf of Cameron River Logging and Tembec and as the woodlands manager of the joint venture licence with West Moberly First Nations, will manage the respective Fort St John licences in accordance with Canfor's SFM commitments.

Canfor's Mission

We will be a highly successful competitor in the global forest products industry, managing with integrity the resources entrusted to our care.

We will be characterized by:

- Employing and developing highly motivated, empowered and committed people who enjoy their work.
- Consistently satisfying customer needs with quality products and services
- Enhancing the forest resource, ensuring responsible stewardship of the environment, and protecting human health and safety.
- Encouraging, recognizing and rewarding excellence in all our endeavours, with an emphasis on innovation and results.
- Increasing value for shareholders.

We will be guided by the core values of integrity, trust, openness and respect for people.

Environment Policy

We are committed to responsible stewardship of the environment throughout our operations.

We will:

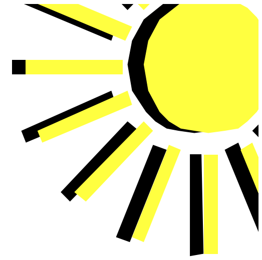
- Comply with or surpass legal requirements.
- Comply with other environmental requirements to which the company is committed.
- Set and review environmental objectives and targets to prevent pollution and to achieve continual improvement in our environmental performance.
- Create opportunities for interested parties to have input to our forest planning activities.
- Practice forest management that recognizes ecological processes and diversity and supports integrated use of the forest.
- Promote environmental awareness throughout our operations.
- Conduct regular audits of our environmental management system.
- Communicate our environmental performance to our Board of Directors, shareholders, employees, customers and other interested parties.

D.L. Emerson
President and Chief Executive Officer

P.J.G. Bentley
Chairman

CANFOR *July 21, 1999*

Canfor's Forestry Principles



Ecosystem Management
We will use the best available science to develop an understanding of ecological responses to natural and human-caused disturbances. We will incorporate this knowledge into higher level and operational plans by applying ecosystem management principles to achieve desired future forest conditions.

Scale
We will define objectives over a variety of time intervals (temporal scales), and at spatial scales of stand, landscape and forest.

Adaptive Management
We will use adaptive management to continually improve forest ecosystem management. This will require the development and implementation of collaborative research and monitoring programs.

Old Growth
We will include old growth and old growth attributes as part of our management strategies and philosophy in the forests where we operate.

Timber Resource
Canfor will ensure a continuous supply of affordable timber in order to carry out its business of harvesting, manufacturing and marketing forest products. Canfor will strive to maximize the net value of the fibre extracted for sustained economic benefits for employees, communities and shareholders.

Forest Land Base
We advocate the maintenance of the forest land base as an asset for the future.

Health and Safety
We will operate in a manner that protects human health and safety.

Aboriginal Peoples
We will pursue business partnerships and cooperative working arrangements with aboriginal people to provide mutual social, cultural and economic benefits and address mutual interests.

Communities
We will engage members of the public, communities and other stakeholders in the delivery of the Forestry Principles. The process will be open, transparent and accountable.

Accountability
We will be accountable to the public for managing the forest to achieve present and future values. We will use credible, internationally recognized, third party verification of our forestry operations as one way of demonstrating our performance.

Slocan/LP

Preamble

The two companies have a 50:50 joint venture company called Slocan-LP OSB Corp. that is assigned to manage the wood supply from each partner's timber tenures for a planned, but not yet constructed, oriented strand board mill in Fort St. John, BC.

With respect to CSA certification, Slocan is seeking registration in its operations before 2006. LP has committed to SFI certification only. Presently neither of the partners has an SFM Policy as such, but individually both companies have an Environmental Policy and Safety Policy (see below). However, both partners have, through separate policy statements or other documented processes, addressed broad SFM System requirements of the CSA Z089 standard as follows, by subsection of Section 7.2:

- Slocan has ISO 14001 EMS certification; and has recently committed to achieve CSA certification by 2006. LP has SFI certification. Both meet the commitment to achieve and maintain SFM.
- LP and Slocan have Environmental policies.
- LP and Slocan are signatory parties to a Memorandum of Agreement (MOA) with six First Nations in the Fort St. John DFA. The MOA is founded in respect of Aboriginal and treaty rights.
- Slocan and LP provide for public participation by managing to legal standards of the forest statutes and regulations. The companies are partners in the Fort St. John Pilot Project Regulation that proscribes the establishment and maintenance of a Public Advisory Group.
- As in "(c)" above, the MOA provides for capacity and participation opportunity for Aboriginal peoples with respect to their rights and interests in SFM.
- Slocan and LP have safety policies addressing this requirement (see below, or attached).

Louisiana-Pacific Canada Ltd.

Corporate Policy on Protection of the Environment

Louisiana-Pacific Corporation is committed to a healthy environment worldwide by taking a leadership role in our communities to be good neighbors. Our Corporate Policy on Protection of the Environment is a statement of our environmental goals. We believe that sound business practices and efforts to enhance the environment are compatible. Therefore, Louisiana-Pacific strives to:

- Meet or surpass the requirements of environmental laws and regulations and to improve the environment.
- Manage natural resources in a responsible and sustainable manner.
- Be environmentally conscious stewards of the land.
- Meet, as verified by third-party audits, the principles recommended to foster multiple-use and the sustainability of world forest resources.
- Conserve non-renewable resources through efficient use and careful planning.
- Properly manage and minimize waste through pollution prevention programs
- Continuously improve environmental programs.

What Is an Environmental Management System (EMS)?

Unlike regulations, which impose requirements on organizations from the outside, an environmental management system is a voluntary action generated from within a business or industry. The intent of EMS is organizing environmental requirements in such a way that they are well understood and become integrated into routine practices. It is a collection of internal policies, plans and procedures, that, when implemented, provide significant benefits for the organization.

Our Environmental Management System Empowers Our People.

LP has built an environmental management system that is unique to our industry. Our exceptional system taps the ingenuity, resourcefulness, and innovation of LP's employees, enabling them to make decisions about how best to protect the environment.

As a part of this system, employees work in teams to develop and continuously improve procedures that either meet or exceed all applicable environmental standards. Every LP plant operates under an environmental management system specific for the facility. As a result, we have experienced an 80 percent reduction in reportable environmental incidents since 1996, and we can attribute improved operational performance to the implementation of the EMS.

At LP, our people take personal responsibility for their actions. They are well informed about the positive impacts that their contributions have on the company and on their communities. They are eager and proud to share their ideas for further improvements, not just meeting environmental compliance requirements but surpassing them.

After all, what is a company but a group of people who are committed to a goal, a promise to their customers, their company, and their world?

Objectives for Sustainable Forestry on LP Forests

- LP will strive to broaden the practice of sustainable forestry by employing an array of scientifically, environmentally, and economically sound practices in the growth, harvest, and use of forests.
    1. Develop policies, programs and plans to implement and achieve the sustainable forestry standard principles and objectives.
    2. Individually, through cooperative efforts, or through American Forest & Paper Association (AF&PA), provide funding for forest research to improve the health, productivity, and management of all forests, as well as to better understand the role of managed forests in sequestering carbon.
    3. Provide public recreational and educational opportunities where consistent with forest-management objectives.
    4. Ensure that long-term harvest levels are sustainable and consistent with appropriate growth and yield models and written plans.

- LP will strive to ensure long-term forest productivity and conservation of forest resources through prompt reforestation, soil conservation, afforestation and other measures.
    1. After final harvest, reforest by planting or by direct seeding within two years, or by planned, natural-regeneration methods within five years.
    2. Promote state-level reporting of the overall success rates of reforestation and afforestation.
    3. Use forest chemicals prudently, following all applicable label requirements Best Management Practices (BMP's). Meet or exceed the laws and regulations concerning the use of fertilizers, herbicides and other forest chemicals to improve forest health and productivity, while protecting employees, neighbors, the public and the forest.
    4. Implement management practices to protect and maintain forest and soil productivity.
    5. Protect forests from damaging agents such as wildfire, pests, and diseases in order to maintain and improve long-term forest health and productivity.
    6. When utilizing genetically improved seedlings, including those derived through biotechnology, the company will use sound scientific methods and follow all appropriate federal and state regulations and other internationally applicable protocols.

- LP will strive to protect the water quality in streams, lakes, and other bodies of water by implementing riparian protection measures based on soil type, terrain, vegetation, and other applicable factors.
    1. Use Best Management Practices (BMP) developed under the Environmental Protection Agency (EPA)-approved state water-quality programs. Meet or exceed all applicable state water-quality laws and regulations, as well as the requirements of the federal Clean Water Act.

2. Develop (where they do not currently exist), implement, and document riparian protection measures for all perennial streams and lakes. Involve experts at the state level to help identify goals and objectives for riparian protection.
3. Individually, through cooperative efforts or through the AF&PA, provide funding for water quality research.
4. Require BMP employee training in woodland management and wood procurement operations. Encourage training for forest management and harvesting contractors.

- LP will strive to manage the quality and distribution of wildlife habitats and contribute to the conservation of biological diversity by developing and implementing stand- and landscape-level measures that promote habitat diversity and conservation of forest plants and animals.
  1. Enact policies and programs promoting habitat diversity at stand and landscape levels.
  2. Individually, through cooperative efforts or through the AF&PA provide funding for research to improve the science and understanding of wildlife management at stand or landscape levels, ecosystem functions, and the conservation of biological diversity.
  3. Apply knowledge gained through research, science, technology and field experience to manage wildlife habitat and contribute to the conservation of biological diversity.

- LP will strive to manage the visual impact of harvesting and other forest operations.
  1. Enact policies and programs to manage the impact of harvesting on visual quality.
  2. Develop and adopt appropriate policies for managing the size, shape, and placement of clear-cut harvests. The average size of clear-cut harvest areas shall not exceed 120 acres, except when necessary to respond to forest health emergencies or other natural catastrophes.
  3. Adopt a "green up" requirement, under which past clear-cut harvest areas must have trees at least 3 years old or 5 feet high at the desired level of stocking before adjacent areas may be clear-cut; or adopt other, more comprehensive methods that provide age, habitat, and aesthetic diversity.
  4. Use harvest methods, age classes and judicious placement of harvest units to promote diversity across the forest landscape.

- LP will strive to manage the visual impact of harvesting and other forest operations.

  Identify special sites and manage them in a manner appropriate to their unique features. We will cooperate with organizations that have expertise in protecting special sites for advice on how these lands can best be managed to maintain their unique character.

- LP will strive to promote the efficient use of forest resources.

  Use appropriate forest harvesting technology and practices to minimize waste and ensure efficient utilization of trees harvested while being consistent with other SFI objectives.

Objectives for Sustainable Forestry in the Procurement of Wood and Fiber From Wood Producers and Landowners

- LP will strive to broaden the practice of sustainable forestry by collaborating with forest landowners, wood producers, consulting foresters, and LP employees who have responsibility in wood procurement and landowner assistance programs.

1. By providing information on the environmental and economic advantages of our practices, encourage landowners to reforest following harvest and to use Best Management Practices.
2. Work closely with state logging and/or state forestry associations, appropriate agencies and others in the forestry community to promote the professionalism of wood producers by establishing state groups (where none exist) and by cooperating with existing state groups to promote the training and education of wood producers in:
    a. Awareness of sustainable forestry principles
    b. Using best management practices, including road construction and retirement, site preparation, streamside management, etc.
    c. Regeneration, forest resource conservation and aesthetics
    d. Awareness of responsibilities under the Endangered Species Act and other measures to protect wildlife habitat
    e. Logging safety
    f. OSHA and wage and hour rules
    g. Transportation
    h. Business management
    i. Public policy and outreach
3. Support and promote efforts of state groups to sponsor training and education programs for wood producers, employees involved in procurement and landowner assistance and contractors.
4. Annually report:
    a. The number of landowners who receive information about the SFI program, forest regeneration, BMP, and wildlife habitat management from contractors, LP employees.
    b. The percentage of wood delivered by qualified logging professionals.
5. Encourage landowners to utilize the services of qualified resource professionals and qualified logging professionals in applying principles of sustainable forest management on their lands.
6. Ensure that their commitment to the sustainable forestry standard principles is communicated throughout their organizations — particularly to mill and woodland managers, wood procurement operations and field foresters.
7. Support and promote efforts by consulting foresters, state and federal agencies, state groups and programs such as the American Tree Farm System®, to educate and assist forest landowners encouraging them to apply principles of sustainable forest management.

8. Clearly define and implement our own policies, programs and plans to ensure that mill inventories and procurement practices do not compromise adherence to the Principles of Sustainable Forestry.

Objectives for Public Reporting and Involvement in the Practice of Sustainable Forestry

- Publicly report our progress in fulfilling our commitment to sustainable forestry.
- By providing information on the environmental and economic advantages of our practices, encourage landowners to reforest following harvest and to use Best Management Practices.
- Provide opportunities for the public and the forestry community to participate in the commitment to sustainable forestry.
  1. Support and promote, at the state or other appropriate levels, mechanisms for public outreach, education and involvement related to forest management, such as, 800 numbers, environmental education, and/or private and public sector technical assistance programs.
  2. Support and promote, at the state or other appropriate levels, procedures to address concerns raised by loggers, consulting foresters, employees, the public or Program Participants regarding practices that appear to be inconsistent with the sustainable forestry standard principles and objectives.

Objectives for Continual Improvement in the Practice of Sustainable Forestry

- Promote continual improvement in the practice of sustainable forestry and monitor, measure and report performance in achieving the commitment to sustainable forestry.

  Establish a management review system that examines findings and progress in implementing the SFI program and policies and make appropriate improvements in policies and plans, and inform their employees of changes.

Slocan Forest Products Ltd.

Environmental Policy

Slocan Forest Products Ltd. (Slocan) believes in conducting its business in a manner that protects the environment and ensures sustainable forest development.

We are committed to a process that continually improves our activities involving environmental performance and stewardship.

To achieve this objective, we must:

- manage all of our operations to comply with or exceed all legal requirements
- identify, evaluate and control potential environmental risks, and implement appropriate preventive measures
- set and review environmental objectives that continually improve environmental performance
- communicate, educate and promote awareness regarding environmental activities with employees and stakeholders
- conduct timely audits of our environmental management systems and implement corrective measures as required

The success of our efforts within Slocan is dependent on sustaining a healthy environment.

Sustainable Forestry

Slocan will be working with communities, environmental groups and scientists to develop "criteria" and "indicators" for sustainable forest management in each of the company's operating areas. For example, a common criteria for achieving ecological sustainability is biological diversity. In some of our operating areas we can maintain biological richness by ensuring that indicators such as key species (the pine marten for example) are well represented throughout their habitat. A criteria for meeting social values could be sustaining water quality and quantity for consumptive use. In this case, an indicator of success might be that water quality in monitored watersheds stays inside the range of natural variability according to drinking water guidelines. Sustaining the long term flow of economic benefits could be an economic criteria with the indicators of success being harvest levels, employment and profitability. We currently have a sustainable forest management pilot project underway.

Slocan's Health and Safety Policy

Slocan Forest Products Ltd. (Slocan) believes that excellence in standards for work site safety, health and cleanliness is important to our employees, customers and shareholders.

We are committed to an ever evolving process which will ensure that work site health and safety will continue to improve. To facilitate this philosophy, we must:

- reinforce pride with commitment to high safety standards in a clean and orderly work environment;
- develop effective safety and health standards;
- encourage all Slocan employees to take responsibility for their personal safety and that of their fellow workers;
- ensure compliance with the requirements of regulatory agencies is pursued in a proactive and cooperative manner;
- create an environment in which training provides our employees the knowledge and skills to implement change which will improve job safety and performance.

The quality of our lives, and that of our families, is directly dependent upon a safe work place. Good health for all employees is the goal Slocan is committed to achieving.

Jim Shepherd
President and Chief Executive Officer
September 2000

Appendix 2: Sustainable Forest Management Matrix

Fort St. John Pilot Project SFM Matrix

6.0 The SFM Performance Requirements: CCFM Criteria and CSA SFM Elements The organization, in conformance with the public participation process requirements set out in Section 5, will identify DFA-specific values, objectives, indicators and targets for each of the CSA SFM Elements described in Clauses 6.1-6.6, as well as any other values associated with DFA.	**Value** Value - a DFA characteristic, component or quality considered by an interested party to be important in relation to a CSA SFM Element or other locally identified element.	**Objective** Objective - a broad statement describing a desired future state or condition for a value.		**Indicator** Indicator - a variable that measures or describes the state or condition of a value.	**Target** Target - a specific statement describing a desired future state or condition of an indicator. Targets should be clearly defined, time-limited, and quantified, if possible.
CCFM Criterion 1 – Conservation of Biological Diversity Conserve biological diversity by maintaining integrity, function and diversity of living organisms and the complexes of which they are part.					
Element 1.1 Ecosystem Diversity Conserve ecosystem diversity at the landscape level by maintaining the variety of communities and ecosystems that naturally occur on the DFA.	Ecosystem Diversity	The diversity and pattern of communities and ecosystems within a natural range.	**1**	Percent distribution of forest type (deciduous, deciduous mixedwood, conifer mixedwood, conifer) >20 years old by landscape unit	100% of forest type groups by landscape unit will be within the target range
			2	The minimum proportion (%) of late seral forest by NDU by LU	The minimum proportion (%) of late seral forest by NDU by LU as identified in tables 10, 11, 12 will be met within the identified timelines
			3	Percent area by Patch Size Class (0-50, 51-100, and >100 ha) by Landscape Unit	A minimum of 19 of 33 (58%) of the baseline targets for early patches will be achieved during the term of this SFM Plan. A minimum of 10 of 11 (91%) of the baseline targets for mature patches will be achieved during the term of this SFM Plan
			4	Average shape index of young patches in a landscape unit	Patches 50 -100 ha: The average Shape Index of young patches in a LU will be at least 2.0. Patches 100 -1000: The average Shape Index of young patches in an LU will be at least 3.0. Patches 1000+: The average Shape Index of young patches in an LU will be at least 4.0.
Element 1.2 Species Diversity Conserve species diversity by ensuring that habitats for the native species found on the DFA are maintained through time.	Species Richness	Suitable habitat elements for indicator species	**5**	Number of snags and/or live trees (>17.5 cm dbh) per ha on prescribed areas	Retain annually an average of at least 6 snags and/or live trees (>17.5 cm dbh) per hectare on prescribed areas
			6	Average Coarse Woody Debris volume/ha on blocks logged in the DFA	Minimum target average retention level over the DFA will be 46 m^3/ha (50% of average pre-harvest volume) on harvested blocks assessed for the period between December 1, 2003 and November 30, 2008
			7	The number of non-compliances to riparian reserve zone standards	No non-compliances to riparian reserve zone standards
			8	The proportion of shrub habitat (%) by Landscape Unit	Each landscape unit will meet or exceed the baseline target (%) proportion of shrub habitat
			9	Cumulative Wildlife Tree Patch percentage in blocks harvested under the FSJPPR in each Landscape Unit	Cumulative Wildlife Tree Patch % will meet or exceed the minimum target in each LU (Blueberry 5%, Halfway 3%, Kahntah 4%, Kobes 5%, Lower Beatton 8%, Milligan 4%, Tommy Lakes 3%, Trutch 4%, Sikanni 4%, Graham 4%, Crying Girl 6%)
			10	The % prohibited and primary noxious weeds, and known invasive weed species of concern, in seed mix analysis	Seed mix analysis will have 0% content of prohibited and primary noxious weeds as identified in the most current publication of "Noxious Weeds in the Peace River Regional District", and known invasive weed species of concern
		Maintain habitats for species at risk	**11**	The percent of species at risk with management strategies developed and being implemented	Develop forest management strategies for all species at risk in the DFA by June 2004. On an annual basis, ensure that 100% of species at risk management strategies are being implemented as scheduled
			12	Proportion of area (%) of forest greater than the baseline target age by caribou management zone	40% of forests will be greater than the baseline target age by caribou management zone

Fort St. John Pilot Project SFM Matrix

6.0 The SFM Performance Requirements: CCFM Criteria and CSA SFM Elements The organization, in conformance with the public participation process requirements set out in Section 5, will identify DFA-specific values, objectives, indicators and targets for each of the CSA SFM Elements described in Clauses 6.1-6.6, as well as any other values associated with DFA.	Value Value - a DFA characteristic, component or quality considered by an interested party to be important in relation to a CSA SFM Element or other locally identified element.	Objective Objective - a broad statement describing a desired future state or condition for a value.	Indicator Indicator - a variable that measures or describes the state or condition of a value.		Target Target - a specific statement describing a desired future state or condition of an indicator. Targets should be clearly defined, time-limited, and quantified, if possible.
Element 1.3 Genetic Diversity Conserve genetic diversity by maintaining the variation of genes within species.	Genetic Diversity	Conserve genetic diversity of tree stock	**13**	The proportion of seeds for coniferous species collected and seedlings planted in accordance with the regulation	All coniferous seeds will be collected and seedlings will be planted in accordance with the regulations
			14	% Natural Regeneration of aspen	We will use 100% natural regeneration for aspen to ensure the conservation of genetic diversity of tree stock
Element 1.4 Protected Areas and Sites of Special Biological Significance Respect protected areas identified through government processes. Identify sites of special biological significance within the DFA and implement management strategies appropriate to their long term maintenance.	Protected Areas and Conservation Emphasis areas, for example Special Management Zones, Ecological Reserves, etc.	To have representative areas of naturally occurring & important ecosystems & rare physical environments protected at both the broad and site-specific levels across or adjacent to the DFA	**15**	Hectares of Forestry Related Harvesting or Road Construction within Class A parks, ecological reserves and LRMP designated protected areas	Zero hectares of forestry related harvesting or road construction within Class A parks, ecological reserves or LRMP designated protected areas
			16	Proportion of activities consistent with objectives of Wildlife Habitat Areas (WHA), Ungulate Winter Ranges (UWR) and the Muskwa-Kechika Management Area (MKMA)	All pilot participant activities will be consistent with objectives of Wildlife Habitat Areas, Ungulate Winter Ranges and the MKMA
			17	Proportion of area (%) of forest stands by leading species by NDU in an unmanaged condition	100% of baseline targets for forested stnads by leading species by NDU will be met
		Management strategies address important values in SMZ areas	**18**	Relative timing of commencement of operational harvesting within clusters in the Graham IRM Plan area	Harvesting will not commence prior to the planned harvest start date for any cluster
			19	Cumulative merchantable hectares within blocks harvested within the Graham IRM area	The cumulative merchantable hectares within blocks will be consistent with the estimated total harvest area, as measured at the end of each time period
			20	Hectares harvested in cutblocks in the Graham IRM area, within the permanent alluvial and non-productive/non-commercial components of the connectivity corridors	No harvesting within the permanent alluvial and non-productive/non-commercial components of the connectivity corridors
			21	The number of drainages in the MKMA in which Clustered Harvest Plans are completed and submitted to government	A minimum of 1 drainage plan submitted no later than October 2007
			22	The percentage of harvested areas that create openings greater than 1 hectare within100 metres of RRZ's in identified major river corridors	No openings exceeding 1 hectare in blocks within the major river corridors harvested under the FSJPPR (i.e. after November 15th, 2001)
			23	% of new main summer road length developed adjacent to harvested areas within identified major river corridors where visual screening is present	100% of summer accessible road lengths within the designated area will have visual screening from adjacent cutblocks

Fort St. John Pilot Project SFM Matrix

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CCFM Criterion 2 – Maintenance and Enhancement of Forest Ecosystem Condition and Productivity Conserve forest ecosystem condition and productivity by maintaining the health, vitality, and rates of biological production.					
Element 2.1 Forest Ecosystem Resilience Conserve ecosystem resilience by maintaining both ecosystem processes and ecosystem conditions.	Ecosystem Resilience	A natural range of variability in ecosystem function, composition and structure with allows ecosystems to recover from disturbance and stress	**2**	See indicator #2	
			24	Permanent access structures (%) within cutblocks	A maximum of 5% of the total cumulative area in cutblocks by participant to be occupied in permanent access structures in which harvesting was completed during that annual reporting period as determined on a 3 year rolling average
			25	% of significant detected forest health damaging events which have treatment plans prepared and implemented	100% of significant detected forest health damaging agents will have treatment plans prepared and implemented within 1 year of initial detection
			6	See indicator #6	
			5	See indicator #5	
			9	See indicator #9	
			26	The relative proportion of salvaged hectares versus total hectares damaged in merchantable stands (as defined in the current TSR) within a management intensity class	The relative proportions of salvage hectares will be highest in the high intensity zones, and lowest in the low intensity zones over an SFM Plan period (December 1, 2003- March 31, 2008)
			27	Percentage of area harvested annually using even aged silvicultural systems	Even aged silvicultural systems will be employed on at least 80% of the total area harvested annually in the DFA
			28	Relative Change in Plantation Composition versus Harvest Composition for Spruce and Pine	The relative proportion of spruce and pine planted annually will equal the proportions harvested annually (excluding fill planting)
			29	Merchantable Volume (m3) for coniferous areas	For coniferous areas, Merchantable Volume will meet or exceed Target Volume within the reforestation period
			30	Establishment Delay (years)	The area weighted average establishment delay for coniferous regeneration will not exceed two years. The area weighted average establishment delay for deciduous regeneration will not exceed two years
Element 2.2 Forest Ecosystem Productivity Conserve ecosystem productivity and productive capacity by maintaining ecosystem conditions that are capable of supporting naturally occurring species.	Ecosystem Productivity	Ecosystem functions capable of supporting naturally occurring species exist within the range of natural variability	**1**	See indicator #1	
			2	See indicator #2	
			20	See indicator #20	
			3	See indicator #30	
			25	See indicator #25	
	Productive Capacity for Timber	Maintain or enhance landscape level productivity	**31**	Long-term harvest level (LTHL) as measured in cubic metres per year (m^3/yr)	We will propose an Allowable Annual Cut (AAC) that sustains the LTHL of the Defined Forest Area (DFA)
			32	Site index	Average post harvest site index will not be less than average pre-harvest site index on blocks harvested under the pilot project regulation
			25	See indicator #25	

Fort St. John Pilot Project SFM Matrix

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CCFM Criterion 3 – Conservation of Soil and Water Resources Conserve soil and water resources by maintaining their quantity and quality in forest ecosystems.					
Element 3.1 Soil Quality and Quantity Conserve soil resources by maintaining soil quality and quantity.	Soil Productivity	Protect soil resources to sustain productive forests	**32**	See indicator #32	
			33	Number of hectares of landslides resulting from forestry practices	0 hectares of landslides due to forestry activities on blocks harvested and roads constructed commencing December 1, 2001
Element 3.2 Water Quality and Quantity Conserve water resources by maintaining water quality and quantity.	Water Quantity	Maintenance of water quantity	**34**	The percent of watersheds achieving baseline targets for the peak flow index and the percent of watershed reviews completed where the baseline target is exceeded	A minimum of 95% of the watersheds will be below the baseline target. All watersheds that exceed the baseline target will have a watershed review completed wherever new harvesting is planned
	Water Quality	Maintenance of water quality	**35**	The percentage of surveyed stream crossings identified with a high WQCR rating on forestry roads within the DFA for which participants are responsible (*WQCR – water quality concern rating)	Less than 25% of surveyed stream crossings on active roads (i.e. not deactivated) will have "High" WQCR of the total, based on a three year rolling average. Less than 30% of surveyed stream crossings on non-active roads (i.e. deactivated) will have "High" WQCR of the total, based on a three year rolling average
			7	See indicator #7	
			36	The number of non-conformances to SLP measures to protect stream bank, stream channel stability and riparian vegetation from harvesting and silviculture activities	No non-conformances related to protecting stream bank, stream channel stability and riparian vegetation due to harvesting or silviculture activities
			37	Number of reportable spills entering water bodies	Zero reportable spills entering water bodies
CCFM Criterion 4 – Forest Ecosystem Contributions to Global Ecological Cycles Maintain forest conditions and management activities that contribute to the health of global ecological cycles.					
Element 4.1 Carbon Uptake and Storage Maintain the processes that take carbon from the atmosphere and store it in forest ecosystems.	Carbon Uptake and Storage	Maintenance of the processes for carbon uptake and storage	**38**	Mean Annual Increment (m^3/ha/yr)	Maintain or increase MAI in the long term
			39	Total Growing Stock (m^3) in the Fort St. John DFA	No decline lower than the long term total growing stock of 95 million m^3
			29	See indicator #29	
			30	See indicator #30	
Element 4.2 Forest Land Conversion Protect forestlands from deforestation or conversion to non-forests.	Forest Land Base	Sustain forest lands within our control within the DFA	**24**	See indicator #24	
		Foster inter-industry cooperation to minimize conversion of forested lands to non forest conditions	**40**	Number of coordinated developments	Report annually the number of proposed coordinated developments that are successful versus unsuccessful

Fort St. John Pilot Project SFM Matrix

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CCFM Criterion 5 – Multiple Benefits to Society Sustain flows of forest benefits for current and future generations by providing multiple goods and services.					
Element 5.1 Timber and Non-Timber Benefits Manage the forest to produce an acceptable and feasible mix of both timber and non-timber benefits.	Timber and Non-Timber Multi-use Benefits	Provide opportunities for a feasible mix of timber, recreational activities, and non-timber commercial activities	**41**	Consistency with mutually agreed upon action plans for range	Operations 100% consistent with resultant range action plans
			42	Number of range improvements damaged by participants' activities	No damage to range improvements by pilot participants activities
			43	The number of recreation sites managed by participants	Participants will provide and maintain a minimum of one recreational site within the DFA
			44	Consistency with Visual Quality Objectives (VQO's)	Pilot participants' forest operations will be consistent with the established VQO's
			45	Percent of area in primitive and semi-primitive non-motorized classifications of the Recreation Opportunity Spectrum (ROS) for Besa-Halfway-Chowade (B-H-C), Graham North (GN), Graham South (GS), and Crying Girl (CG) Resource Management Zones (RMZ)	Maintain the primitive level ROS percentage of area for the B-H-C at 1996 levels. Retain a minimum of 50% of area by RMZ as semi-primitive non-motorized ROS class for the Graham North, Graham South and Crying Girl RMZ
			18	See indicator #18	
			19	See indicator #19	
			21	See indicator #21	
			46	Consistency with mutually agreed upon action plans for guides, trappers and other known non-timber commercial interests	Operations 100% consistent with the resultant action plans
			47	Volume of timber processed in the DFA in proportion to volume harvested in the DFA	The annual equivalent of 70% of the DFA's harvest is primary processed in the DFA

Fort St. John Pilot Project SFM Matrix

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			Indicator - a variable that measures or describes the state or condition of a value.		
Element 5.2 Communities and Sustainability Contribute to the sustainability of communities by providing diverse opportunities to derive benefits from forests and to participate in their use and management.	Sustainable and Viable Communities	Viable timber processing facilities in the DFA	**48**	Volume (m^3) of timber delivered annually to mills between May 1st and November 30th	2003: Minimum of 100,000 m^3 coniferous to FSJ sawmill. 2004+: Minimum of 150,000 m^3 coniferous to FSJ sawmill and 185,000 m^3 delivered to the deciduous manufacturing facilities
			49	% of coniferous area harvested using conventional ground based harvesting equipment	95% of the coniferous harvested area will utilize conventional ground based harvesting equipment
			50	Joint FOS	All FOS's will be jointly prepared by active participants
			51	The percentage of blocks and roads assessed in which avoidable waste and residue levels are within the target range	Annually, 100% of cutblocks and roads will fall within the target avoidable waste and residue range
		No decrease in the LTHL in the DFA	**52**	The proportion (%) of area of height class two pine types to total cutblock area, in blocks harvested	November 15th, 2001 - March 31th 2006: 8% or more of the total cutblock area of coniferous blocks harvested will be in height class two pine inventory types Subsequent 5 year periods: 8% or more of the total cutblock area of coniferous blocks harvested between will be in height class two pine inventory types
			32	See indicator #32	
			53	The percentage of the actual periodic cut control relative to target periodic cut control	Harvest volumes will not exceed 110% of the 5 year periodic cut control volume on each participant's licence
	Communities Participate in the Use and Management of the Forest	Diverse local forest employment opportunities exist in the DFA	**54**	Percentage of dollars spent locally on each woodlands phase in proportion to total expenditures	Logging/hauling: 80%, road construction and maintenance: 80%, silviculture: 8%, planning and administration: 50%
Element 5.3 Fair Distribution of Benefits and Costs Promote the fair distribution of timber and non-timber benefits and costs.	Fair Distribution of Benefits and Costs	Provide opportunities for a range of interests to access benefits	**55**	Value of tendered contracts in proportion to the total value of all awarded contracts on an annual basis	A minimum of 50% of the total value of contracts will be tendered on an annual basis

Fort St. John Pilot Project SFM Matrix

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CCFM Criterion 6 – Accepting Society's Responsibility for Sustainable Development Society's responsibility for sustainable forest management requires that fair, equitable, and effective forest management decisions are made.					
Element 6.1 Aboriginal and Treaty Rights Recognize and respect Aboriginal and treaty rights.	Aboriginal and Treaty Rights	Recognition of Treaty 8 rights and respect aboriginal rights in development of plans	**56**	% conformance by participants to SFM elements pertinent to treaty rights (i.e., hunting, fishing and trapping) defined in Treaty 8	Participants will conform 100% to the SFM Indicators and Targets of the SFM Elements pertinent to sustaining hunting, fishing and trapping, as follows: Element 1.2 Species Diversity, and the Habitat elements indicators (5 - 9 inclusive), and Element 3.2 Water Quality and Quantity, and indicators (34 - 37 inclusive)
Element 6.2 Respect for Aboriginal Forest Values, Knowledge and Uses Respect traditional Aboriginal forest values and uses identified through the Aboriginal input process.	Aboriginal Forest Values, and Uses	Respect known traditional Aboriginal forest values, and uses	**57**	% of known traditional site-specific aboriginal values and uses identified during SFMP, FOS, FDP, or PMP referrals addressed in operational plans	100% of known traditional site-specific aboriginal values and uses identified during SFMP, FOS, FDP, or PMP referrals will be addressed in operational plans
Element 6.3 Public Participation Demonstrate that the public participation process is designed and functioning to the satisfaction of the participants	Opportunity for Public Participation	Satisfactory public participation processes	**58**	Public Review and Comment Process for the FSJPPR	Obtain PAG acceptance of Public Review and Comment Process; comply with Public Review and Comment Process
			59	Terms of reference (TOR) for the FSJPPR public participation process	Obtain PAG acceptance of TOR for public participation process; complete annual review of TOR
			60	The percentage of timely responses to Public Inquiries	Respond to 100% of public inquiries regarding our forestry practices, that are additional to the Pilot Public Review and Comment processes, within one month of receipt
Element 6.4 Information for Decision-Making Provide relevant information to interested parties to support their involvement in the public participation process, and increase knowledge of ecosystem processes and human interactions with forest ecosystems.	Information for Decision-Making	Relevant info used in decision making process is provided to PAG, FNAG, general public and affected parties	**60**	See indicator #60	
			61	Scientific/Technical Advisory Committee (STAC)	Establish and maintain a scientific technical committee until December 2003

Appendix 3: Growth & Yield Monitoring Plan

Growth & Yield Monitoring Plan for the Fort St. John Timber Supply Area

Version 2.0

Prepared for

Don Rosen
Canadian Forest Products Ltd.
Chetwynd, BC

Project: CFC-005

March 31, 2003

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

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1. INTRODUCTION

1.1 BACKGROUND

The Fort St. John Timber Supply Area (TSA) licencees are developing a sustainable forest management (SFM) plan that links TSA forest management activities to Canadian Standards Association (CSA) standards. Most activities supporting the SFM plan include setting forest management goals and objectives (through public consultation), developing targets for these objectives, and developing indicators to measure progress toward meeting the targets. One component of this SFM plan is to ensure that the productive capability of the landbase is maintained; this can be done by tracking growth & yield (G&Y) through a G&Y monitoring[1] program.

1.2 PROJECT GOAL & OBJECTIVES

The primary goal of this project is to develop a G&Y monitoring program for the Fort St. John TSA. This program will be designed to monitor the critical G&Y indicators and as many other indicators as possible to track progress towards meeting the SFM plan targets.

The specific objectives of this project are to:

1) Identify the business needs for a G&Y monitoring program in the TSA.
2) Define specific objectives for the G&Y monitoring program.
3) Identify where the G&Y monitoring program can provide data on other SFM indicators.
4) Develop a sampling design to meet the business needs and objectives.

1.3 TERMS OF REFERENCE

This project was completed by J.S. Thrower & Associates Ltd. (JST) for Don Rosen of Canadian Forest Products Ltd. (Canfor) of Fort St. John, BC. The JST project team was Eleanor McWilliams, *MSc RPF* (project manager), Jim Thrower, *PhD RPF* (technical support), Ron Zayac, *B.Comm* (GIS manager) and Wendy Creighton, *Dipl. Tech. GIS* (GIS technician).

Additional contributors to the G&Y monitoring options were Greg Taylor, *RPF* (Canfor), Jeff Beale, *RPF* (Slocan- Louisiana Pacific OSB Corp), Roger St. Jean, *RPF* (BC Timber Sales), Dave Menzies *RPF* (Canfor), Rod Brooks *RPF* (Louisiana Pacific Ltd.), Doug Russel (Louisiana Pacific Ltd.), Winn Hays-Byl, *RPF* (Ministry of Sustainable Resource Management [MSRM]), and Rod Kronlachner (Ministry of Forests [MOF]).

[1] General information on monitoring is provided in Appendix I.

2. BUSINESS NEEDS & OBJECTIVES FOR G&Y MONITORING

2.1 Background

Clearly defined business needs and program objectives are critical components of a well-designed monitoring program. Business needs should focus on information requirements to support forest management decisions and processes (e.g., SFM planning, allowable annual cut determinations). One example of a business need is to periodically measure the actual G&Y of post-harvest and regenerated (PHR) stands to check against the corresponding projections used in timber supply analysis.

Business needs should be defined with a clear understanding of the importance of how different information impacts forest management decisions. Understanding the risk of using incorrect information in decision-making processes is important in determining the key variables (indicators) to be monitored. For example, large errors in some estimates may have very little impact on management decisions, but small errors in others may have large consequences. A sensitivity analysis of managed stand volumes done for the Fort St. John timber supply analysis[2] showed that if managed stands yields were increased by 10%, the initial conifer harvest would increase by 4.1%. Conversely, if these yields are reduced by 10%, the initial conifer harvest is reduced by 9.5%.

2.2 The Process

The Fort St. John TSA G&Y monitoring business needs were identified through discussions with licencee, MOF, and MSRM staff. Different monitoring needs for the TSA were considered including monitoring all stands, only PHR stands, and subsets of PHR stands (e.g., mixedwood, conifer and deciduous). The need to monitor timber and non-timber forest attributes was also discussed. Many potential uses and needs for information derived from a monitoring program were evaluated and included analysis of their costs, benefits, uncertainty in management processes, and potential future changes.

2.3 Primary Business Needs

The primary business needs identified for G&Y monitoring on the Fort St. John TSA are to:

1) Periodically measure actual G&Y of managed stands to check projections used in timber supply analysis.
2) Provide data on indicators to support SFM requirements.
3) Provide data for inventory and G&Y model development.

2.4 Secondary Business Needs

The secondary business need is to monitor G&Y and stand dynamics in mature stands (particularly mixedwood stands) to check corresponding projections used in timber supply analysis. Monitoring mixedwood stands could become a key component of a mixedwood strategy that tests assumptions of how mixedwood stands change over time.

2.5 G&Y Monitoring Objectives

Based on these business needs, the specific objectives of the G&Y monitoring program for the Fort St. John TSA are to:

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[2] Ministry of Forests. 2002. Timber supply review, Fort St. John Timber Supply Area analysis report. June 2002. 142p.

1) Monitor change in volume, species composition, top height, and site index in managed stands beginning 15 years post-harvest. This data will be compared with predicted values of the same attributes used in timber supply analysis to provide a level-of-comfort that the projections used in timber supply analysis are accurate and precise. This data can also be used to track SFM indicators should the harvest level change in future.
2) Provide data on snags, coarse woody debris, and shrubs to address SFM objectives.
3) Provide data on stand growth that can be used as a subset of the data required to develop new G&Y models.
4) Develop a sample design that can be modified in future to incorporate plot establishment in mature stands and link with Vegetation Resources Inventory (VRI) Phase II ground sampling.[3]
5) Link the G&Y monitoring plots with silviculture surveys designed to monitor the first 15 years post-harvest.

[3] If all or a randomly chosen subset of the G&Y monitoring plots are re-measured at the same time as the temporary sample plots are established for VRI ground sampling, then the two data sources can be combined to give a better estimate of current yield.

3. SAMPLE DESIGN

3.1 Overview

The key features of the proposed sample design are:

1) Potential sample points are located on a systematic grid across the TSA.
2) Samples are 400 m^2 circular plots centered at these grid points.
3) Plots are installed in managed stands established 15 years post-harvest.
4) All sample plots will be installed over more than one year.
5) Sample plots will be re-measured every 10 years (funding permitting).

3.2 Purpose

The purpose of this sample design is to provide tree-level and non-timber data from a representative sample of managed stands on the TSA. This design is intended to provide data to address the program objectives (Section 2.5), be compatible with the MOF Change Monitoring Inventory (CMI) protocol[4], and to provide this information in a cost-effective manner.

G&Y monitoring is *the process of comparing the actual G&Y of a forest or stand to the predicted or expected G&Y for that forest or stand.* This program is intended to check existing G&Y predictions for managed stands and not to estimate stand response from silviculture treatments.

3.3 Target Population

The target population is all managed stands at least 15 years post-harvest in the timber harvesting land base (THLB) of the TSA.[5] The target population will expand as stands are harvested and regenerated. This definition may change in future if natural stands are included in the G&Y monitoring program.

Pre-stratifying the target population is not recommended because it is extremely difficult to maintain the stratification over time. The system should be designed to be simple and flexible in order to ensure its longevity. Changes in species composition and silviculture treatments can affect stratification schemes when stands "jump" between strata.

3.4 Sample Location

We recommend locating monitoring plots in managed stands on a systematic grid across the TSA. Plots can be randomly or systematically located without compromising the statistical validity of the design. Plots located systematically on a grid will cover as many conditions as random plots, and have added convenience since plot locations are known once the grid size is defined.

The intent is that these plots provide a statistically valid sample of the target population. Thus, all stand types should be sampled, plot locations are not moved to "representative conditions of the stand", nor are plots protected or buffered. If plots are buffered or treated differently than the rest of the target population, they cease to be a valid sample.

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[4] Ministry of Sustainable Resource Management. 2002. Change monitoring inventory ground sampling procedures for the provincial change monitoring inventory program, *version 1.2*. http://srmwww.gov.bc.ca/tib/publications.htm.

[5] The THLB is approximately 23% of the total TSA area according to the Fort St. John timber supply area analysis report.

3.5 Plot Numbering

We recommend using a plot numbering system based on Universal Transverse Mercator (UTM) coordinates. These numbers can be used to uniquely identify plots and their locations and limit the possibility for numbering errors as plots are added over time.

Table 1. Distribution of 3 km grid points in managed stands by major species.

Species Group	Post-harvest (yrs) 0-14	15 +	Total
Sw > 80%	21	10	31
Mixedwood SxAt	3	16	19
Mixedwood AtSx	5	13	18
At > 80%		10	10
Sw leading conifer	2	8	10
Pl > 80%	6	2	8
Pl leading conifer	1	4	5
Mixedwood AtPl	2	2	4
Mixedwood PlAt	2		2
Total	*42*	*65*	*107*

3.6 Sample Size

Several grid sizes (1, 2, 3, 4, and 5 km) were superimposed on the TSA inventory and all points in the THLB were identified. Preliminary analyses, which balanced sample size and cost, suggests a grid size between 3 and 4 km to sample the managed stand population. A 3 km grid provides one plot every 900 ha, while a 4 km grid provides one plot every 1,600 ha.

Table 2. Forecasted harvest levels for the Fort St. John TSA.

Year	Harvest (ha/year) Conifer	Deciduous
2003	3,000	200
2004	3,000	200
2005	3,600	1,500
2006	3,600	3,000
2007	3,800	3,500
2008	3,800	4,200
⋮	⋮	⋮
2052	3,800	4,200

Prior to further analyses, the inventory data for the 3 km grid points was checked to ensure that it was correct. This included ensuring harvest updates were complete and reconciling stand ages and harvest history data. This information was used to produce a summary of the distribution of 3 km grid points in managed stands by major species (Table 1).[6]

The 3 km grid data was used to proportionately estimate the distribution of grid points (by major species and years since harvest) in managed stands on 3.2, 3.4, 3.6, 3.8, and 4 km grids. Inventory records were used to estimate the number of plots to be established in the next 14 years. Forecasted harvest levels (Table 2) provided by Canfor were used to estimate the number of plots to be established 15 years and later. The distribution of these future plots was projected by major species group and assumed that current species distribution will be maintained as coniferous- or deciduous-leading. This distribution was obtained from the Fort St. John TSA analysis report (June 2002) (Table 3) and was applied to the projected number of G&Y monitoring plots to be established on areas not yet harvested.

Table 3. Species distribution within deciduous and coniferous leading stands.[7]

Species Group	%
Deciduous	65
Mixedwood At-Pl	16
Mixedwood At-Sx	19
Deciduous Total	*100*
Mixedwood Sx-At	11
Mixedwood Pl-At	11
Pl > 80%	24
Pl-leading conifer	19
Sw > 80%	19
Sw-leading conifer	16
Conifer Total	*100*

3.6.1 Post-stratification

The choice of grid sizes is partly a function of the ability to post-stratify the plots into large enough[8] groups to check the G&Y projections for those groups (Section 3.11). Species groups are usually categorized by conifer, deciduous, conifer mixedwood, and deciduous mixedwood. However,

[6] Lodgepole pine (Pl), white spruce (Sw), and trembling aspen (At).

[7] Data is compiled from the June 2002 Fort St. John TSA analysis report (Tables A3 and A16).

[8] A minimum sample size of 30 plots is recommended for G&Y estimates. Estimates of growth have less variability than estimates of yield and therefore require smaller sample sizes to obtain the same precision.

since the objective of checking G&Y projections, mixedwoods should be divided into Pl-At[9] mixtures and Sw-At mixtures.

G&Y models for Pl-At and Sw-At mixtures will be different because Pl and Sw have different shade tolerances; thus, the models will be developed separately. Further, Pl-At mixtures are easier to model and new models will likely be developed for this mixture before models are developed for a Sw-At mixture. Thus, given the objective of checking G&Y projections, we recommend splitting the mixedwood stands by conifer species.

Table 5. Estimated distribution of plots by general species composition, grid size and year.

	Grid Size (km)					
Species Group	3.0	3.2	3.4	3.6	3.8	4.0
			2005			
Deciduous	10	9	8	7	6	6
Mixedwood (Pl-At)	2	2	2	2	1	1
Mixedwood (Sw-At)	31	27	24	22	19	17
Conifer	30	26	23	21	19	17
Total	*73*	*64*	*57*	*51*	*45*	*41*
			2015			
Deciduous	10	9	8	7	6	6
Mixedwood (Pl-At)	6	5	5	4	4	3
Mixedwood (Sw-At)	36	32	28	25	22	20
Conifer	51	45	40	35	32	29
Total	*103*	*91*	*80*	*72*	*64*	*58*
			2025			
Deciduous	25	22	20	17	16	14
Mixedwood (Pl-At)	13	12	10	9	8	7
Mixedwood (Sw-At)	45	39	35	31	28	25
Conifer	79	69	61	55	49	44
Total	*162*	*142*	*126*	*112*	*101*	*91*
			2035			
Deciduous	56	49	43	39	35	31
Mixedwood (Pl-At)	25	22	20	18	16	14
Mixedwood (Sw-At)	58	51	45	41	36	33
Conifer	112	98	87	77	70	63
Total	*251*	*220*	*195*	*174*	*156*	*141*
			2045			
Deciduous	86	75	67	60	53	48
Mixedwood (Pl-At)	37	33	29	26	23	21
Mixedwood (Sw-At)	72	63	56	50	45	40
Conifer	144	127	112	100	90	81
Total	*340*	*299*	*264*	*236*	*212*	*191*

The projected plot distribution by species groups over time (Table 5) shows that by 2005 a 3 km grid would contain enough plots to check conifer and mixedwood Sw-At stands as individual groups (30 and 31 plots, respectively), but insufficient plots to check either deciduous or mixedwood Pl-At stands separately. The latter would be checked as part of the overall average of managed stand performance. By 2015, the 3 km grid would produce enough plots to extract pure Sw stands from the conifer group and analyze them separately (Table 6, Appendix II). In contrast, a 4 km grid would not provide enough plots to analyze conifer stands as a group unit 2015 and mixedwood Sw-At stands until approximately 2030 (Table 5). The estimated difference in average annual costs between a 3 and 4 km is $11,500 per year over the first three decades (Table 4).

Table 4. Estimated average annual cost for plot establishment and re-measurement by decade and grid size. Assuming $2,500 per plot for establishment and $1,000 per plot for re-measurement.

	Grid size (km)					
Decade	3.0	3.2	3.4	3.6	3.8	4.0
2003-2012	$23,300	$20,400	$18,100	$16,100	$14,500	$13,100
2013-2022	$19,900	$17,500	$15,500	$13,800	$12,400	$11,200
2023-2032	$35,700	$31,400	$27,800	$24,800	$22,300	$20,100
2033-2042	$44,600	$39,200	$34,700	$31,000	$27,800	$25,100
2043-2052	$53,500	$47,000	$41,700	$37,200	$33,400	$30,100

The ability to post-stratify the data to provide information on coarse woody debris, snags and shrubs, and range species to meet SFM information requirements has not yet been fully considered. It is not clear how potential strata would be defined besides using the major species groups. A summary of the data available to meet SFM requirements is provided in Appendix III.

[9] Pl-At mixtures include the full range of mixtures from 21 – 79% of either species, with Pl being the leading conifer. In contrast the symbols Pl-Aand At-l are used to refer to Pl leading and At leading stands respectively.

The choice of grid size is a function of available funding. It is important to recognize that establishing a monitoring program is an ongoing commitment that will require annual funding. Details of estimated costs and the quantity of G&Y data supplied by the different grid sizes are provided in Appendix II (Table 7, Table 8)

3.7 Plot Design

We recommend using a slightly modified version of the standard MSRM CMI plot (Figure 1). Tree measurements taken from the Main plot and Small-tree plot would be consistent with CMI standards. The Main Plot is 400 m^2 (11.28 m radius) where all trees greater than 9 cm diameter at breast-height (DBH) are measured and tagged. Trees between 4 and 9 cm are measured and tagged in the Small-tree plot (100 m^2, 5.64 m radius). The proposed modification is to the increase the radius of the Regeneration plot from 2.5 m to 3.99 m.[10] In this plot, all trees taller than 30 cm but less than 4 cm DBH are measured and tagged (50 m^2, 3.99 m radius). This will make the Regeneration plot the same size as the proposed full-measure silviculture survey plots (Section 4) that have previously been established at the same plot center and re-measured over the first 15 years post-harvest.

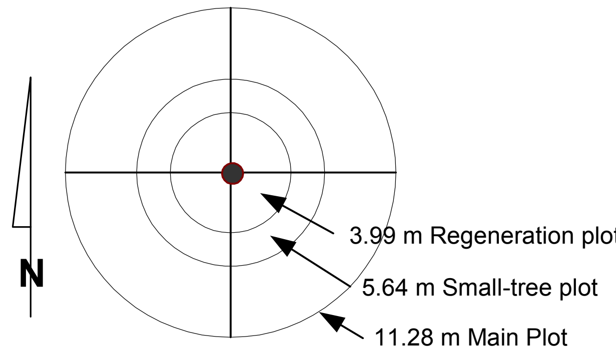

Figure 1. Monitoring plot design for tree measurements.

Coarse woody debris, ecological, vegetation and range data will be collected to CMI standards.

3.8 Re-measurement Period

We recommend a ten-year re-measurement period to coincide with every second five-year Management Plan cycle. In other management units, five-year re-measurement schedules have been recommended but the growth rates in the Fort St. John TSA do not warrant re-measurement every five years.

3.9 Plot Measurements

3.9.1 Overview

We propose that most MSRM CMI standard field procedures be used; however, stem-map information should not be collected and a modified selection of site trees is proposed. A summary of procedures is provided in Appendix IV.

3.9.2 Tree Tags

Brown tree tags should be affixed at breast-height rather than at stump height as recommended in the CMI protocol. This simplifies the work without making the plot unduly visible.

3.9.3 Top Height & Site Trees

Top height trees should be selected as per CMI guidelines from the Small-tree plot. We recommend that leading and second species not be determined prior to site trees selection.

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[10] If required, a 2.5 m radius could be used and trees within this plot recorded to maintain consistency with other CMI projects.

The age of the largest diameter, dominant or co-dominant tree of each species in each quadrant should be measured. This ensures that the age of the leading and second species are recorded. If the largest diameter tree of a given species (coded as "S" tree) is not suitable for height and age measurement, the next largest diameter tree suitable for height and age will be selected (and coded as "O" tree). If site trees between 4 and 9 cm DBH are outside the Small-tree plot (but inside the Main plot) they should not be tagged during plot establishment. In this case, site trees should be tagged and the height and age recorded in the site tree section on Card 10.

3.10 Data Management

Data will be entered into the most recent version of the VRI Data Entry (VIDE) software, suitable for both VRI and CMI data. JST can compile the data using the MSRM CMI data compiler.

3.11 Data Analysis & Interpretation

Data from the first measurement provides yield estimates only. These can be used to audit the projected yield of managed stands in timber supply analysis. Change is estimated when two or more measurements are available and then is it possible to determine differences between measured and predicted G&Y for the main attributes of interest. Graphical analysis includes plotting actual versus predicted values and plotting differences (actual-predicted) versus stand age or any other chosen variable to examine trends. The statistical analysis includes the average differences and associated confidence intervals.[11]

When the sample is large enough, it is possible to post-stratify the data to examine issues on subsets of managed stands. A minimum sample size in a stratum is approximately 30 plots.

The graphical and statistical analysis is intended to examine overall trends of over- or under-prediction in the data. If the analyses suggest over- or under-prediction, then possible sources of the differences should be identified. For example, when considering volume estimates, potential factors to consider as sources of error are the differences between the inventory inputs into the model and the actual stand attributes. Potential inventory attributes to examine include stocking, site index, treatment, species composition, stand structure, and pest or disease incidence.

The monitoring plot data could be used to adjust yields, but we recommend the data not be used to adjust growth projections (yield curves) based on observed growth. Both activities address the symptom of a problem rather its actual cause. Adjusting current yields for the sampled population is acceptable if data are representative of current yields. Adjusting yield curves to reflect observed growth in one time period is risky because this trend may not continue over time. The more prudent approach is to determine why differences occur. Often they result from incorrect inputs to the models.

The main objective of the monitoring program is to detect differences in growth. This program is limited in its ability to determine the causes of the differences. Consequently, additional samples or studies may be needed to identify possible sources of differences, should they occur.

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[11] J.S. Thrower & Associates Ltd. 2000. Graphical and statistical analysis for monitoring estimates of change at the management-unit level. Version 2.0. Contract report to B.C. Ministry of Forests, Resources Inventory Branch, Victoria, B.C. Project MFI-055.

3.12 Future Modifications

Future modifications to the G&Y monitoring program could include:

1) **Decreasing sample intensity –** Sampling intensity can be decreased in future as more plots are located in managed stands. The number of plots will increase as natural stands are harvested, regenerated, and brought to the minimum 15 years from disturbance. If the program becomes too costly, randomly selected plots can be dropped from older managed stands where the comfort of predicting stand yield is higher. As well, costs can be reduced by increasing the re-measurement period of some plots.

2) **Expanding the monitoring program to natural stands –** The G&Y monitoring program could be expanded to include natural stands. This would form a separate target population and a separate analysis would be needed to determine potential sample sizes. One possibility is using a grid size that is a multiple of that chosen for the managed stands so that once plots in the natural stand grid are harvested, the same plot centers could be used for silviculture surveys and PHR monitoring program. Initial analyses suggest that a 7.2 km grid size (twice 3.6 km) would provide approximately 50 plots in natural mixedwood stands. Expanding the grid into natural stands should be coordinated with VRI ground sampling to minimize sampling costs.

3) **Re-measure the G&Y monitoring plots as part of the VRI ground sample –** If all or a randomly chosen subset of the G&Y monitoring plots are re-measured with the VRI Phase II ground sampling, then the two data sources can be combined to give a better estimate of current yield.

4. LINK TO SILVICULTURE SURVEYS

4.1 OVERVIEW

The proposed monitoring plots will track the G&Y of managed stands beginning at 15 years post-harvest. "Full-measure" silviculture survey plots will be established at permanent points on a 200 m grid at the time of the first survey and re-measured in subsequent surveys over the next 15 years. A subset of these 200 m grid points will form part of the G&Y monitoring plot sample.[12]

4.2 FULL-MEASURE SILVICULTURE SURVEY PLOTS

Each full-measure plot includes a 50 m^2 (3.99 m radius) plot (Main plot) divided into quadrants along cardinal directions to measure tree attributes, and a 100 m^2 (5.64 m radius) plot (Site Index plot) to collect height and age data from site trees (located at the same plot center) (Figure 2). Suitable site trees have three or more years height growth above breast-height. Site tree data should be collected from one tree of each species located in the Site Index Plot with a suitable site tree.

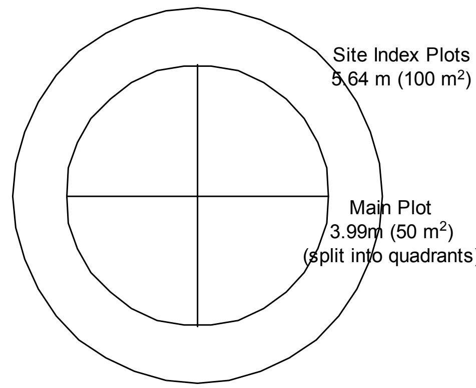

Figure 2. Full-measure plot design.

4.2.1 Plot Location

Full-measure plots are established on the 200 m grid. Plot centers should be permanently marked with a steel pin[13] and global positioning system (GPS) coordinates recorded. Plot locations should be geo-referenced in the geographic information system (GIS). These sample points should not be visible in order to avoid treating the plot area differently than other portions of the stand (which may bias the information from the sample point at subsequent measurements). The same center point will be used for the subset of full-measure plot locations chosen for the G&Y monitoring program.

4.2.2 Main Plot – 50 m^2

Quadrant Information – Each quadrant is recorded as stocked if it contains at least one healthy tree of an acceptable species that is free of brush competition (according to current free growing regulations). If a non-stocked quadrant could support tree growth, comment on why there are no trees (e.g., type of non-productive (NP) ground, missed plantable spots, brush competition, or health problems).

Tree Information – Data for each tree in the plot includes:

i) Quadrant number (1-4).
ii) Tree species.
iii) Height (measure some for reference and visually estimate others).
iv) Forest health codes (use the same codes used in other silviculture surveys).

Brush Information – Record percent cover and average height of brush by species in each quadrant.

NP Area Information – Record the type of NP area (e.g., rock, water) and percent cover in each quadrant.

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12 All proposed grid sizes for the G&Y monitoring plots are multiples of 200 m.

13 Any pin type could be used as long as it does not degrade and can be detected with a metal detector.

4.2.3 Site Index Plots – 100 m^2

Record site index information for one site tree of each species from the Site Index Plot located at each plot center. Site trees are:

i) The tallest tree in the 100 m^2 plot for that species.[14]
ii) Undamaged (stem damage resulting in less than 5% reduction in height growth).
iii) Not overtopped by other trees or competing vegetation where height growth may be affected.

The second tallest tree can be measured for site index if the tallest is not suitable. This must be noted on the field card. Information collected for each tree should include:

i) Total height.
ii) Age at breast-height.
iii) Total age.
iv) Rank in height relative to other trees in the plot of that species (e.g., tallest, 2nd tallest, etc.).

4.3 INFORMATION PROVIDED

If full-measure plots are repeatedly revisited as part of regular surveys during the first fifteen years post-harvest, they will provide a large observational database that can be linked to silviculture history and ecological data to determine trends in stand development. The same plot size (3.99 m radius) must be used and the same measurements (species, quadrant, estimated heights, damage codes, percent brush cover, and brush height[15]) must be taken during each survey. The data collected will provide information on:

1) **Early height growth** – This data can be used to check assumed years to breast-height and years to green-up. Other data can be used to check juvenile height growth curves or the juvenile height assumed with site index curves.
2) **Ingress patterns** – This data can be used to assess planting requirements and expected species composition.
3) **Growth following different silviculture treatments** – This data will not provide information on treatment response[16], but will provide feedback and demonstrate growth trends following various treatments.
4) **Stand-level details required to assign yield curves for timber supply** – The full-measure plots can be post-stratified and summarized by analysis units to provide statistically-defensible information to generate yield curves for timber supply analysis.
5) **Data on SFM indicators** – This includes data to check site productivity (early height growth), presence of snags and shrubs. A summary of the data provided on SFM indicators is presented in Appendix III.

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[14] Where site trees are less than 1.3 m in height they must be selected by height as opposed to DBH. Generally, it is more efficient to select site trees in young stands based on height and in older stands based on DBH. The VRI procedure is to choose trees based on DBH (Section 3.9.3). Site trees could be tagged on all or a subset of plots and the tagged trees could be re-measured in subsequent surveys to examine how site trees changes over time and how this influences site index estimates.

[15] If brush is a significant management issue, then surveys should be done at the same time of the year to ensure consistent % cover estimates.

[16] Treatment response is defined as the incremental gain (or loss) due to the treatment. It is the growth in the treated stands minus the growth that would have occurred if the stand had not been treated.

5. RECOMMENDATIONS

As a result of this analysis and discussions with the licensees and MOF and MSRM stakeholders, we recommend:

1) A 3 to 4 km monitoring grid size be used. The final choice of grid size will depend on funding and the level of detailed data needed. If possible, we recommend choosing a 3.6 km (or smaller) grid size to allow for sufficient plots for post-stratification into major species groups.
2) If the G&Y monitoring program is expanded into mature stands, it should be coordinated with VRI Phase II ground sampling.
3) Early stand establishment and stand dynamics be monitored with full-measure silviculture survey plots. This will provide a large database that can link silviculture history and ecological data to examine trends in stand development. This can be complimented with well-designed trials to determine cause and effect relationships.
4) G&Y monitoring plots provide some of the data necessary to calibrate G&Y models. However, calibrating the models requires a collaborative effort needed to develop a mixedwood growth model. One of the first strategic decisions the licensees need to consider is whether the work already completed to calibrate TASS should be used or whether a new model should be developed. It is also important to determine the appropriate scope for collaborative work to ensure that local issues are adequately addressed. The proposed G&Y monitoring plots could provide a portion of the data required for model calibration. Additional data from designed experiments (i.e., WESBOGY trials) and natural stands will be required.

APPENDIX I – GENERAL INFORMATION ON MONITORING

WHAT IS MONITORING?

The term "monitoring" is widely used and is very ambiguous. The term "monitoring" is generally used to describe the process of checking or regulating some defined activity. It is also used interchangeably with the word "measuring". The literature is filled with numerous kinds of "monitoring", for example: adaptive monitoring, biodiversity monitoring, change monitoring inventory, compliance monitoring, ecosystem monitoring, effectiveness monitoring, environmental monitoring, fertilizer application monitoring, fertilizer response monitoring, forest health monitoring, forest monitoring, growth and yield monitoring, habitat monitoring, herbicide application monitoring, implementation monitoring, silviculture monitoring, trend monitoring, validation monitoring, etc. So the bottom line is, don't worry what a monitoring program is called, focus on what is being done and why. What are the objectives? Where can the results be applied? How can the results be used?

Under the principles of SFM, monitoring is defined as the periodic measurement and assessment of change of an indicator, where an indicator is a variable used to report progress towards achieving a goal. Goals are broad, general statements that describe a desired state or condition related to one or more forest values.[17] In this context, two broad categories of monitoring can be recognized. The first, which may be referred to as "administrative monitoring", checks that planned SFM activities are implemented (i.e., did we do what we said we were going to do?). An example is monitoring to ensure conformance with established visual quality objectives. Most administrative monitoring can be carried out internally by individual licensees.

The second category of monitoring may be referred to as monitoring the state of the forest, which includes activities that measure timber and non-timber variables over time. **G&Y monitoring**, which is the process of checking G&Y estimates for a defined population, is in this broad category. Monitoring the state of the forest requires a long-term commitment to establishing and re-measuring plots over time. To be cost-effective, it is best addressed as a joint venture among licensees.

Some of the variables a program designed to monitor the state of the forest could track include volume, wood quality, species composition, site productivity, and coarse woody debris.

Monitoring is a key process in adaptive management. It is the feedback loop that provides information for continuous improvement. The level of success in achieving objectives can be evaluated, and planning and management activities can be improved accordingly.

LINKS BETWEEN G&Y MONITORING AND OTHER DATA COLLECTION PROGRAMS

Monitoring the state of the forest requires permanent sample plots (PSPs) and associated establishment and re-measurement costs. Field costs[18] for plot establishment on other G&Y monitoring projects have ranged between $1,500 - $2,000/plot. Plot establishment costs are a function of access and the number of variables to be measured. Costs increase significantly if a single plot cannot be established in one

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[17] These are the Canadian Standards Association CAN/CSA-Z808/809-96 definitions.

[18] Field costs include planning (hiring crews, arranging transportation, equipment, etc.), crew time, helicopter time where necessary, training and quality assurance, and data entry.

day. In addition to field costs, there are costs for sample plan development, data analysis, and reporting. Given the expense of plot establishment, it is prudent that the data collection is closely linked to the business needs, and that the data collected be used for as many purposes as possible. The following outlines potential linkages between a monitoring program and other data collection programs.

VRI Phase II Ground Plots

PSPs established for G&Y monitoring purposes could be used as a portion of the plots established for VRI Phase II ground sampling. Data from fixed area PSPs and variable radius temporary sample plots (TSPs) currently established for VRI Phase II can be combined. Single fixed area PSPs are less efficient[19] for estimating current volume than the VRI Phase II prism plot cluster, but if the plots are already established, they could be used to reduce the number of Phase II plots needed to be established. Theoretically, inventory and G&Y monitoring plots should be kept separate so that the G&Y monitoring plots provide an independent check of the inventory and inventory projections. Practically, the implications of using plots for both inventory and G&Y monitoring should be minimal if the monitoring plots make up a small portion of the inventory plots and the cost savings offsets these minimal implications.

For the Fort St. John TSA, the G&Y monitoring plots will make up all of the VRI Phase II ground plots in managed stands. This means the G&Y monitoring data can be used to check growth projections, but cannot be used to conduct an independent check of future yields. There will be a small chance that the G&Y monitoring plots will give an estimate of yield significantly removed from the true value for the area, and this situation will persist over time. For example, if the G&Y monitoring plots happen to under-estimate the true yield at time 1, they will likely under-estimate the true yield at time 2 while the observed growth rates will likely be representative of the area. An independent check of yields can be carried out at any time in the future with a set of temporary plots randomly or systematically established to represent the population of interest.

Developing Growth Models

BC has a long history of establishing and re-measuring PSPs[20] to develop and maintain G&Y models. Most of these PSPs were subjectively[21] located in natural and treated stands, or established as part of designed experiments. G&Y monitoring plots could be used to augment the data sets used for model development. There is risk to doing this as it could result in incorrect conclusions from monitoring. This risk is a function of the degree to which the monitoring data have influenced the model. For example, the risk would be highest where most of the same data used to develop a model (e.g., VDYP) were also used to the check the estimates from the model. Ideally, completely independent PSPs would be used to develop and check models, however, the costs of maintaining two independent sets of plots is likely prohibitively expensive and unnecessary.

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[19] Empirical evidence from TFL 37 suggests that the single CMI plot is approximately 30% less efficient for estimating current volume than the VRI Phase II prism plot cluster. That is, sampling for net volume using the single CMI plot would require 30% more plots than would the five-point VRI cluster, to attain the same target sampling error.

[20] For example, the Growth Natural Program.

[21] Plots purposely established in fully stocked portions of stands. Monitoring plots will be randomly or systematically located.

In the Fort St. John TSA, models need to be developed for mixedwood stands. Most provincial G&Y models (e.g., TASS, VDYP7, and PrognosisBC) are developed using data from a range of areas and stand conditions. Consequently, the risk of a model projection being largely influenced by the data from any given management unit is low. It should be noted that other types of modeling data (e.g., experimental plots to determine treatment responses) are still needed in addition to plots established for monitoring and model development.

Site Index Adjustment (SIA)

Many TFLs and most Innovative Forestry Practices Agreement (IFPA) areas in the province have chosen a statistical approach to provide unbiased estimates of potential site index (PSI) for yield projection in PHR stands in timber supply analysis. The data are collected from randomly selected plots across the management unit and used to adjust preliminary estimates attached to each polygon for the entire management unit. This approach has been widely used by industry (on more than 20 land bases) and is accepted for generating managed stand yield tables for application in timber supply projections.

A G&Y monitoring program does not provide enough samples in suitable stand types to complete an SIA project. However, data from G&Y monitoring plots can be used for this purpose. Using data from the monitoring plots to develop the SIA theoretically compromises the independence to monitor the site index estimates over time. However, this potential problem is probably not of practical significance if the proportion of G&Y monitoring plots in the overall sample used for SIA is low.

Site Index-Biogeoclimatic Ecosystem Classification (SIBEC).

Data from all suitable PSPs should be used to contribute to the provincial SIBEC database. Data from G&Y monitoring PSPs are probably more suitable for the SIBEC database as they will be from randomly or systematically located plots as opposed to the current policy of subjectively locating SIBEC plots.

Predictive Ecosystem Mapping (PEM)

G&Y monitoring plots could be used to provide point estimates of site series to check PEM estimates of site series. However, the observations from this program should be supplemented with many more samples to achieve the objective.

APPENDIX II – DETAILED PROJECTIONS OF FUTURE PLOT DISTRIBUTIONS

Table 6. Estimated distribution of plots by detailed species composition, grid size and year

	Grid Size (km)					
	3	3.2	3.4	3.6	3.8	4
			2005			
Deciduous	10	9	8	7	6	6
Mixedwood AtPl	2	2	2	1	1	1
Mixedwood PlAt	0	0	0	0	0	0
Mixedwood AtSx	15	13	12	10	9	8
Mixedwood SxAt	16	14	12	11	10	9
Pl > 80%	3	3	2	2	2	2
Pl leading conifer	4	4	3	3	2	2
Sw > 80%	15	13	12	10	9	8
Sw leading conifer	8	7	6	6	5	5
Total	*73*	*64*	*57*	*51*	*45*	*41*
			2015			
Deciduous	10	9	8	7	6	6
Mixedwood AtPl	4	4	3	3	2	2
Mixedwood PlAt	2	2	2	1	1	1
Mixedwood AtSx	18	16	14	13	11	10
Mixedwood SxAt	18	16	14	13	11	10
Pl > 80%	8	7	6	6	5	5
Pl leading conifer	4	4	3	3	2	2
Sw > 80%	29	25	23	20	18	16
Sw leading conifer	10	9	8	7	6	6
Total	*103*	*91*	*80*	*72*	*64*	*58*
			2025			
Deciduous	25	22	20	17	16	14
Mixedwood AtPl	8	7	6	5	5	4
Mixedwood PlAt	5	5	4	4	3	3
Mixedwood AtSx	22	20	17	16	14	13
Mixedwood SxAt	22	20	17	16	14	13
Pl > 80%	16	14	12	11	10	9
Pl leading conifer	11	10	9	8	7	6
Sw > 80%	37	33	29	26	23	21
Sw leading conifer	15	13	12	10	9	8
Total	*162*	*142*	*126*	*112*	*101*	*91*
			2035			
Deciduous	56	49	43	39	35	31
Mixedwood AtPl	15	13	12	11	9	9
Mixedwood PlAt	10	9	8	7	6	6
Mixedwood AtSx	31	28	24	22	20	18
Mixedwood SxAt	27	24	21	19	17	15
Pl > 80%	26	23	20	18	16	14
Pl leading conifer	19	17	15	13	12	11
Sw > 80%	45	40	35	31	28	25
Sw leading conifer	22	19	17	15	14	12
Total	*251*	*220*	*195*	*174*	*156*	*141*
			2045			
Deciduous	86	75	67	60	53	48
Mixedwood AtPl	23	20	18	16	14	13
Mixedwood PlAt	15	13	11	10	9	8
Mixedwood AtSx	40	35	31	28	25	23
Mixedwood SxAt	32	28	25	22	20	18
Pl > 80%	36	32	28	25	22	20
Pl leading conifer	27	24	21	19	17	15
Sw > 80%	53	47	41	37	33	30
Sw leading conifer	29	25	22	20	18	16
Total	*340*	*299*	*264*	*236*	*212*	*191*

Table 7. Estimated number of plots to establish and re-measure by year on a 3 km grid. Total cost is based on $2,500 for establishment and $1,000 for re-measurement.

Year	Establish	Re-measurement 1st	2nd	3rd	4th	Total Cost
2003	25					$62,500
2004	24					$60,000
2005	24					$60,000
2006	2					$5,000
2007	1					$2,500
2008	3					$7,500
2009	0					$0
2010	2					$5,000
2011	8					$20,000
2012	4					$10,000
2013	2	25				$30,000
2014	8	24				$44,000
2015	0	24				$24,000
2016	0	2				$2,000
2017	4	1				$11,000
2018	4	3				$13,000
2019	4					$10,000
2020	6	2				$17,000
2021	7	8				$25,500
2022	8	4				$24,000
2023	9	2	25			$49,500
2024	9	8	24			$54,500
2025	9		24			$46,500
2026	9		2			$24,500
2027	9	4	1			$27,500
2028	9	4	3			$29,500
2029	9	4				$26,500
2030	9	6	2			$30,500
2031	9	7	8			$37,500
2032	9	8	4			$34,500
2033	9	9	2	25		$58,500
2034	9	9	8	24		$63,500
2035	9	9		24		$55,500
2036	9	9		2		$33,500
2037	9	9	4	1		$36,500
2038	9	9	4	3		$38,500
2039	9	9	4			$35,500
2040	9	9	6	2		$39,500
2041	9	9	7	8		$46,500
2042	9	9	8	4		$43,500
2043	9	9	9	2	25	$67,500
2044	9	9	9	8	24	$72,500
2045	9	9	9		24	$64,500
2046	9	9	9		2	$42,500
2047	9	9	9	4	1	$45,500
2048	9	9	9	4	3	$47,500
2049	9	9	9	4		$44,500
2050	9	9	9	6	2	$48,500
2051	9	9	9	7	8	$55,500
2052	9	9	9	8	4	$52,500

Table 8. Estimated numbers of plots with yield data (one measurement) or growth data (multiple measurements) over time.

Grid Size (km)	Plots with data to compare:				
	Yield	Growth for:			
		10 yrs	20 yrs	30 yrs	40 yrs
			2005		
3.0	73				
3.2	64				
3.4	57				
3.6	51				
3.8	45				
4.0	41				
			2015		
3.0	103	73			
3.2	91	64			
3.4	80	57			
3.6	72	51			
3.8	64	45			
4.0	58	41			
			2025		
3.0	162	103	73		
3.2	142	91	64		
3.4	126	80	57		
3.6	112	72	51		
3.8	101	64	45		
4.0	91	58	41		
			2035		
3.0	251	162	103	73	
3.2	220	142	91	64	
3.4	195	126	80	57	
3.6	174	112	72	51	
3.8	156	101	64	45	
4.0	141	91	58	41	
			2045		
3.0	340	251	162	103	73
3.2	299	220	142	91	64
3.4	264	195	126	80	57
3.6	236	174	112	72	51
3.8	212	156	101	64	45
4.0	191	141	91	58	41

APPENDIX III – PROVIDING DATA ON SFM INDICATORS

Table 9. Data for SFM indicators developed for the Fort St. John TSA provided by a network of systematically established G&Y monitoring plots.

Indicator	Target	Data Provided	VRI/CMI Cards
4. Snags/Cavity Sites	4.1 Establish a minimum of 6 snags and/or merchantable live trees (i.e., potential cavity sites) per hectare, as averaged over the total are harvested annually.	Number of snags and merchantable live trees per hectare. The issue here is the high variability resulting in low precision (wide confidence interval). Most of the plots will have 0 snags and a few will have 1 or 2.	Tree Details (TD)
5. Coarse Woody Debris Volume (relative %)	5.1 Maintain 50%+ of pre-harvest levels as measured in representative monitoring plots.	Gross volume of coarse woody debris by decay class. The issue will be whether there are sufficient plots to post-stratify into the strata developed for CWD target retention ranges. If the sample size is insufficient, the plots could still be used as part of the total sample required.	Coarse Woody Debris (EW) Coarse Woody Debris (EC)
7. Shrubs	7.1 Evaluate and determine baseline shrub levels (species diversity, distribution, and abundance) across seral stages and forest types.	Biogeoclimatic site series, successional stage, % cover and heights for trees, shrubs, herbs and mosses. Re-measurements will provide data on the changes over time. The issue will be whether the sample size is sufficient to allow for the required post-stratification.	Ecological Description 1 (EP) Ecological Description 2 (ED) Tree and Shrub Layer (ET) Herb and Moss Layer (EH) Succession Interpretations (EO)
15. Long term harvest level measured in m^3/yr	15.1 Harvest at a rate that does not adversely affect the long-term harvest level.	Growth & yield data for managed stands that can be used to check the accuracy of yield curves used to project managed stands in timber supply.	Tree Details (TD) Tree Loss Indicators (TL) Small Tree, Stump, and Site Tree Data (TS)
16. Site index	16.1 Post-harvest site index will not be less than pre-harvest.	Estimates of site index from monitoring plots can be used to check current inventory site indices and compare to pre-harvest site indices. The sample size should be sufficient to determine across the population of regenerated stands if the site indices are the same, lower or higher than pre-harvest site indices. Data on site tree height growth can be compared to height growth curves (site index curves) to check that the site index curves accurately reflect site tree height growth.	Small Tree, Stump, and Site Tree Data (TS)
21. Mean annual increment	21.1 Maintain or increase MAI for the TSA over time.	Growth & yield data for managed stands that can be used to provide a representative sample of the MAI in managed stands (15 years post-harvest) over time.	Tree Details (TD) Tree Loss Indicators (TL) Small Tree, Stump, and Site Tree Data (TS)
22. Total growing stock	22.1 Analyze and determine target range for growing stock (THLB and NHLB)	Growth & yield data for managed stands that can be used to check the accuracy of yield curves used to project growing stock in managed stands in the THLB.	Tree Details (TD) Tree Loss Indicators (TL) Small Tree, Stump, and Site Tree Data (TS)

Table 10. Data for SFM indicators provided by a network of systematically established and re-measured silviculture survey plots.

Indicator	Target	Data Provided
4. Snags/Cavity Sites	4.1 Establish a minimum of 6 snags and/or merchantable live trees (i.e., potential cavity sites) per hectare, as averaged over the total are harvested annually.	Number of snags and merchantable live trees per hectare could be determined if snags and merchantable live trees were recorded on the plots. The issue here is the high variability resulting in low precision (wide confidence interval). Most of the plots will have 0 snags and a few will have 1 or 2.
7. Shrubs	7.1 Evaluate and determine baseline shrub levels (species diversity, distribution, and abundance) across seral stages and forest types.	Percent cover of shrub species could be recorded and summarized by forest type.
16. Site index	16.1 Post-harvest site index will not be less than pre-harvest.	The plots will provide a large observational database on early height growth that can be compared to juvenile height growth curves or assumed early height growth patterns from site index curves used in timber supply.
15. Long term harvest level measured in m^3/yr	15.1 Harvest at a rate that does not adversely affect the long-term harvest level.	Plot data can be post-stratified by analysis units and used to assign appropriate yield curves for timber supply analysis.

APPENDIX IV – FIELD SAMPLING METHODS

OVERVIEW

For the most part, Ministry of Sustainable Resource Management Monitoring procedures should be followed to establish the plots. This appendix outlines proposed changes to these procedures (by VRI/CMI card number) for review and consideration for use in the Fort St. John TSA. It should be noted that any changes require modification of the standard compilation procedures.

1 Header Card (CH)

Plot number – There are four spaces to enter a plot number on this card. It is recommended that plot numbers incorporate the UTM coordinates of the plot to ensure unique plot numbers over time. This also allows for easy location of the plot. A plot number based on UTM coordinates could be recorded in the notes section. A sequential plot number (for plots established in any given year) could be entered in the plot sample # field. This information along with the date of establishment will be stored in the database, allowing plot XXXX-XXXX to be cross-referenced as the Yth plot established in year Z.

2 Compass Card (CP)

Complete following CMI procedures.

3 Cluster Layout (CL) (Version 99/3)

Complete following CMI procedures.

4 Range Sampling (RS) Shrub Transect #1

Complete following CMI procedures.

5 Range Sampling (RS) Shrub Transect #2

Complete following CMI procedures.

6 Coarse Woody Debris (EW) Transect #1

Complete following CMI procedures.

7 Coarse Woody Debris (EW) Transect #2

Complete following CMI procedures.

8 Tree Details (TD)

***Regeneration plot radius* –** The regeneration plot radius is changed from 2.5 m to 3.99 m to be compatible with full-measure silviculture survey plots previously established at the same center point.
Height to live crown

CMI procedures specify recording height to live crown to the nearest m. For this project, since we are measuring small trees, record to the nearest decimeter. For example, 0.4 m is entered as 04 in columns 21 and 22.

Call Grading is not completed.

9 Tree Loss Indicators (TL)

Complete and enter following CMI procedures with the exception of stem mapping.

10 Small Tree, Stump and Site Tree Data (TS)

Top height tree (T) – Measured as per CMI standards.

Leading (L) and second (S) species – Do not determine prior to selecting site trees. The age of the largest diameter, dominant or co-dominant, tree of each species in each quadrant is measured. If the largest diameter tree of a given species (coded as "S" tree) is not suitable for height and age, the next largest diameter tree suitable for height and age will be selected (and coded as "O" tree). If a site tree is between 4 and 9 cm DBH, outside the Small-tree plot but inside the Main plot, this site tree will be tagged and the height will be recorded in the site tree section on Card 10.

11 Auxiliary Plot Card (TA)

Not used.

12 Ecological Description 1 (EP)

Complete following CMI procedures.

13 Ecological Description 2 (ED)

Complete following CMI procedures.

14 Tree and Shrub Layers (ET)

Complete following CMI procedures except use the 11.28 m radius plot was instead of a 10.0 m radius plot.

15 Herb and Moss Layers (EH)

Complete following CMI procedures.

16 Succession Interpretations (EO)

Complete following CMI procedures.

Appendix 4: Stocking Estimators and Future Volume

Silviculture Note #??
Stocking estimators and future volume

Pat Martin
September 4, 2002

1. Introduction

Tree stocking, the degree to which growing space is occupied, is an important forestry concept. In a young stand, stocking is a main determinant of future stand volume/ha and the distribution of tree sizes at harvest (Clutter et al. 1983). A variety of estimators have been developed to quantify the stocking in regenerated stands (Stein 1978; Shreuder, Gregoire and Woods 1993, pg 291). Typically, these estimators are designed to take on greater values as density and uniformity of tree distribution increase, and many are capped at some maximum value. When stocking estimators are evaluated, the focus has been on ease of use, cost, and the extent to which they exhibit desired behaviour over a range of tree density and uniformity (Stein 1978). Historically, the ability of a stocking estimator to predict future volume has not been an important evaluation criterion.

Recently in B.C. interest has grown in the relationship between stocking estimators and future volume. Bergerud (2001) demonstrated the relationship between the stocking estimator “total well-spaced trees/ha” and TASS predicted merchantable volume/ha at age 67 years for lodgepole pine on site index 18 m. J.S. Thrower and Associates (2002) developed a new stocking estimator “MSQ” and demonstrated it’s relationship to TASS predicted merchantable volume/ha at age 80 years for lodgepole pine on site index 20 m.

Martin, Browne-Clayton, and McWilliams (2002) described a new system for managing reforestation that is based on the future volume predicted, in part, from the stocking observed in young stands. Though this new system uses the stocking estimator “MSQ,” it could be re-formulated to use other stocking estimators. In future implementations of this new system, it is desirable to ensure that the stocking estimator used has high predictive power. In this paper, I report the results of a cursory assessment of the ability of four stocking estimators to predict merchantable volume/ha at age 80 years for lodgepole pine on site index 18 m.

2. Methods

The spatially explicit, individual tree growth model TASS (Mitchell 1975, Mitchell and Cameron 1985) was used to generate a variety of tree spatial patterns in a 100 m x 100 m plot. From bare ground the stand represented by each plot was grown to the silviculture survey date at which time surveys were simulated in the stand. The survey parameters were computed and the stand was grown for 100 years. Volumes at ages 60, 80, and 100 years (site heights of 18.8, 21.9, and 24.0 m, respectively) were extracted from the TASS output, though only the volume at age 80 is reported here. Regression analysis was used to assess the strength of the relationship between the four stocking estimators and merchantable volume/ha at age 80.

2.1 Stocking estimators

Though a total of seven stocking estimators were evaluated, in this paper I report only the results for four (Table 1):

Table 1. Description of the four stocking estimators that were assessed.

Code	Name	Plot procedure	Compilation
TTPH	Total trees per hectare	In a 3.99 m radius plot, the surveyor counts all live trees.	Plot counts are averaged and expanded to a per hectare basis.
WSTPH	Well-spaced trees per hectare	In a 3.99 m radius plot, the surveyor maximizes the count of well-spaced trees. No "M" cap. 2.0 m MITD.	Plot counts are averaged and expanded to a per hectare basis.
MSQ	Mean stocked quadrants	In a 3.99 m plot divided into quarters along cardinal directions, the surveyor counts the number of quarters containing at least one live tree.	Plot counts are averaged.
PERSP	Percent stocked 1.4 m radius plots	The surveyor counts a 1.4 m plot as stocked if it contains at least one live tree.	Percent of all plots that were tallied as stocked is computed.

2.2 TASS simulations

Fifty different tree spatial distributions were taken from the many stem maps used to produce Land Management Handbook 50 (Bergerud 2002). From those distributions classified as clumped, maps with the following initial trees/ha were used: 300, 425, 550, 650, 750, 900, 950, 1020, 1150, 1240, 1400, 1500, 1750, 2000, 2250, 2500, 2750, 2900, 3100, 3265, 3906, 4500, 5200, 5917, 6944, 8000, 10000, and 20000. From those distributions classified as natural (random spatial pattern), maps with the following initial trees/ha were used: 300, 550, 750, 950, 1150, 1400, 1750, 2250, 2750, 3100, 3906, 5200, 6944, and 10000. From those distributions classified as planted (grid spatial pattern), maps with the following initial trees/ha were used: 425, 650, 950, 1240, 1750, 2500, 4500, and 8000.

The following run specifications were used for each TASS simulation:

TASS version:	v2.07.14WS
Species:	interior lodgepole pine
Site index:	18 m
Site index curve code:	PI_THROWNIGH
Merchantable volume	
Minimum dbh:	12.5 cm
Top dib:	10 cm
Stump height:	0.3 m
OAFs:	No OAFs applied
Plot size:	100 m X 100 m

The TASS runs and the survey simulations were conducted by RamSOFT Systems Ltd.

2.3 Survey simulation

Each stem map was grown to a site height of 5 m, which occurred 16 years from run initialization. Surveys were simulated at this time. Ten plots were randomly located on the stem map, plot values taken, and the sample mean computed. This was repeated 1000 times. Last, the 1000 sample means were averaged. Thus, each survey value is a mean from 10,000 plots. In counting trees, no minimum height criteria were applied. To reduce costs by re-using data previously compiled, one set of plot centers was used for WSTPH and MSQ and a different set for the other estimators.

2.4 Data analysis

A single equation form was identified that could provide a good fit to each of the four volume-stocking estimator relationships. A function in the Weibull family was fit with nonlinear least squares using the SYSTAT statistical software (SPSS Inc. 1998):

$$V = b_0\left(1-\exp\left(b_1\left(X/\phi\right)^{b_2}\right)\right)$$

where V is merchantable volume/ha at age 80,
b_0, b_1, and b_2 are parameters, and
X is the stocking estimator (TPH, WSTPH, MSQ, and PERSP). ϕ is a constant assigned before fitting equal to the largest X value in the data set: $\phi = 16712$ for TPH, $\phi = 2182$ for WSTPH, $\phi = 4$ for MSQ, and $\phi = 100$ for PERSP.

The fit statistics and a visual examination of residuals indicated that excellent fits were obtained. Two fit statistics, the mean square error and the squared correlation between observed and predicted values, were taken to indicate the ability of a stocking estimator to predict future volume/ha (Table 2).

The complete data set is provided in Appendix A.

3. Results

The relationship between each stocking estimator and TASS-predicted volume at age 80, with the fitted curve, is displayed in Figures 1-4.

Though volume/ha at 80 years is approximately linearly related to MSQ, the relationship is curvilinear with TTPH, WSTPH, and PERSP. A visual assessment suggests that the stocking estimators TPH, WSTPH and PERSP produce values that are spread more widely, while many of the 50 stem maps assessed returned MSQ values very close to 4. However, an increased spread is not associated with an improved ability to predict future volume (Table 2).

MSQ predicts future volume/ha slightly better than WSTPH and PERSP do and much better than TTPH does (Table 2). The relationships between future volume and WSTPH, PERSQ, and MSQ are so strong that little improvement can be expected from adding additional explanatory variables or stratifying the data.

Table 2. Fit statistics from regressions relating stocking estimators to future volume.

Stocking estimator	Mean square error	R^2: Correlation of observed and predicted values (squared)
TTPH	703	0.84
WSTPH	142	0.97
MSQ	44	0.99
PERSP	152	0.97

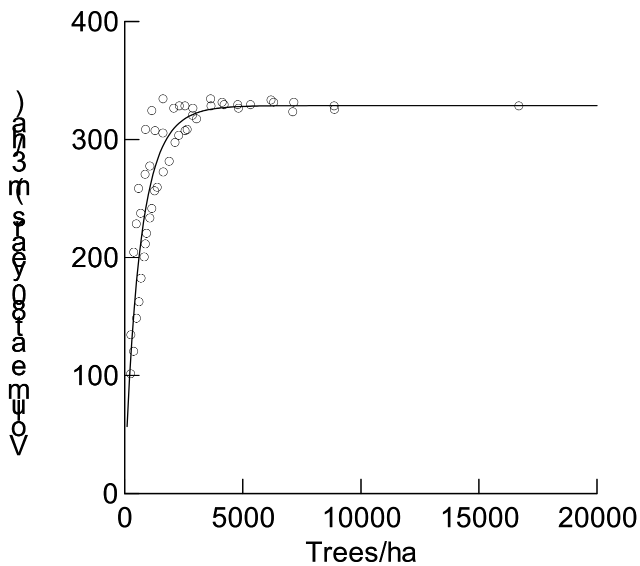

Figure 1. Relationship between merchantable volume/ha at age 80 and total trees/ha at survey. Solid line is fitted regression.

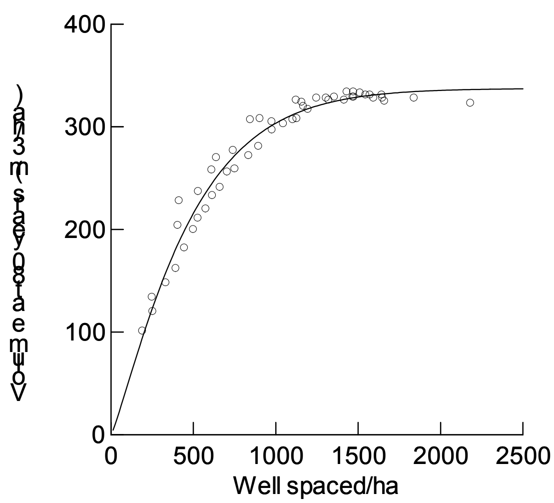

Figure 2. Relationship between merchantable volume/ha at age 80 and total well spaced trees/ha at survey. Solid line is fitted regression.

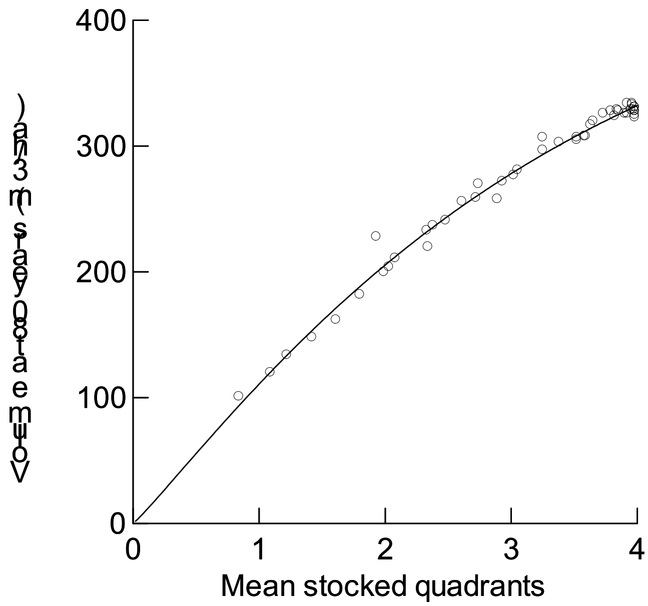

Figure 3. Relationship between merchantable volume/ha at age 80 and mean stocked quadrants at survey. Solid line is fitted regression.

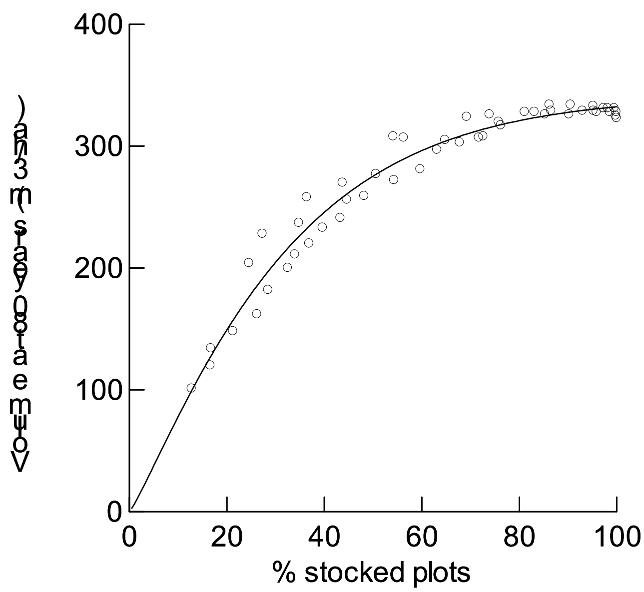

Figure 4. Relationship between merchantable volume/ha at age 80 and percent stocked plots at survey. Solid line is fitted regression.

4. Discussion

In terms of its ability to predict future volume, the stocking estimator MSQ is superior to the three others examined (TTPH, WSTPH, and PERSP). However, WSTPH and PERSP are almost as good so when other factors are considered, such as cost, ease of use, or familiarity of procedure – the use of MSQ, WSTPH, or PERSP could easily be justified. As expected, TTPH is a poor estimator of future volume and, for this purpose, its use is not recommended.

Bergerud (2001) found that the relationship between TASS-predicted future volume and well-spaced trees/ha varied with tree spatial pattern. Though this issue was not specifically examined in this analysis, the excellent fits suggest that little could be gained by stratifying by tree distribution type (random, clumped, or grid). Additional replicates of the planted and natural spatial pattern stem maps and subsequent analysis is recommended to further examine this issue.

The volumes used in this study are TASS-predicted volumes, not actual volumes observed in real stands that originated with the specified tree spatial patterns. Thus, the fit statistics grossly over-state the accuracy with which these stocking estimators will predict real stand future volumes. Moreover, if there is some systematic bias in TASS predictions, for example, if volumes are consistently over-estimated at low stockings, then the shape of the volume-stocking relationships displayed in Figure 1-4 will be incorrect.

These results indicate the correlation between future volume and a stocking estimator when sample size is enormous. Each data point is the mean of 10,000 sample plots. The correlation under operationally realistic sample sizes should be investigated. Furthermore, it would certainly cost less to take a single PERSP plot than to take a single WSTPH plot. In dense stands, TPH is also time consuming to tally. However, cost has not been considered in this analysis. Subsequent study should attempt to identify the stocking estimator that provides the most accurate prediction of future volume at a realistic fixed cost.

5. Literature cited

Bergerud, W.A. 2002. The effect of the silviculture survey parameters on the free-growing decision probabilities and projected volume at rotation. B.C. Min. of For., Land Mgmt. Handbook 50, Victoria, B.C.

Clutter J.L., Fortson, J.C., Pienaar, L.V., Brister, G.H., Bailey, R.L. 1983. Timber management: a quantitative approach. John Wiley and Sons Inc. New York, NY. 333 p.

J.S. Thrower and Assoc. Ltd. 2002. Stand survey and growth modelling for the TFL 49 results-based pilot project. Contract report to Riverside Forest Products Ltd., Kelowna, B.C.

Martin, P.J., Browne-Clayton, S.B., and E McWilliams. 2002. A results-based system for regulating reforestation obligations. For. Chron (in press).

Mitchell, K.J. 1975. Dynamics and simulated yield of Douglas fir. For. Sci. Monogr. 17,

39 pp.

Mitchell, K.J. and I.R. Cameron. 1985. Managed stand yield tables for coastal Douglas fir: initial density and pre-commercial thinning. British Columbia Ministry of Forests, Land Management Report 31. Victoria, B.C.

SPSS Inc. 1998. SYSTAT 8.0 Statistics. Chicago, IL, USA. 1086 p.

Schreuder, H.T., Gregoire, T.G., Wood, G.B. 1993. Sampling methods for multi-resource inventory. John Wiley and Sons, Inc. New York, NY. 446 p.

Stein, W.I. 1978. Reforestation evaluation. In B.D. Cleary, R. D. Greaves, and R.K. Hermann (eds.). Regenerating Oregon's forests. Oregon State University, Corvallis, OR.

Appendix A: Complete data set

Stem map number	TASS initialization density (#/ha)	Tree spatial distribution type	Trees per hectare at survey (#/ha)	Well-spaced trees per hectare (#/ha)	Mean stocked quadrants with unrotated 3.99 m plots	Percent stocked 1.4 m radius plots (percent)	Merch. volume at age 80 (m3/ha)
1	300	clumped	278	192	0.84	12.81	101
2	425	clumped	402	254	1.09	16.64	120
3	550	clumped	524	334	1.42	21.28	148
4	650	clumped	628	394	1.61	26.23	162
5	750	clumped	716	446	1.80	28.50	182
6	900	clumped	852	500	1.99	32.54	200
7	950	clumped	898	528	2.08	33.99	211
8	1020	clumped	948	576	2.34	36.91	220
9	1150	clumped	1086	616	2.33	39.68	233
10	1240	clumped	1170	662	2.48	43.32	241
11	1400	clumped	1290	706	2.61	44.67	256
12	1500	clumped	1400	752	2.72	48.21	259
13	1750	clumped	1658	836	2.93	54.34	272
14	2000	clumped	1908	896	3.05	59.73	281
15	2250	clumped	2156	978	3.25	63.15	297
16	2500	clumped	2314	1046	3.38	67.82	303
17	2750	clumped	2582	1104	3.52	71.72	307
18	2900	clumped	2670	1128	3.58	72.64	308
19	3100	clumped	2894	1168	3.65	75.81	320
20	3265	clumped	3064	1196	3.63	76.23	317
21	3906	clumped	3676	1306	3.79	83.15	328
22	4500	clumped	4234	1356	3.84	86.54	329
23	5200	clumped	4842	1416	3.92	90.25	326
24	5917	clumped	5350	1468	3.95	93.00	329
25	6944	clumped	6218	1512	3.96	95.21	333
26	8000	clumped	7184	1572	3.98	97.32	331
27	10000	clumped	8892	1648	3.98	98.58	328
28	20000	clumped	16712	1840	3.98	99.95	328
29	300	random	286	250	1.22	16.76	134
30	550	random	518	414	1.93	27.34	228
31	750	random	702	530	2.38	34.83	237
32	950	random	890	640	2.74	43.77	270
33	1150	random	1086	742	3.02	50.62	277
34	1400	random	1310	846	3.25	56.31	307
35	1750	random	1642	976	3.52	64.82	305
36	2250	random	2102	1124	3.73	73.93	326
37	2750	random	2578	1248	3.85	81.13	328
38	3100	random	2910	1322	3.90	85.30	326
39	3906	random	3662	1432	3.96	90.55	334
40	5200	random	4810	1474	3.97	95.25	329
41	6944	random	6332	1546	3.98	98.17	331
42	10000	random	8906	1660	3.98	99.79	325
43	425	planted	406	406	2.03	24.58	204
44	650	planted	612	612	2.89	36.40	258
45	950	planted	906	904	3.59	54.18	308
46	1240	planted	1170	1158	3.82	69.25	324
47	1750	planted	1646	1472	3.92	86.22	334
48	2500	planted	2336	1594	3.98	95.90	328
49	4500	planted	4150	1644	3.98	99.55	331
50	8000	planted	7138	2182	3.98	100.00	323

Appendix 5: Survey Design and Field Procedures

Survey Design and Field Procedures

Scope of this document

This document describes only the survey methods to be employed to meet the requirements of yield assessment and inventory labels. It is limited, at this time, to data collection for conifer plantations.

Prior to collecting plot data in the field the following information should be reviewed and used to develop strata within each cutblock. Minimum strata size is 2 ha.

1. Pre-harvest prescription or plan

   Ensure survey map reflects original prescription or plan map and any subsequent revisions. Place SU boundaries with different species or stocking standards on the survey map. Review the prescription or plan for any other requirements or conditions that would affect stocking levels and set boundaries as required.

2. Establish plot locations

   Locate 100m grid locations on the survey map following NAD 83 datum. If the survey map has not been accurately geo-referenced then this step will not be practical and plots will need to be established in the field and added to the map. Plots that fall outside the NAR will be null plots

3. Block assessment in the field

   A block walkthrough prior to plot establishment is required to complete the following:

   1) Review blocks in the field and update the map. This may require identification of unmapped features, traversing of boundaries, etc.
   2) Map inventory polygons utilizing current procedures by reviewing species composition, site productivity and stocking. Separate those areas below minimum stocking levels.
   3) Identify and map areas that may require further treatment to reach well growing status

Data Collection

Count Plot
A count plot is located where the last three digits of either or both of the UTM easting and northing are 100, 300, 500, 700, or 900. Area for the plot is $50m^2$ (3.99m radius). Quadrants are established along cardinal directions. At a count plot, the following is done:

a) Record the Strata

Based on the strata mapping as above.

b) Count stocked quadrants

Record the number of quadrants that contain at least one acceptable tree. An acceptable tree is:

i) Preferred or acceptable species (as listed in the SP for the SU)
ii) Healthy (Meets forest health standards)
iii) Acceptable advance regeneration (meets adv. regen. standards)
iv) Well Growing

c) Count potential stocked quadrants after brushing

Record the number of quadrants that would contain at least one acceptable tree following a brushing treatment.

d) Record UTM coordinates

Record the UTM coordinates of the plot.

Data Collection at Full Measure Plot
A Full Measure Plot is one where the last three digits of both the UTM easting and northing are 000, 200, 400, 600, or 800. At an enhanced plot, collect all of the data required at a Count Plot plus the following:

a) Record BEC

Assess site series in an area approximately 5.64 m around plot center. Based on a rough ocular estimate, assign the area to the dominant site series. Record BEC zone/subzone/variant/site series.

b) Record species class.

Assess species composition in an area approximately 5.64 m around plot center. Based on a rough ocular estimate, assign the area to 1 of 3 species groups: >= 80% Pl, >= 80% Sx, or mix based on 20% divisions.

b) Height Measure tree

In a 5.64 m radius plot, make a rough ocular estimate of whether Pl or Sx is more common. Locate the tallest tree of this species that is live and not a residual. Measure and record total height and species code. If this tree is also a suitable growth intercept sample tree (healthy, undamaged and unsuppressed), record breast height age by counting whorls.

c) Additional Data

In a 3.99 m plot, collect total tree count, and total conifer count and average height by species.

Map areas of low stocking
If during the survey, a mappable patch (2 ha or larger) of low stocking was found, transfer its boundaries onto the survey map. Map patches that a rough ocular estimate suggests have < MSS preferred and acceptable species, free from brush and healthy. And provide a description of the area and recommendations for treatment.

Map treatment units
If during the survey a mappable area (2 ha or larger) that would benefit from further treatment i.e. fill planting, vegetation control, etc. is found then transfer the boundaries to the map and provide a description of the area and recommended treatment.

Map areas of high density stocking
If during the survey, a mappable patch (2 ha or larger) of stocking >10,000sph was found, transfer its boundaries onto the survey map and provide a description of the area and recommendations for treatment.

Data Format
In an ASCII or excel format file provide the following:

For each plot:
1. Cutblock identity (e.g., CP838 Block 1A)
2. Plot identity (e.g., plot # 1)
3. UTM coordinates of the plot (e.g., 307200; 5639200)
4. Stratum identity (e.g., species class, density class, target stocking class)
5. Stocked quadrant tally (e.g., 0, 1, 2, 3, or 4)
6. Potential stocked quadrant tally following a brushing treatment (e.g., 0, 1, 2, 3, or 4)
7. Plot type (S=count plot, E=full measure plot)

In addition to the above, for each enhanced plot:
8. Height sample tree species (e.g., Pl or Sx)
9. Sample tree height (e.g., 2.5 m)
10. If height sample tree is suitable GI tree, record breast height age (e.g., 4 years)
11. BEC classification (zone/subzone/variant/site series) (e.g., MSdm2 01)
12. Average height by species
13. Total tree count (e.g., 25)
14. Total conifer count (e.g., 21)

Supporting Data
Stratum Description
Brief description of stratum and criteria used to establish the stratum.
Inventory Label
Label for each stratum

Appendix 6: Silvicultural Requirements for Crop Trees

1. Coniferous Areas:

The Landscape Level Reforestation Strategy disapplies Sections 32(1), (3), (4), (5), (6) and (8) for coniferous areas logged after November 15, 2001. The above will also apply to coniferous areas with commencement dates before November 15, 2001 if the participant currently carries reforestation liability and has submitted a statement to the district manager that the cutblock(s) will be subject to the SFMP under Section 42 of the FSJPPR.

1.1 Definition, Use of Seed and Use of Livestock

Since portions of Section 32 and corresponding schedule F of the FSJPPR have been disapplied, the definition of "commencement date", the requirements for use of seed and the requirements for use of livestock in site preparation need to be re-stated.

For the purposes of Section 42 of the FSJPPR for coniferous areas logged after November 15, 2001 and coniferous areas with commencement dates before November 15, 2001 that the participant currently carries reforestation liability and has submitted a statement to the district manager that the cutblock(s) will be subject to the SFMP under Section 42 of the FSJPPR:

"Commencement date" means the date of
(a) the commencement of harvesting in the cutblock, other than harvesting associated with roads and landings,
(b) the determination for areas in which there was a contravention of section 96 of the Act.

Use of seed

A participant who carries out planting coniferous species to reforest an area must
(a) use only seedlots or vegetative lots collected and registered in accordance with the Tree Cone, Seed and Vegetative Material Regulation,
(b) use the best genetic quality source available,
(c) store tree seeds with the ministry,
(d) if the participant knows or should know of forest health concerns that affect the health of the species of trees that are required by the prescription, use only naturally or genetically improved resistant seed sources, seedlings or vegetative propagules if they are available,
(e) not exceed the limits for seed or vegetative material transfer specified in the Ministry of Forests' publication "Seed and Vegetative Material Guidebook", as amended from time to time, and
(f) keep a record of the registration numbers of the seedlots or vegetative lots used and the locations in which they are planted.

Use of livestock in site preparation

A participant who uses livestock for site preparation or brush control must
(a) ensure that all necessary measures are taken to
  (i) minimize conflict between livestock and animals that could prey on livestock,
  (ii) prevent transmission of disease from livestock to wildlife, and
  (iii) maintain the health of livestock,

(b) establish a buffer zone on the area if required to do so by a designated environmental official and prevent livestock from entering the zone,
(c) notify a designated forest official and a designated environmental official before the arrival of the livestock, and
(d) use livestock only if they have been inspected and certified as required by the Minister of Agriculture, Food and Fisheries.

1.2 Well Growing Requirement for Conifer Crop Trees

Section 1.2.2 " Free from Vegetative Competition"' will be the only section in "Well Growing requirement for Conifer Tree" subject to Section 42 of the FSJPPR.

The "Establishment to Free Growing Guidebook, Revised Ed. May 2000" will guide the process of determining well growing status for crop trees with the exceptions/ clarification noted below:

1.2.1 Well Spaced

At the reforestation assessment (indicator 6.29) phase of fifteen growing seasons the crop trees will be surveyed using a Mean Stocked Quadrant Plot and inter tree distance criteria does not apply.

1.2.2 Free from Vegetative Competition

For the purposes of Section 42 of the FSJPPR for coniferous areas logged after November 15, 2001 and coniferous areas with commencement dates before November 15, 2001 that the participant currently carries reforestation liability and has submitted a statement to the district manager that the cutblock(s) will be subject to the SFMP under Section 42 of the FSJPPR the following will be used to determine if a crop tree is well growing:

All herbaceous, brush and deciduous competition within a 1m radius cylinder of the crop tree must be assessed.

A. A crop tree that is 150% of all herbaceous, brush and deciduous competition within a 1m radius cylinder is well growing.
B. A crop tree that is 100% of all herbaceous (including grass) competition within a 1m radius cylinder is well growing.
C. A crop tree is well growing if it is taller than vegetation (includes birch and brush species), excluding aspen, cottonwood, on three of four quadrants in the 1m radius cylinder.
D. A crop tree is well growing if it is taller than countable aspen and/or cottonwood in at least three of four quadrants of the 1m radius cylinder and the number of countable aspen or cottonwood does not exceed 2. Quadrants may be aligned to minimize the number of quadrants with vegetation taller than the crop trees. A countable aspen cottonwood is a tree that is greater than the median height of all potentially well growing trees within the 3.99m radius plot.
E. Despite the above clauses A through D, a crop tree may be accepted as well growing if the vegetation does not impede the growth of the crop tree and is not expected to impede the future growth of the tree. The forester must stratify these areas and provide a rationale for accepting the crop trees.

1.3 Stocking Requirement for Conifer Crop Trees

For the purposes of Section 42 of the FSJPPR for coniferous areas logged after November 15, 2001 and coniferous areas with commencement dates before November 15, 2001 that the participant currently carries reforestation liability and has submitted a statement to the district manager that the cutblock(s) the following stocking requirements for conifer crop trees will be subject to the SFMP under Section 42 of the FSJPPR with the following exceptions:

1. The target stocking (TSS) as set out in Table A is required for the SLP and for a landscape level calculation of PMV at the time of the reforestation assessment (indicator 6.29), however it is not subject to Section 42 of the FSJPPR at establishment delay or as a cutblock specific measure at the time of the reforestation assessment and may vary as set out below.
2. The minimum stocking standard (MSS) as set out in Table A is required for the SLP and determination of Establishment Delay, however it is not subject to Section 42 of the FSJPPR at the time of the reforestation assessment.

1.3.1 Stocking Standards

Table A provides a standard for Site Level Plans and documenting Establishment Delay. The values are well spaced numbers.

The professional forester may modify target and minimum stocking, however decreases in target and minimum stocking will require a documented field condition that would justify a lower target stocking. Conditions such as, poor site with a low preharvest stocking, wet site with limited suitable microsite, areas with high likelihood of natural ingress would be considered to justify reduced TSS.

A decrease in the TSS and /or MSS in Table A to be applied across the landscape to a large number of cutblocks will require a documented justification by a professional forester and approval from the Regional Manager.

If the professional forester who prepared the site level plan for the area is of the opinion that the area in the cutblock in which reforestation is required is a complex of different types of sites interspersed, then the minimum and target stocking requirements for the complex are the number of trees per hectare determined by the following procedure:

(i) first, estimate the amount of area in each type of site:

(ii) second, for each type of site, multiply the amount of area of that type by the stocking requirement for that type of site determined in accordance with Table A;

(iii) third, add the total number of well spaced trees required for all types of sites as determined under subparagraph (ii);

(iv) fourth, divide the total number of trees required for the complex by the area of the cutblock.

The minimum strata size is 2 hectares.

Table A				
Type of Area	***Type of Site***	***Min. No. of Trees per ha. (MSS)****	***Target No. Trees per ha. (TSS)****	***Countable conifer* ESSF/BWBS**
Coniferous	Xeric-Subxeric	500	1000	Sw, Pl, Bl
Coniferous	Submesic-Mesic	700	1200	Sw, Pl, Bl, Sb
Coniferous	Subhygric	500	1000	Sw, Pl, Bl, Sb, Lt
Coniferous	Hygric-Subhydric	400	800	Sw, Pl, Bl, Sb, Lt

*well spaced trees per hectare (see Table B for equivalent MSQ)

Table B	
Well-spaced trees/ha	**MSQ**
0	0.0
100	0.3
200	0.7
300	1.2
400	1.7
500	2.1
600	2.5
700	2.8
800	3.1
900	3.3
1000	3.5
1100	3.6
1200	3.7
1300	3.8
1400	3.9
1500	3.9
1600	3.9
1700	3.9
1800	4.0

1.3.2 Minimum Inter-Tree Distance

The minimum inter-tree spacing at establishment will be 1.5m Further reductions to a 1.0m minimum will require a documented justification from the implementing forester. Reductions below the recommended 2.0m inter-tree spacing are expected occur frequently on the subhygric and wetter sites.

For MSQ plots minimum inter tree distance does not apply.

2. Deciduous Areas:

For the purposes of Section 35(5) of the FSJPPR the Landscape Level Reforestation Strategy does not affect Field Performance Requirements relating to reforestation of deciduous areas in Section 32 of the FSJPPR.

2.1 Well Growing and Health Requirement for Deciduous Crop Trees

The following well growing and health requirement for deciduous crop trees will be used for guidance.

Health

- Live aspen tree must be at least 2m in height and the tree pith must not be laterally displaced more than 30 cm from the root crown pith location[1].
- Aspen tree must not originate from a cut stump[2].
- Aspen tree must have at least one live leader[3].
- Aspen tree stem must not have a wound that is greater than 10% of the stem circumference, or is greater than 10% of the total length of the stem.[4].
- Aspen tree stem must not have any fungal infections or insect infestations affecting tissues below the bark surface, visible without destructive sampling[5].
- Aspen tree must not be browsed so as to limit its ability to become a crop tree.

Well Growing

- Minimum height 1.5m 6
- Minimum inter tree spacing 0.5m 7
- 100% or more than the tallest competing vegetation within a 1m radius of the crop tree 8

[1] A requirement of the Establishment to Free Growing Guidebook, Prince George Forest Region, May 2000, Appendix 6, Boreal Broadleaf Stocking Guidelines, BWBS.
[2] Stems originating from the sides or cut surface of stumps are very susceptible to breakage at the coppice point
[3]The objective is that the tree have a single stem that will develop into a healthy crop tree. Accordingly, a healthy, free growing aspen tree must have an identifiable live leader. It is not important that a portion, though not all, of the leader may be killed by for example venturia blight or be browsed. There is no agreement on a minimum leader length of a healthy aspen tree and as a result no minimum length is prescribed.
[4] This standard is modified from the conifer standard, and threshold percent values are chosen subjectively. Research should be undertaken to determine more exactly the size of an open wound at free growing assessment that is likely to limit the development of a healthy crop tree. A wound is defined as an injury in which the cambium is dead or completely removed from the tree exposing the sapwood. Measure the wound across the widest point of the exposed sapwood. Healed over wounds (=scars) are acceptable. Causes of mechanical damage to aspen commonly include gnawing by beaver, cattle, deer, elk or moose; logging activities; or windthrow scrapping. Fire or sunscald damage can also be the source of the wound. Injury of young aspen stems is considered an important entry court for decay organisms. Injury of mature aspen would pose a lesser concern since the resulting potential damage of decays would be much less.
[5] Stem infections that may be seen are likely caused by cyptospora canker or sooty-bark canker, and infestations that may be seen are likely caused by poplar borer. The significance of some diseases, such as armillaria, to aspen is not clear, and as well it is expected that such diseases could not be identified at the time of free growing.
[6] A requirement of the FSJPPR, December 2001
[7] A requirement of the FSJPPR, December 2001
[8] A requirement of the FSJPPR, December 2001

2.2 Stocking Requirement for Deciduous Crop Trees

The applicable performance standard for deciduous stocking, and well growing is set out in "Stocking requirements for Deciduous Crop Trees" and "Well Growing and Health Requirement for Deciduous Crop Trees". This is an interim standard that will be revised.

Stocking requirements are set out in the Site Level Plan (SLP) and are measured at establishment delay.

2.2.1 Stocking Standards

For the purposes of 32(5)(a)(i) of the FSJPPR the applicable performance standard for stocking requirements of deciduous areas is:

Table C provides a standard for Site Level Plans and silviculture regimes. The values are well spaced numbers. Minimum intertree spacing 0.5m.

Table C				
Type of Area	***Type of Site***	***Min. No. of Trees per ha. (MSS)****	***Minimum height***	***Countable Deciduous***
Deciduous	Xeric-Submesic	4000	1.5m	At
Deciduous	Mesic-Subhydric	4000	1.5m	At, Ac (max. component of 15% birch)

Appendix 7: Stand Survey & Growth Modeling for the Fort St. John TSA

Stand Survey & Growth Modeling for the Fort St. John TSA

Prepared for

Don Rosen
Greg Taylor, RPF
Canadian Forest Products Limited
Chetwynd, BC

Project: CFC–004

January 17, 2003

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

Executive Summary

Riverside Forest Products Ltd., as part of their Forest Practices Code (FPC) pilot project on TFL 49, developed a prototype silviculture survey and modeling system to assess reforestation obligations at the landscape level. This report describes the first steps in adapting the prototype system for use in the Fort St. John TSA. The initial Riverside system uses stand, site and tree information collected in surveys 10 years post-harvest to predict merchantable volumes 80 years post-harvest for lodgepole pine and interior spruce stands. Silviculture obligations are met if the overall average predicted merchantable volume meets or surpasses the target merchantable volume set for the harvested area.

For the Fort St. John TSA, the model to predict future merchantable volumes was re-fit to use survey data 15 years post-harvest as the inputs and provide merchantable volumes for lodgepole pine and interior spruce stands 80, 90 and 100 years post-harvest as the outputs. In addition, the post-stratification procedures for the survey data have been simplified and improved using inventory attributes and target stocking standards as the variables to assign plots to the required strata for determination of future merchantable volumes.

The proposed survey methodology uses a combination of *full-measure* and *count-plots* established on a 100 m grid. The *full-measure* plots are established on the 200 m grid where all trees are measured for height, species, and health condition. The *count-plots* are established on a 100 m grid between the full-measure plots where less detailed measurements are taken. Pins are used to mark the location of the full-measure plots so they can be relocated and included in subsequent surveys. This will then provide data that can be used to estimate change in these young stands over time. In addition, the use of a grid allows linkage to a growth and yield monitoring program where permanent sample plots can be established on a small subset of the points used for the full measure plots.

To fully implement the silviculture survey and modeling system in the Fort St. John TSA additional work is required to improve estimates of site productivity and include projections of aspen and mixedwood merchantable volumes and changes in species composition in the model. The later are dependent on improved growth and yield modeling of aspen and mixedwood stands which has been identified as a high priority for the TSA.

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1. INTRODUCTION

1.1 BACKGROUND

Participants in the Fort St. John Results Based Forest Practices Code pilot project expressed interest in adapting the prototype silviculture survey and modeling system developed by Riverside Forest Products for TFL 49.[1,2] The prototype system, developed for lodgepole pine (Pl) and interior spruce (Sx) stands, was completed in 2001-02 by Riverside as part of their Results Based Code pilot project. The primary objectives of the system were to assess reforestation performance at a level of resolution above the individual cutblock, allow silviculturalists more options to achieve the desired stand at harvest for the lowest costs, and to highlight the relationships between silviculture activities and future yields. A key component of the prototype system is the ability to compare silviculture performance against a predetermined target. The major steps in the system are to:

1) Use a simple survey to collect information on regenerated stands.
2) Use the survey information to predict future harvest volume.
3) Compare the predicted volume to a target future volume for those blocks.

This results based system ensures that overall silviculture performance goals are achieved while avoiding the high cost of micro-managing individual blocks and portions of blocks.

1.2 PROJECT GOAL & OBJECTIVES

The primary goal of this project is to adapt the Riverside silviculture survey and modeling system to the Fort St. John TSA for the results based code pilot project. The system will be adapted for Pl and Sx this year and aspen (At) and At/conifer mixtures in subsequent years.

The specific objectives of this project are to:

1) Re-fit the Pl and Sx models developed for Riverside with different post-harvest times for the survey and subsequent harvest.[3]
2) Identify potential linkages between the survey and modeling system and monitoring requirements.
3) Provide sufficient information to describe the survey and modeling system in the Fort St. John sustainable forest management plan (SFMP).
4) Assess the direct applicability of the Riverside system to the Fort St. John TSA and document required adjustments, including those needed for At and At/conifer stands. (The intent is that adjustments not addressed in this project will be included in a future research proposal[4]).

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[1] J.S. Thrower & Associates. 2002. Stand surveys and growth modeling for the TFL 49 results-based pilot project: final report. Contract report for Riverside Forest Products Ltd. January 2002.

[2] Martin, P.J., Browne-Clayton, S., McWilliams, E. 2002. A results-based system for regulating reforestation obligations. For. Chron. 78(4):492-498.

[3] The Riverside models used 10 years post-harvest as the survey time and 80 years post-harvest as the future harvest time.

[4] Current indications are that there will be an FII call for research proposals in February 2003.

1.3 Terms of Reference

This project was completed by J.S. Thrower & Associates Ltd. (JST) for Canadian Forest Products Ltd. (Canfor), Fort St. John operations. The JST project team was Eleanor McWilliams, *MSc RPF*, Jim Thrower, *PhD RPF,* Ian Cameron, *MSc RPF,* and Guillaume Thérien, *PhD*. The Canfor project leaders were Don Rosen and Greg Taylor, *RPF*.

Three main groups collaborated in developing this system: the Ministry of Forests lead policy development and provided the TASS simulations; the licensees (Riverside and Canfor) lead operational implementation; and J.S. Thrower & Associates lead the design of the survey and modeling system. Key contributors from the Ministry of Forests were Pat Martin, *RPF,* Lorne Bedford, *RPF*, Ken Polsson, and Wendy Bergerud. Shane Browne-Clayton, *RPF*, is the Riverside project leader, and Gary Bouthillier (Resource West Consulting Ltd., Kelowna) provided valuable input into the survey design.

2. STAND SURVEY

2.1 Overview

The key components of the proposed stand survey (described below) are:

1) Stands are surveyed 15 years after harvest to estimate the predicted merchantable volume (PMV) at a given age (80, 90, or 100 years after harvest).

2) Sample plots are located on a 100 m grid (generated from UTM coordinates), and all grid points in the net area to be reforested (NAR) are sampled.

3) Full-measure plots are located on the 200 m grid points, and count plots are located on the 100 m grid points.

4) Both plot types use a 3.99 m radius plot (50 m^2) to measure tree attributes. A 5.64 m radius site index plot (100 m^2) is established at the full-measure plots to collect site tree data.

5) Measurements in full-measure plots include:
   a) Species, height (visually estimated), and health of all trees.
   b) An assessment of stocked or not stocked for each quadrant (a stocked quadrant must contain at least one healthy free-growing tree).
   c) An assessment of non-productive area and brush.
   d) Height and age of one site tree per species.

   Full-measure plots are marked with a steel[5] pin and GPS coordinates are taken for future relocation to include in subsequent surveys.

6) Measurements in count plots are also recorded by quadrant and include only:
   a) An assessment of stocked or not stocked for each quadrant, and why quadrants are not stocked (e.g., brush, non-productive (NP) area, health).
   b) A tally of trees by species.

2.2 Survey Objectives

The goal of the survey is to describe stand characteristics in sufficient detail to estimate the PMV at 80, 90, or 100 years after harvest to compare with a target merchantable volume (TMV) for that age. The objectives of the stand survey are to:

1) Measure tree conditions, stand structure, and site productivity (where possible) to predict future volume.
2) Produce inventory labels.
3) Identify potential areas for silviculture treatments.
4) Update block maps to define areas where volume should be predicted and where other values take precedence (e.g., wildlife).

[5] Any type of pin that can be located with a metal detector is acceptable.

2.3 Target Population

The target population to sample in a given year is the NAR created from harvesting 15 years previously. For example, the target population to sample in the year 2003 is the NAR from harvesting in 1988. The modeling procedures developed in this project assume stands are surveyed 15 years after harvest.

2.4 Post-Stratification

Three primary objectives to post-stratify the target population are to:

1) Assess regeneration performance. Stands are grouped to calculate TMV and PMV.
2) Delineate forest-cover polygons.
3) Identify areas for silviculture treatments.

A secondary objective to post-stratify the target population is to:

1) Improve integration of silviculture and inventory records and the link between silviculture decision-making and timber supply.

The target population is post-stratified using information from the inventory labels and target stocking standards (TSS). For each defined stratum, a TMV is set, and data from all plots are pooled to determine an overall mean number of stocked quadrants (MSQ), effective age, and site index to calculate the PMV. The procedures for post-stratification are described in Sections 2.5.2 and 2.6.1, and the procedures to compile the data are described in Section 4.

2.5 Office Procedures

2.5.1 Map & Previous Data

A Silviculture Prescription (SP) map (or equivalent) should be used to develop the plot locations of the stand survey and should be updated following each survey. This map should show block boundaries, NP area, non-commercial cover (NCC), wildlife tree patches (WTPs), riparian management areas (RMAs), permanent access structures (PASs), and temporary roads. If permanent sample points were established in a previous survey (Section 5.1), the data should be downloaded to hand-held computers for comparison and error checked during the survey. The surveyor should be familiar with the block history.

2.5.2 Office Stratification

Prior to field sampling, the following information should be added to the survey map:

1) Transfer NAR boundary to the survey map (the NAR is the target area to sample).
2) Transfer TSS boundaries from the SP to the survey map.

Standards units (SUs) can be combined if they have: a) the same TSS; and b) the same preferred and acceptable (p+a) species. Record the TSS and the p+a species for each unit (this information is required during the survey).

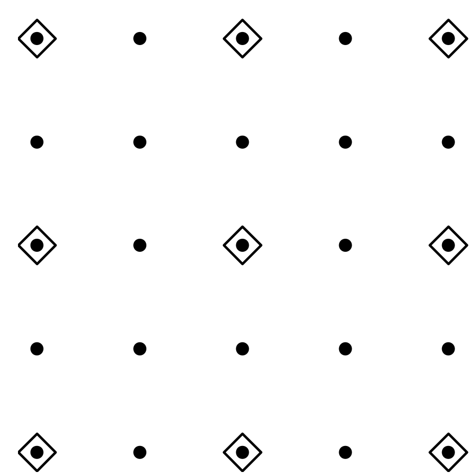

Figure 1. Example of sample points on a 100 (•) and 200 (◇) m grid.

2.5.3 Plot Locations

Sample plots are located on a 100 m grid (Figure 1) using UTM NAD 83 coordinates. These grid points can be generated in the GIS by plotting points evenly divisible by 100. Plot locations should be marked on the map prior to field sampling and all points in the NAR should be sampled.

2.6 FIELD SAMPLING

2.6.1 Stratification

During field sampling the following information should be added to the survey map:

1) Update NAR boundaries if necessary.
2) Map inventory polygons. Follow current procedures to map inventory polygons using species composition, site productivity, and stand density. Distinguish between areas considered SR and NSR.
3) Map potential treatment units. If the cutblock contains a viable treatment unit, add to the map the approximate location of the treatment unit and describe the treatment opportunity.

2.6.2 Full-Measure Plots

Each full-measure plot includes a 50 m^2 (3.99 m radius) plot divided into quadrants along cardinal directions to measure tree attributes and a 100 m^2 (5.64 m radius) plot to collect height and age data from site trees (located at the same plot center) (Figure 2). Suitable site trees have three or more years height growth above breast height. Site tree data should be collected from one tree of each species located in the site index plot with a suitable site tree.

Plot Location

Full-measure plots are established on the 200 m grid. Plot centers should be permanently marked with a steel pin and GPS coordinates recorded. Plot locations should be documented in the GIS. These sample points should not be visible when walking through the stand to avoid treating the plot area differently than other portions of the stand (which may bias the information from the sample point at subsequent measurements).

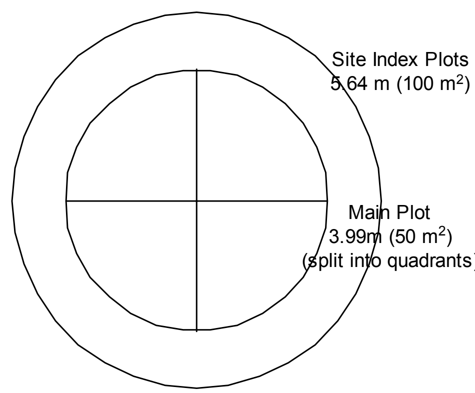

Figure 2. Full-measure and count plot design.

Main Plot – 50 m^2

Quadrant Information - Record each quadrant as stocked if it contains at least one healthy tree of an acceptable species that is free of brush competition (according to current free growing regulations). If a non-stocked quadrant could support tree growth, comment on why there are no trees (e.g., type of NP ground, missed plantable spots, brush competition, health problems).

Tree Information - Data for each tree in the plot includes:

i) Quadrant number (1-4).
ii) Tree species.
iii) Height (measure some for reference and visually estimate others).

iv) Forest health codes (use the same codes used in other silviculture surveys).

Brush Information - In each quadrant record percent cover and average height of brush by species.

NP Area Information - In each quadrant record the type and percent cover of NP area (e.g., rock, water).

Site Index Plots – 100 m^2

Record site index information for one site tree of each species from the site index plot located at each plot center. Site trees are:

i) The tallest tree in the 100 m^2 plot for that species.
ii) Undamaged (stem damage resulting in less than 5% reduction in height growth).
iii) Not overtopped by other trees or competing vegetation where height growth may be affected.

The second tallest tree can be measured for site index if the tallest is not suitable. This must be noted on the field card. Information collected for each tree should include:

i) Total height.
ii) Age at breast height (yrs).
iii) Total age (yrs).
iv) Rank in height relative to other trees in the plot of that species (e.g., tallest, 2nd tallest, etc.).

2.6.3 Count Plots

Count plots consist of a 50 m^2 plot to collect stocked quadrant information.

Plot Location

Count plots are established at the 100 m grid points between each full-measure plot. Count plots are not permanently marked, and GPS coordinates are not recorded.

Main Plot – 50 m^2

Quadrant Information - Record each quadrant as stocked if it contains at least one healthy tree of an acceptable species that is free of brush competition (the same as in full-measure plots). For non-stocked quadrants, record whether the quadrant is NP (and type of NP) or could support tree growth. If a non-stocked quadrant can support tree growth, comment on why there are no trees (e.g., missed plantable spots, brush competition, health problems, etc.).

Tree Information - Tally the number of trees by species. This is used to estimate stand density and species composition.

3. PREDICTING FUTURE VOLUME

3.1 OVERVIEW

The same TASS simulations used to develop equations for Riverside were used in this project. TASS was used to simulate 433 different Pl and Sx stand types with varying species composition, stand density, spatial distributions, and ingress patterns. The simulated stands were surveyed using the stem maps generated for a range of young stand ages using the procedures described in Section 2. Survey statistics were compiled and compared to merchantable volumes 80, 90, and 100 years after harvest. The single best predictor of future volume was mean number of stocked quadrants (MSQ). A quadrant is considered stocked when it has at least one healthy tree of an acceptable species that is free of brush competition.

Based on these results, a model was developed to predict merchantable volumes 80, 90, and 100 years after harvest from survey data collected 15 years after harvest. Model inputs include species composition (limited to Pl, Sx, or PlSx), MSQ, site index, and effective total stand age (determined from site index and total average site tree height).

3.2 OBJECTIVES

The goal of predicting future stand merchantable volumes is to compare the estimates with target merchantable volumes to measure silviculture performance. The objectives of the modeling are to:

1) Predict stand merchantable volumes 80, 90, and 100 years after harvest.
2) Use the simplest method that accounts for key factors influencing future volume.

3.3 MODEL DEVELOPMENT

3.3.1 TASS Simulations

The TASS simulations generated a wide range of stand structures to develop and test a model to predict future merchantable volumes from stand survey data. These simulations were completed by the MOF Research Branch and included 433 combinations of planting and natural stand densities, species compositions, and spatial and temporal distributions (Table 1). The various factors were combined in a factorial structure so that initial stand density[6] ranged from 400 to 9,400/ha and species composition ranged from 100% Pl or Sx and a full range of mixtures.

Table 1. Factors in the matrix of TASS runs used for model development.

Factor	Level
Site Index	20 m
Species	Pl, Sx
Planting Density (no/ha)	0, 400, 800, 1,000, 1,200, 1,400 [a]
Natural Density (no/ha)	0, 400, 800, 1,200,1,600, 2,000, 5,000, 8,000
Spatial distribution of naturals	Random, Clumped [b]
Ingress period of naturals	TASS default (truncated Normal (2, 1.5)), Poisson (4.0) [c]

[a] Planting was assumed to occur one year after harvest with one year old stock.
[b] Naturals were apportioned 75% to clumps and 25% random, with an average of 25 trees/clump.
[c] Normal (2.0, 1.5) is a Normal distribution with mean of 2.0 and standard deviation of 1.5. Poisson (4.0) is a Poisson distribution with a mean and variance of 4.0.

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6 The number of trees simulated by TASS prior to mortality.

The height vigor coefficient was included in all simulations (so top height trees track the height-age curve for the assigned site index, regardless of stand density). Each TASS simulation was for a 3.0 ha block (100 x 300 m). No operational adjustment factors (OAFs) were applied, however, the natural clumped distributions with no planting resulted in holes distributed throughout the stands.

The following were generated for each TASS simulation:

1) A standard run summary with output from ages 1 – 15 and then every five years to age 120.
2) Stem maps for ages 10, 13, 15, and 18 years. These included x-y coordinates, species, and heights. Stand density at these ages varied due to ingress and mortality patterns simulated in TASS.

3.3.2 Simulated Surveys

We simulated surveys in each stand using the survey procedures (Section 2) where plots were established on randomly oriented 25 m grids. This gave about 48 plots for each simulated survey (a 25 m grid gives 16 plots/ha, each stand is 3 ha). For each plot, the species and height of each tree in each quadrant was recorded. For each of the 433 TASS simulations, 30 surveys were simulated for each of ages 10, 13, 15, and 18 years, for 51,960 simulated surveys (Table 2).

Table 2. Mean number of stocked quadrants (MSQ) from 30 simulated surveys at age 15 using TASS with different combinations of planted and natural Pl.

Naturals		Planted Density (no/ha)					
Spatial Distribution	Stand Density (no/ha)	0	400	800	1,000	1,200	1,400
	0		1.87	3.30	3.62	3.78	3.84
	400	1.54	2.75	3.63	3.84	3.93	3.95
	800	2.48	3.16	3.74	3.91	3.96	3.97
	1,200	3.04	3.49	3.86	3.94	3.98	3.98
Random	1,600	3.38	3.69	3.91	3.97	3.98	3.99
	2,000	3.62	3.79	3.94	3.98	3.99	4.00
	5,000	3.98	3.99	4.00	4.00	4.00	4.00
	8,000	4.00	4.00	4.00	4.00	4.00	4.00
	400	0.88	2.40	3.56	3.81	3.91	3.95
	800	1.59	2.68	3.67	3.86	3.93	3.96
	1,200	2.18	3.09	3.73	3.90	3.96	3.97
Clumped	1,600	2.62	3.24	3.80	3.92	3.97	3.98
	2,000	2.90	3.45	3.85	3.94	3.97	3.99
	5,000	3.81	3.90	3.97	3.99	4.00	4.00
	8,000	3.98	3.99	4.00	4.00	4.00	4.00

3.3.3 Model Fitting [7]

The Riverside project showed that MSQ was the best predictor of future volume (Table 2). Several equation forms were tested with the best fit provided by a quadratic equation:

$$PMV = a + b*MSQ + c*MSQ^2$$

Where **PMV** is *predicted merchantable volume* at a defined post-harvest time; ***a***, ***b***, and ***c*** are coefficients (Appendix I); and **MSQ** is the number of *mean stocked quadrants* from the sample of a stand or stratum. Analyses showed that anamorphic curves (parameters *b* and *c* are held constant) could be fit to the data with separate intercepts (parameter *a*) for each of 12 stand age and species combinations. In the Riverside project, four stand ages (5, 7, 10, and 13) were used to represent the range of potential stand ages 10 years post-harvest. The three species groups were pure Pl (≥ 80% Pl based on stand density at the time of the survey), pure Sx (≥ 80% Sx based on stand density at the time of the survey), Pl/Sx mix (21-79% Pl and Sx based on SPH at the time of the survey). Two mixed species groups were tested (one Pl leading and

[7] Further details of the model fitting procedures are provided in Appendix I.

Sx leading), but they did not provide a better fit than a single mixed group.

The same species groups were used in this project as for Riverside, but the age of the stand survey was changed to 10, 13, 15, and 18. In addition, the PMV was 80, 90, and 100 years post-harvest for this project and was 80 years for Riverside.

Two procedures were used to fit the equations for 80, 90, and 100 years post-harvest. First, three separate sets of anamorphic equations were fit for each post-harvest age. Second, one set of anamorphic equations was fit for all three post-harvest times.[8] The first procedure resulted in equations that better fit the data, but the three equations overlapped at low MSQ values (< 1.5) resulting in inconsistent predictions. For example, for the same MSQ value the PMV 80 years post-harvest was slightly higher than the PMV 90 years post-harvest. The second procedure resulted in equations that provided a good fit to the data and produced consistent results. As a result, these equations were chosen as the final set (Figure 3).

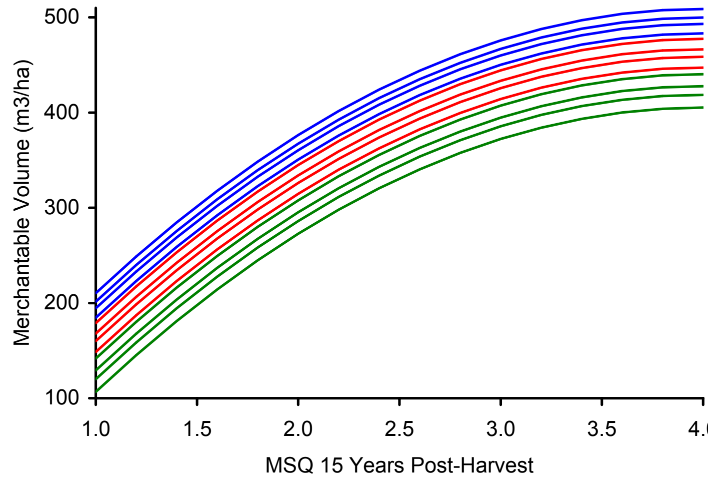

Figure 3. Anamorphic curves showing merchantable volume 80 (—), 90 (—) and 100 (—) years after harvest by MSQ 15 years post-harvest. Effective stand ages of 10, 13, 15, and 18 years are displayed from bottom to top in each set of curves. These curves are for pure Pl at site index 20 m.

3.3.4 Site Index

As a first approximation for this project, the procedures to incorporate different site indices and stand ages will follow the methods developed for the Riverside project. For Riverside and this project, the equations to predict future merchantable volume were fit with data from TASS simulations of site index 20 stands. Subsequently adjustment factors were developed for site indices other than 20. An objective of this year's Riverside project is to improve the current model's ability to predict future volumes across a range of site indices. The results of this initiative will be available March 31, 2003.

Fixed Site Index for Target and Predicted Volumes

The objective of the volume comparison is to focus on the impacts that silviculture performance has on volume growth. For each stratum, the same site index estimates should be used to set the target merchantable volume and determine the PMV. The differences in volume are then associated with differences in stand structure, and not on potential differences in site index. Site index estimates should be based on the best available information for each block (e.g. Site Index Adjustment, growth intercepts, SIBEC). In most cases, with the surveys occurring 15 years post-harvest, the site trees should be tall enough to use growth intercept equations.

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[8] In the first case different *b* and *c* coefficients were fit for each post-harvest time. In the second case, *b* and *c* were held constant across the three post-harvest times.

Effective Age – Early Height Growth

Early height growth is a function of many variables including site productivity, stock and planting quality, and brush and health impacts; as a result, early height growth can be highly variable. Implicit in TASS and the prediction models are a set of site curves (height-age curves) that define site tree height growth. Once a site index has been chosen for a stratum, there is a defined height-age curve that the site trees follow. Furthermore, for the purposes of this project, the height-age curve is assumed to represent the target height growth pattern. If management practices result in trees growing faster or slower than assumed, then licensees should be rewarded or penalized accordingly. To achieve this, the following steps can be taken:

1) Determine a site index for the leading species in the stratum.
2) Calculate the average site tree height of the leading species from the survey data.
3) Determine the effective total stand age by using the average site tree height and the appropriate height-age curve.

If management practices are better than assumed in the height-age model, then the effective total stand age is older than the physiological age. The reverse is also true (Figure 4).

This method depends on average, realistic site index estimates. If estimated site indices are low, then effective stand ages would be too high on average. These higher ages would not represent better stand management practices, but would be higher because productivity is better than estimated.

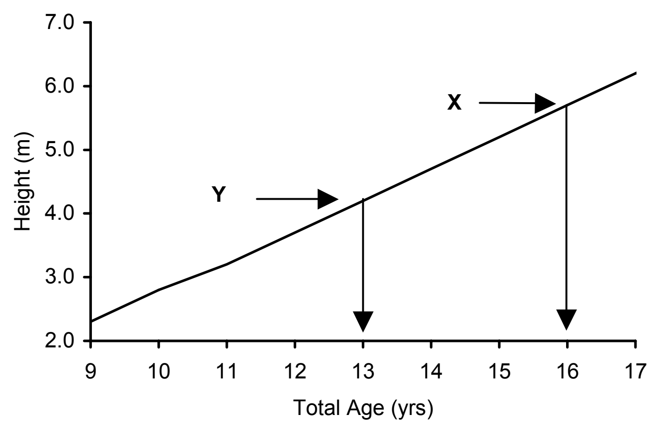

Figure 4. Height-age curve for Pl site index 20 m. Assume the target is set so the stand is 15 years total age 15 years post-harvest. For a site index 20 m stand, site trees are assumed to be 5.2 m tall. If the site trees are growing better than expected (X), the effective total stand age is 16 years. If they are poorer than expected (Y), the effective total stand is 13 years.

Volume Adjustment by Site Index

The equations for predicted merchantable volume were fit with data for site index 20. Ideally, separate equations would be fit for the full range of site indices; this is currently being tested for Riverside. As an alternative, adjustment factors have been developed to correct for different site indices.

Merchantable volumes at ages 80, 90, and 100 for a range of site indices and initial stand densities were expressed as a percentage of merchantable volume at age 80, 90, and 100 for site index 20 (Figure 5). Similar relationships were found for Pl and Sx, and planted and natural stands. The general pattern observed was percent volume increasing (for site index < 20) or decreasing (for site index > 20) below approximately 2,000 SPH and then remaining fairly constant above this density. Table 3 shows the adjustment factors developed using these results. For stands under 2,000/ha these multipliers will slightly under predict volume for site index > 20 m and slightly over predict for site index < 20 m.

3.3.5 Brush and Health Impacts

Brush and health impacts are incorporated into the system by defining if a quadrant is stocked (where stocked quadrants must contain at least one tree which meets the current free-growing standards for health and brush).

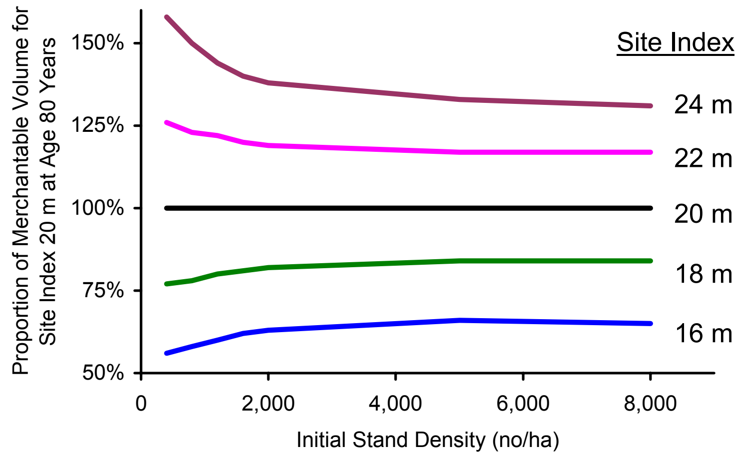

Figure 5. Proportion of merchantable volume (m3/ha) for Pl at age 80 by site index and initial stand densities. Data are from TIPSY.

3.4 SETTING TMVS

The TMV should be defined in a higher-level plan (possibly by site series and management zone). Policy decisions are required to set the values used to determine TMVs. The current approach described by Forest Practices Branch sets TMVs at 90% of the maximum PMV that could be attained with a very aggressive reforestation regime.[9] The maximum PMV for Riverside is determined using an MSQ of 4.0, site index 20 m, and an effective age of 12 years.[10] To determine the TMV, the maximum PMV is then multiplied by 0.9, and adjusted for lower TSS and different site index (Table 3) if required. It is important that the same equations are used to determine TMVs and PMVs so no bias is introduced.

Table 3. Volume multipliers to adjust target and predicted merchantable volume for different site indices.

Years from Harvest	Site Index (m)								
	14	15	16	17	18	19	20	21	22
80	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20
90	0.50	0.60	0.70	0.75	0.80	0.90	1.00	1.10	1.20
100	0.50	0.60	0.70	0.75	0.80	0.90	1.00	1.10	1.20

9 Forest Practices Branch. July 9, 2002. Sample design for the 2002 pilot of Riverside's new approach to silviculture obligations. Unpublished. Available from Pat Martin.

10 Riverside surveys are conducted 10 years post-harvest. An effective age of 12 assumes late winter harvest early in the calendar year, and 1-year-old stock planted in the spring so that the trees are 2 years old in the fall of the year harvesting occurred. Surveys are assumed to occur 10 years post-harvest in the fall.

4. TRACKING OBLIGATIONS

4.1 Overview

This section outlines the steps to summarize the survey data and determine PMVs at 80, 90, or 100 years post-harvest. The six main steps described below are:

1. Choose a post-harvest age for the PMV.
2. Post-stratify the surveyed area.
3. Determine effective age for each stratum.
4. Estimate the MSQ.
5. Estimate the PMV for site index 20.
6. Adjust the PMV for site index.

4.2 Choose a Post-Harvest Age for PMV

The model was developed to generate PMVs for 80, 90, or 100 years post-harvest; one of these post-harvest times should be chosen for the entire target population. Selecting one post-harvest time results in higher weights (higher volumes) for more productive sites when determining if the overall target volume is achieved. For example, using 80 years for high sites and 100 years for low sites more closely reflects potential future harvest ages; however, it also reduces the difference in the volume targets between high and low sites. The intent of the system is to focus proportionally more effort on the higher sites that provide better returns from silviculture investments.

4.3 Post-Stratify the Survey Area

Post-stratify the sampled area after the plot data has been entered into a spreadsheet or database. <u>This is done based on the plots location – not using the plot survey data</u>. The strata are based on: a) species group; b) site index[11]; c) SR or NSR[12]; and TSS (Figure 6, Table 4).

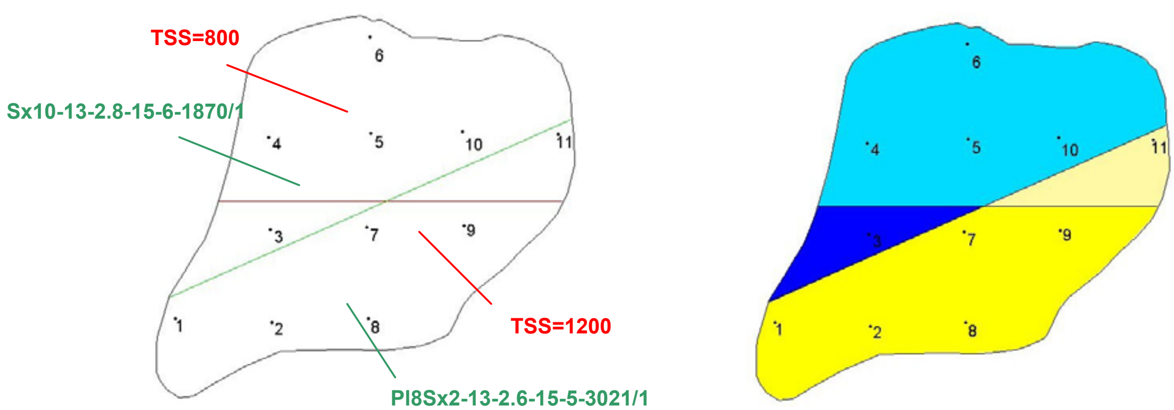

Figure 6. Block map showing plot locations, inventory polygons, and TSS (left) and strata for PMV calculations (right).

[11] Initial adjustments for site index (Table 3) result in a linear relationship between site index and PMV across MSQ values, suggesting there is no need to stratify by site index. However, site index is included as it is expected improved adjustments for site index will not be linear.

[12] The definitions of SR and NSR are a policy decision.

Table 4. Example showing inventory label, TSS and stratum.

Plot	Inventory label	Species group	Site index (m)	SR/NSR	TSS	Stratum
1	Pl8Sx2-13-2.6-15-5-3021/1	Pl	15	SR	1,200	Pl - SI 15 - SR -TSS 1200
2	Pl8Sx2-13-2.6-15-5-3021/1	Pl	15	SR	1,200	Pl - SI 15 - SR -TSS 1200
7	Pl8Sx2-13-2.6-15-5-3021/1	Pl	15	SR	1,200	Pl - SI 15 - SR -TSS 1200
8	Pl8Sx2-13-2.6-15-5-3021/1	Pl	15	SR	1,200	Pl - SI 15 - SR -TSS 1200
9	Pl8Sx2-13-2.6-15-5-3021/1	Pl	15	SR	1,200	Pl - SI 15 - SR -TSS 1200
11	Pl8Sx2-13-2.6-15-5-3021/1	Pl	15	SR	800	Pl - SI 15 - SR -TSS 800
3	Sx10-13-2.8-15-6-1870/1	Sx	15	SR	1,200	Sx - SI 15 - SR - TSS 1200
4	Sx10-13-2.8-15-6-1870/1	Sx	15	SR	800	Sx - SI 15 - SR - TSS 800
5	Sx10-13-2.8-15-6-1870/1	Sx	15	SR	800	Sx - SI 15 - SR - TSS 800
6	Sx10-13-2.8-15-6-1870/1	Sx	15	SR	800	Sx - SI 15 - SR - TSS 800
10	Sx10-13-2.8-15-6-1870/1	Sx	15	SR	800	Sx - SI 15 - SR - TSS 800

The strata shown in Figure 6 can be determined by overlaying the inventory polygons and the TSS strata. The Fort St. John requirements of stratification by licensee and management zone could also be included in the stratification without further requirements for mapping in the field. Information on stand type (conifer, deciduous, mixed-wood) can also be addressed by assigning inventory polygons to appropriate stand types. Defining divisions within the mixed-wood group will require more work to address changes in species composition over time. This will be tied to efforts to improve modeling of these stand types.

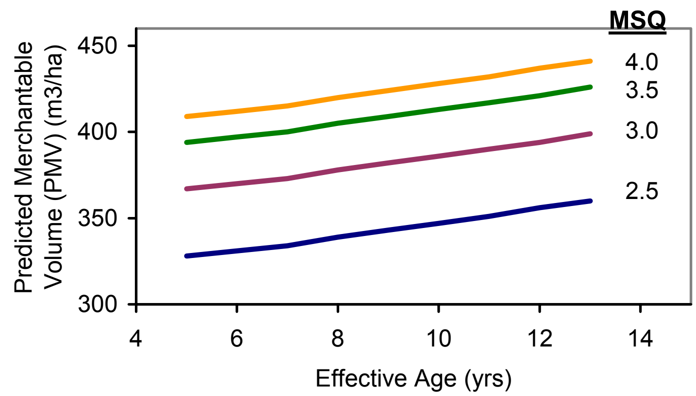

Figure 7. Relationship of PMV to effective age for different MSQs (Pl at site index 20 m).

The need to include effective age in the strata definition was examined. There is a constant linear relationship between effective age and PMV across MSQ values, thus there is no need to stratify based on age (Figure 7).

4.4 Determine Effective Age For Each Stratum

Based on inventory information, each stratum will have a defined site index. Using data from all site index plots within the stratum calculate the average height of the site trees of the leading species. The effective stand age can then be derived by looking up the site index and average height in the effective age tables (Appendix II). For each Pl-Sx stratum, the effective ages for Pl and Sx should be determined separately using the appropriate tables and then averaged to give an effective age for the stratum.

4.5 Estimate the MSQ

Calculate the MSQ for the sample plots using all full-measure and count plots in the stratum.

4.6 Estimate the PMV for Site Index 20

Choose the appropriate PMV table (Appendix III) based on species composition and 80, 90, or 100 years post-harvest. Use MSQ and effective stand age to determine the PMV.

4.7 Adjust the PMV for Site Index

Multiply the PMV by the factor given in Table 3. This gives the final PMV for entry for the silviculture obligation ledger for comparison with the target merchantable volumes.

An example calculation is presented in Appendix IV.

5. POTENTIAL LINK TO OTHER SURVEY SYSTEMS & MONITORING

5.1 Link to Other Surveys

The stand survey can be linked with other surveys by using a common sample grid for all surveys. Full-measure plots (Section 2) located on the 200 m grid point can be included in all surveys. This will provide the data to develop a chrono-sequence of measurements over time similar to a permanent sample plot. The 200 m grid points are marked with steel pins and GPS (post-processed) UTM coordinates recorded to assist plot relocation for subsequent surveys. The permanent markers at these 200 m sample plots should be installed at the first survey completed in a stand.

As an example, the same plot locations could be measured during pay plot surveys following planting, stocking surveys, and a pole-stage survey done at 30 years of age. The same plot size (3.99 m radius) must be used and the same measurements (species, quadrant, estimated heights, damage codes, percent brush cover and brush height[13]) must be taken during each survey. This provides data to track changes over time to give feedback on silviculture treatments, and provides data to indirectly check PMV estimates by providing growth data to check TASS projections. We recommend the costs and benefits of this approach be examined.

5.2 Link to Growth & Yield Monitoring

Accurate projections of future merchantable volumes are critical to the success of the proposed survey and modeling system. Establishing a set of monitoring plots to track actual growth and yield of a representative sample of post-harvest regenerated stands provides data to check predicted volumes. The proposed permanent points (one every 4.0 ha on a 200 m grid) provide information on early stand development (approximately ages 0 – 30) if full-measure plots are repeatedly established over this period. After approximately age 30, larger plots will be needed to obtain accurate estimates of volume and volume growth.

One option to consider is linking the survey system with the proposed growth and yield monitoring program by establishing the growth and yield monitoring plots on the same grid used in the survey system. For example, the growth and yield monitoring plots could be established on a 5.0 km grid using the same UTM base as the 200 m grid used for the full-measure survey plots. If this were done, the growth and yield monitoring plots would not have to be established immediately after harvest to obtain information on early stand growth. Early stand data would be obtained from re-measured full-measure survey plots.

5.3 Monitoring Site Productivity

The repeat measurement of the full measure survey plots will also provide valuable information to track the changes in top height (and site index) over time.

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[13] If brush is a significant management issue, then surveys should be done at the same time of the year to ensure consistent % cover estimates.

6. FURTHER WORK REQUIRED

6.1 Background

A meeting was held November 5, 2002 in Fort St. John to discuss the applicability of the Riverside system to the Fort St. John TSA. The preceding sections of this report document the work done in the current fiscal year to begin adapting the Riverside system to the Fort St. John TSA. This section documents the top priority issues identified at the November 5 meeting to be addressed in subsequent fiscal years.

6.2 Sample Size

The meeting participants agreed that survey plots would be installed on a 100 m grid (i.e., one plot/ha; the same as on Riverside's TFL 49). However, the appropriateness of this sample intensity and the potential to reduce the intensity should be examined after the first year of data collection is complete.

6.3 Early Height Growth & Site Productivity

This survey system relies heavily on measurements of early height growth and site index. These measurements impact the survey system and the link to the volume predictions – which is the core of this system. Furthermore, the information from these surveys will be used to update inventory files and will likely be used for stand-level growth and yield modeling for timber analysis. However, forest managers in the area are generally uncertain of the reliability of current site index estimation tools for the Ft. St. John TSA area. Some of the items discussed where additional work is needed include:

1) Check the growth intercept equations. The meeting participants agreed to use growth intercepts to estimate site index in this survey (where stands are measured 15 years after harvest). However, some trees at these ages may have only a few years growth above breast height, which may introduce additional variation (and possibly bias) into the estimates.
2) Examine early height growth patterns. This survey system relies heavily on the assumption that early height growth patterns in the Ft. St. John area are the same as was used to develop the site index equations, growth intercepts, and the growth models on which this survey is developed. Some practitioners expect that early height growth may be different on some sites in the area (e.g., wet areas).
3) Identify a minimum breast height age and height for estimating site index.
4) Develop ecologically-based site indices for the TSA. There is a need to improve the estimates of potential site index in the TSA. This will positively impact harvest forecast for the area and provide key information for the SFMP. The two main approaches to consider are:
    a. SIBEC estimates with PEM or TEM. Some practioners believe that the SIBEC estimates for the area under-estimate site productivity. The MOF recently release the second approximation SIBEC estimates, which may address some of these potential under-estimates; however, this should be checked, and more work will be needed to improve these estimates, if required. This approach will also require a completed PEM or TEM for the area.
    b. Site index adjustment (SIA) with PEM, TEM, or biophysical model. An SIA project will provide the same results as the SIBEC approach but has the additional advantage of developing site index estimates that more accurately reflect the actual landbase. The

SIA approach can also be done without a completed PEM or TEM, and can be retrofit in the future if a TEM or PEM is completed.

An additional consideration is that a growth and yield monitoring program is being developed for the Fort St. John TSA. There is the option to use the growth and yield monitoring as a subset of the plots for an SIA project for the TSA.

5) Develop an overall plan to address site productivity issues in the short and longer term. The general issue of site productivity in the TSA is that it includes many related components and impacts many aspects of forest management and planning. Consequently, it is worth considering developing a plan to specifically address these and other related issues. This could be done under a general growth and yield plan, or in a plan that specifically addresses site productivity.

6.4 PLOT SIZE – SAMPLE SIZE FOR ASPEN STANDS

The recommended plot size for coniferous stands (3.99 m radius) is potentially larger than needed for many At stands that may have 200,000 or more stems/ha. Different plot and sample size combinations should be tested at different stand ages to determine optimal procedures.

6.5 DEVELOPMENT OF A MIXED-WOOD G&Y MODEL

The meeting participants generally agreed that a collaborative effort is desired to promote developing a mixed-wood growth model. One of the first strategic decisions is to decide between taking advantage of work already completed and calibrate an existing model (e.g., TASS) or to commit to the substantial work of developing a new model. It is also important to decide on the appropriate scope for collaborative work to ensure that local issues are adequately addressed. Once these decisions are made, a plan to collect the required data can be developed. Again, the proposed growth and yield monitoring plots could provide a portion of the data required for model calibration. Additional data from designed experiments (such as WESBOGY trials) will also be required.

6.6 PMV MODELS FOR OTHER SPECIES

This first approximation of the survey and modeling system addresses only the relatively simple stand types in the area (i.e., Pl, Sx, and PlSx). More work is needed to adapt the system to different stand types to implement the system across the TSA. The meeting participants agreed that initially the focus would be coniferous stands, and that the models developed for Pl and Sx (adapted to different survey and harvest ages) would be appropriate. The following species substitutions could be used in the interim:

1) For Bl use Sx.
2) For Lt use Pl.
3) For Sb use Sx.

In the future, the system should be refined to include projections for coniferous stands, mixed-wood stands (coniferous and deciduous leading), and deciduous stands. High priority species combinations were identified as:

1) At
2) AtSx
3) AtPl
4) PlAt

5) SxAt
6) Ep = At

The largest concern is the lack of a mixed-wood model. The meeting participants agreed there is a need to support mixed-wood modeling.

6.7 PREDICTING FUTURE SPECIES COMPOSITION

Predicting change in species composition was not addressed in this system. Again, the ability to address this issue depends on having a mixed-wood model that has this capability. This is another reason to promote some form of mixed-wood modeling for the area.

APPENDIX I – MODEL FITTING DETAILS

A total of 51,960 (433 TASS runs X 30 surveys X 4 ages) observations were used to fit the equation PMV = a + b*MSQ + c*MSQ^2 (Table 5). Parameters b and c were held constant (at 265.774 and –33.251, respectively) to produce anamorphic curves. A separate intercept (parameter a) was estimated for each species, effective age, and harvest age combination (Table 6).

Table 5. Summary statistics for the fitted model.

Source	Degrees of Freedom	Sum of Squares (m^2)	Mean Square (m)	F value
Intercepts	36	269,782,204	7,493,950	21,506
MSQ	1	71,920,496	71,920,496	206,392
MSQ*MSQ	1	38,969,861	38,969,861	111,833
Error	155842	54,305,691	348	
		R^2 = 0.91	Root MSE = 18.8	

Table 6. Intercept (parameter a) estimates for the equation PMV = a + b*MSQ + c*MSQ^2.

Species Group	Effective Stand Age	Harvest Year 80	90	100
Pl	10	-125.795	-83.818	-47.877
Pl	13	-112.412	-72.415	-37.995
Pl	15	-103.252	-64.571	-31.166
Pl	18	-90.706	-53.625	-22.172
Pl/Sx	10	-117.915	-68.010	-26.232
Pl/Sx	13	-101.912	-54.627	-15.127
Pl/Sx	15	-91.287	-45.669	-7.640
Pl/Sx	18	-76.796	-33.467	2.379
Sx	10	-104.378	-42.623	5.494
Sx	13	-84.540	-26.874	17.499
Sx	15	-71.391	-16.477	25.378
Sx	18	-53.674	-2.759	36.497

APPENDIX II – TABLES TO DETERMINE EFFECTIVE AGE

Table 7. Total height (m) by total age and site index for Pl.[14]

Total	SI										
age	15	16	17	18	19	20	21	22	23	24	25
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6
4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0
5	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.2	1.3	1.4
6	0.9	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8
7	1.2	1.3	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.2
8	1.4	1.5	1.6	1.6	1.8	1.9	2.1	2.3	2.4	2.6	2.8
9	1.6	1.7	1.8	2.0	2.1	2.3	2.5	2.7	3.0	3.2	3.4
10	1.9	2.0	2.1	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.1
11	2.1	2.3	2.5	2.7	2.9	3.2	3.5	3.8	4.1	4.4	4.8
12	2.4	2.6	2.9	3.1	3.4	3.7	4.0	4.4	4.7	5.1	5.4
13	2.7	3.0	3.2	3.5	3.8	4.2	4.6	4.9	5.3	5.7	6.1
14	3.0	3.3	3.6	3.9	4.3	4.7	5.1	5.5	6.0	6.4	6.8
15	3.4	3.7	4.0	4.4	4.8	5.2	5.7	6.1	6.6	7.0	7.5
16	3.7	4.1	4.4	4.8	5.2	5.7	6.2	6.7	7.2	7.7	8.2
17	4.1	4.4	4.8	5.2	5.7	6.2	6.7	7.3	7.8	8.3	8.9
18	4.4	4.8	5.2	5.7	6.2	6.7	7.3	7.8	8.4	9.0	9.5
19	4.7	5.2	5.7	6.1	6.7	7.2	7.8	8.4	9.0	9.6	10.2
20	5.1	5.6	6.1	6.6	7.1	7.7	8.3	8.9	9.6	10.2	10.8
21	5.4	5.9	6.5	7.0	7.6	8.2	8.8	9.5	10.1	10.8	11.5
22	5.8	6.3	6.9	7.4	8.0	8.7	9.4	10.0	10.7	11.4	12.1
23	6.1	6.7	7.3	7.9	8.5	9.2	9.9	10.6	11.3	12.0	12.7
24	6.5	7.0	7.7	8.3	8.9	9.6	10.4	11.1	11.8	12.5	13.3
25	6.8	7.4	8.0	8.7	9.4	10.1	10.8	11.6	12.3	13.1	13.8
26	7.1	7.8	8.4	9.1	9.8	10.6	11.3	12.1	12.8	13.6	14.4
27	7.4	8.1	8.8	9.5	10.2	11.0	11.8	12.5	13.3	14.1	14.9
28	7.8	8.5	9.2	9.9	10.6	11.4	12.2	13.0	13.8	14.6	15.4
29	8.1	8.8	9.5	10.3	11.0	11.9	12.7	13.5	14.3	15.1	16.0
30	8.4	9.1	9.9	10.6	11.4	12.3	13.1	13.9	14.8	15.6	16.5
Years to BH	7.2	6.9	6.6	6.4	6.1	5.8	5.5	5.3	5.1	4.9	4.7

[14] These are the site curves currently used in TASS. They are not in the current versions of Site Tools or Tipsy. The Thrower (1994) and Nigh and Love (1999) Pl curves are spliced together by using the Nigh/Love curve below breast height age 0, the Thrower curve above breast height 2, and linearly interpolating heights between breast height age 0 and 2. Nigh, G.D. 1999. Smoothing top height estimates from two lodgepole pine height models. B.C. Min. For., Res. Br., Victoria, B.C. Ext. Note 30. J.S. Thrower and Associates Ltd. 1994. Revised height-age curves for lodgepole pine and interior spruce in British Columbia. Report to the Res. Br., B.C. Min. For., Victoria, B.C. 27 p.

Table 8. Total height (m) by total age and site index for Sx.[15]

Total Age	SI 15	16	17	18	19	20	21	22	23	24	25
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
5	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5
6	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7
7	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0
8	0.6	0.7	0.7	0.8	0.8	0.8	0.9	1.0	1.1	1.2	1.2
9	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.2	1.3	1.4	1.4
10	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.4	1.5	1.6	1.7
11	1.2	1.3	1.3	1.3	1.3	1.4	1.5	1.6	1.7	1.8	2.0
12	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.8	2.0	2.2	2.4
13	1.4	1.5	1.6	1.7	1.7	1.8	2.0	2.2	2.4	2.6	2.8
14	1.5	1.7	1.8	1.9	1.9	2.0	2.3	2.5	2.7	3.0	3.3
15	1.7	1.8	2.0	2.1	2.2	2.3	2.6	2.9	3.1	3.4	3.7
16	1.9	2.1	2.2	2.4	2.5	2.7	3.0	3.3	3.6	3.9	4.3
17	2.1	2.3	2.5	2.7	2.8	3.0	3.3	3.7	4.0	4.4	4.8
18	2.3	2.5	2.8	3.0	3.1	3.4	3.7	4.1	4.5	4.9	5.3
19	2.5	2.8	3.1	3.3	3.5	3.7	4.2	4.6	5.0	5.4	5.9
20	2.8	3.1	3.4	3.6	3.8	4.1	4.6	5.0	5.5	6.0	6.5
21	3.0	3.3	3.7	4.0	4.2	4.5	5.0	5.5	6.0	6.5	7.0
22	3.3	3.6	4.0	4.3	4.6	5.0	5.5	6.0	6.5	7.1	7.6
23	3.6	3.9	4.3	4.7	5.0	5.4	5.9	6.5	7.0	7.6	8.2
24	3.8	4.2	4.7	5.0	5.4	5.8	6.4	7.0	7.6	8.2	8.8
25	4.1	4.6	5.0	5.4	5.8	6.2	6.8	7.4	8.1	8.7	9.4
26	4.4	4.9	5.3	5.8	6.2	6.7	7.3	7.9	8.6	9.3	9.9
27	4.7	5.2	5.7	6.2	6.6	7.1	7.8	8.4	9.1	9.8	10.5
28	5.0	5.5	6.1	6.5	7.0	7.5	8.2	8.9	9.6	10.4	11.1
29	5.3	5.9	6.4	6.9	7.4	8.0	8.7	9.4	10.2	10.9	11.7
30	5.6	6.2	6.8	7.3	7.8	8.4	9.2	9.9	10.7	11.5	12.2
Years to BH	11.5	11.1	10.7	10.4	10.4	10.2	9.7	9.2	8.9	8.5	8.2

[15] These are the site curves currently used in TASS. They are not in the current versions of Site Tools or Tipsy. These curves result from the splicing together of the juvenile height curves by Nigh and Love (2000) and the height-age curves by Goudie (1984). Nigh, G.D. and B.A. Love. 2000. Juvenile height development in interior spruce stands of British Columbia. West. J. Appl. For. 15: 117-121. Goudie, J.W. 1984. Height growth and site index curves for lodgepole pine and white spruce and interim managed stand yield tables for lodgepole pine in British Columbia. B.C. Min. For., Res. Br. Unpubl. Rep. 75 p.

APPENDIX III – TABLES TO ESTIMATE VOLUME 80, 90, & 100 YEARS POST-HARVEST

The following tables are used to predict future merchantable volumes for site index 20 based on MSQ and effective age values from surveys 15 years post-harvest. In all tables, PMVs for effective ages 10, 13, 15, and 18 were obtained from the fitted equations; all other values were linearly interpolated.

Table 9. Predicted merchantable volumes 80 years post-harvest for pure Pl site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	107	111	116	120	125	129	133	138	142
1.1	126	131	135	140	144	149	153	157	161
1.2	145	150	154	159	163	168	172	176	180
1.3	164	168	172	177	181	186	190	194	199
1.4	181	186	190	194	199	204	208	212	216
1.5	198	203	207	211	216	221	225	229	233
1.6	214	219	223	228	232	237	241	245	249
1.7	230	234	239	243	248	252	257	261	265
1.8	245	249	254	258	263	267	272	276	280
1.9	259	264	268	273	277	282	286	290	294
2.0	273	277	282	286	291	295	299	304	308
2.1	286	290	295	299	304	308	312	317	321
2.2	298	302	307	311	316	321	325	329	333
2.3	310	314	319	323	328	332	336	340	345
2.4	321	325	329	334	338	343	347	351	356
2.5	331	335	340	344	349	353	358	362	366
2.6	340	345	349	354	358	363	367	371	376
2.7	349	354	358	363	367	372	376	380	384
2.8	358	362	367	371	376	380	384	389	393
2.9	365	370	374	379	383	388	392	396	400
3.0	372	377	381	386	390	395	399	403	407
3.1	379	383	387	392	397	401	405	409	414
3.2	384	389	393	398	402	407	411	415	419
3.3	389	394	398	403	407	412	416	420	424
3.4	393	398	402	407	411	416	420	424	429
3.5	397	402	406	410	415	420	424	428	432
3.6	400	405	409	413	418	423	427	431	435
3.7	402	407	411	416	420	425	429	433	437
3.8	404	408	413	417	422	427	431	435	439
3.9	405	409	414	418	423	428	432	436	440
4.0	405	410	414	419	423	428	432	436	440

Table 10. Predicted merchantable volumes 80 years post-harvest for pure Sx site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	128	135	141	148	155	161	167	173	179
1.1	148	154	161	168	174	181	187	193	198
1.2	167	173	180	187	193	200	206	211	217
1.3	185	192	198	205	211	218	224	230	236
1.4	203	209	216	222	229	236	241	247	253
1.5	219	226	233	239	246	252	258	264	270
1.6	236	242	249	256	262	269	275	281	286
1.7	251	258	265	271	278	284	290	296	302
1.8	266	273	280	286	293	299	305	311	317
1.9	281	287	294	300	307	314	319	325	331
2.0	294	301	307	314	321	327	333	339	345
2.1	307	314	320	327	334	340	346	352	358
2.2	319	326	333	339	346	352	358	364	370
2.3	331	338	344	351	357	364	370	376	382
2.4	342	349	355	362	368	375	381	387	393
2.5	352	359	365	372	379	385	391	397	403
2.6	362	368	375	382	388	395	401	407	413
2.7	371	377	384	391	397	404	410	416	422
2.8	379	386	392	399	406	412	418	424	430
2.9	387	393	400	407	413	420	426	432	437
3.0	394	400	407	414	420	427	433	438	444
3.1	400	407	413	420	426	433	439	445	451
3.2	406	412	419	425	432	439	445	450	456
3.3	411	417	424	430	437	444	449	455	461
3.4	415	421	428	435	441	448	454	460	466
3.5	419	425	432	438	445	451	457	463	469
3.6	421	428	435	441	448	454	460	466	472
3.7	424	430	437	444	450	457	463	469	474
3.8	425	432	439	445	452	458	464	470	476
3.9	426	433	440	446	453	459	465	471	477
4.0	427	433	440	447	453	460	466	472	477

Table 11. Predicted merchantable volumes 80 years post-harvest for Pl/Sx site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	115	120	125	131	136	141	146	151	156
1.1	134	140	145	150	156	161	166	170	175
1.2	153	158	164	169	174	180	185	189	194
1.3	171	177	182	187	193	198	203	208	213
1.4	189	194	200	205	210	216	220	225	230
1.5	206	211	217	222	227	233	237	242	247
1.6	222	228	233	238	244	249	254	258	263
1.7	238	243	248	254	259	264	269	274	279
1.8	253	258	263	269	274	279	284	289	294
1.9	267	272	278	283	288	294	298	303	308
2.0	281	286	291	297	302	307	312	317	322
2.1	294	299	304	310	315	320	325	330	335
2.2	306	311	317	322	327	332	337	342	347
2.3	317	323	328	333	339	344	349	354	359
2.4	328	334	339	344	350	355	360	365	370
2.5	339	344	349	355	360	365	370	375	380
2.6	348	354	359	364	370	375	380	385	389
2.7	357	363	368	373	379	384	389	394	398
2.8	366	371	376	382	387	392	397	402	407
2.9	373	379	384	389	395	400	405	409	414
3.0	380	385	391	396	401	407	412	416	421
3.1	386	392	397	402	408	413	418	423	428
3.2	392	397	403	408	413	419	424	428	433
3.3	397	402	408	413	418	424	428	433	438
3.4	401	407	412	417	423	428	433	438	442
3.5	405	410	416	421	426	432	436	441	446
3.6	408	413	419	424	429	435	439	444	449
3.7	410	416	421	426	432	437	442	447	451
3.8	412	417	423	428	433	439	443	448	453
3.9	413	418	424	429	434	439	444	449	454
4.0	413	419	424	429	434	440	445	449	454

Table 12. Predicted merchantable volumes 90 years post-harvest for pure Pl site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	149	153	156	160	164	168	172	175	179
1.1	168	172	176	180	184	188	191	195	198
1.2	187	191	195	199	203	206	210	214	217
1.3	205	209	213	217	221	225	228	232	236
1.4	223	227	231	234	238	242	246	250	253
1.5	240	244	248	251	255	259	263	267	270
1.6	256	260	264	268	272	276	279	283	286
1.7	272	276	280	283	287	291	295	298	302
1.8	287	291	294	298	302	306	310	313	317
1.9	301	305	309	313	316	320	324	328	331
2.0	315	319	322	326	330	334	338	341	345
2.1	328	331	335	339	343	347	351	354	358
2.2	340	344	348	351	355	359	363	366	370
2.3	352	355	359	363	367	371	374	378	382
2.4	363	366	370	374	378	382	385	389	393
2.5	373	377	380	384	388	392	396	399	403
2.6	382	386	390	394	398	402	405	409	413
2.7	391	395	399	403	407	411	414	418	422
2.8	400	403	407	411	415	419	423	426	430
2.9	407	411	415	419	423	427	430	434	437
3.0	414	418	422	426	430	433	437	441	444
3.1	421	424	428	432	436	440	443	447	451
3.2	426	430	434	438	441	445	449	453	456
3.3	431	435	439	443	446	450	454	458	461
3.4	435	439	443	447	451	455	458	462	466
3.5	439	443	447	450	454	458	462	466	469
3.6	442	446	450	453	457	461	465	469	472
3.7	444	448	452	456	460	464	467	471	475
3.8	446	450	454	457	461	465	469	473	476
3.9	447	451	455	458	462	466	470	473	477
4.0	447	451	455	459	463	467	470	474	477

Table 13. Predicted merchantable volumes 90 years post-harvest for pure Sx site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	190	195	200	206	211	216	221	225	230
1.1	209	215	220	225	230	236	240	245	249
1.2	228	234	239	244	249	255	259	264	268
1.3	247	252	257	262	268	273	277	282	287
1.4	264	270	275	280	285	290	295	300	304
1.5	281	286	292	297	302	307	312	317	321
1.6	297	303	308	313	318	324	328	333	337
1.7	313	318	324	329	334	339	344	348	353
1.8	328	333	339	344	349	354	359	363	368
1.9	342	348	353	358	363	368	373	378	382
2.0	356	361	366	372	377	382	387	391	396
2.1	369	374	379	385	390	395	400	404	409
2.2	381	386	392	397	402	407	412	416	421
2.3	393	398	403	409	414	419	423	428	433
2.4	404	409	414	419	425	430	434	439	444
2.5	414	419	424	430	435	440	445	449	454
2.6	424	429	434	439	445	450	454	459	463
2.7	433	438	443	448	454	459	463	468	472
2.8	441	446	451	457	462	467	472	476	481
2.9	448	454	459	464	469	475	479	484	488
3.0	455	461	466	471	476	482	486	491	495
3.1	462	467	472	477	483	488	492	497	502
3.2	467	473	478	483	488	494	498	503	507
3.3	472	478	483	488	493	498	503	508	512
3.4	477	482	487	492	498	503	507	512	516
3.5	480	486	491	496	501	506	511	516	520
3.6	483	488	494	499	504	509	514	519	523
3.7	486	491	496	501	506	512	516	521	525
3.8	487	492	498	503	508	513	518	522	527
3.9	488	493	499	504	509	514	519	523	528
4.0	488	494	499	504	509	515	519	524	528

Table 14. Predicted merchantable volumes 90 years post-harvest for Pl/Sx site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	165	169	173	178	182	187	191	195	199
1.1	184	189	193	197	202	206	211	215	219
1.2	203	207	212	216	221	225	229	234	238
1.3	221	226	230	235	239	244	248	252	256
1.4	239	243	248	252	257	261	265	269	273
1.5	256	260	265	269	274	278	282	286	290
1.6	272	277	281	285	290	294	299	303	307
1.7	288	292	297	301	306	310	314	318	322
1.8	303	307	312	316	321	325	329	333	337
1.9	317	321	326	330	335	339	343	347	351
2.0	331	335	339	344	348	353	357	361	365
2.1	343	348	352	357	361	366	370	374	378
2.2	356	360	365	369	374	378	382	386	390
2.3	367	372	376	381	385	390	394	398	402
2.4	378	383	387	392	396	401	405	409	413
2.5	389	393	398	402	406	411	415	419	423
2.6	398	403	407	412	416	421	425	429	433
2.7	407	412	416	421	425	430	434	438	442
2.8	415	420	424	429	433	438	442	446	450
2.9	423	428	432	436	441	445	450	454	458
3.0	430	435	439	443	448	452	456	461	465
3.1	436	441	445	450	454	459	463	467	471
3.2	442	446	451	455	460	464	468	472	477
3.3	447	451	456	460	465	469	473	477	481
3.4	451	456	460	465	469	474	478	482	486
3.5	455	459	464	468	473	477	481	485	489
3.6	458	462	467	471	476	480	484	488	492
3.7	460	465	469	474	478	482	487	491	495
3.8	462	466	471	475	480	484	488	492	496
3.9	463	467	472	476	481	485	489	493	497
4.0	463	468	472	476	481	485	489	494	498

Table 15. Predicted merchantable volumes 100 years post-harvest for pure Pl site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	185	188	191	195	198	201	204	207	210
1.1	204	208	211	214	218	221	224	227	230
1.2	223	226	230	233	236	240	243	246	249
1.3	241	245	248	251	255	258	261	264	267
1.4	259	262	266	269	272	276	279	282	285
1.5	276	279	283	286	289	293	296	299	302
1.6	292	296	299	302	306	309	312	315	318
1.7	308	311	314	318	321	325	328	331	334
1.8	323	326	329	333	336	339	342	345	348
1.9	337	340	344	347	350	354	357	360	363
2.0	351	354	357	361	364	367	370	373	376
2.1	364	367	370	373	377	380	383	386	389
2.2	376	379	382	386	389	393	396	399	402
2.3	388	391	394	397	401	404	407	410	413
2.4	398	402	405	408	412	415	418	421	424
2.5	409	412	415	419	422	425	428	431	434
2.6	418	422	425	428	432	435	438	441	444
2.7	427	431	434	437	441	444	447	450	453
2.8	436	439	442	445	449	452	455	458	461
2.9	443	447	450	453	457	460	463	466	469
3.0	450	453	457	460	463	467	470	473	476
3.1	456	460	463	466	470	473	476	479	482
3.2	462	465	469	472	475	479	482	485	488
3.3	467	470	474	477	480	484	487	490	493
3.4	471	475	478	481	485	488	491	494	497
3.5	475	478	482	485	488	492	495	498	501
3.6	478	481	485	488	491	495	498	501	504
3.7	480	484	487	490	494	497	500	503	506
3.8	482	485	489	492	495	499	502	505	508
3.9	483	486	489	493	496	500	503	506	509
4.0	483	486	490	493	497	500	503	506	509

Table 16. Predicted merchantable volumes 100 years post-harvest for pure Sx site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	238	242	246	250	254	258	262	265	269
1.1	258	262	266	270	274	277	281	285	289
1.2	277	281	285	289	292	296	300	304	308
1.3	295	299	303	307	311	315	318	322	326
1.4	312	316	320	324	328	332	336	340	343
1.5	329	333	337	341	345	349	353	357	360
1.6	346	350	354	358	362	365	369	373	377
1.7	361	365	369	373	377	381	385	389	392
1.8	376	380	384	388	392	396	400	403	407
1.9	390	394	398	402	406	410	414	418	421
2.0	404	408	412	416	420	424	428	431	435
2.1	417	421	425	429	433	437	441	444	448
2.2	429	433	437	441	445	449	453	457	460
2.3	441	445	449	453	457	461	464	468	472
2.4	452	456	460	464	468	472	475	479	483
2.5	462	466	470	474	478	482	486	489	493
2.6	472	476	480	484	488	492	495	499	503
2.7	481	485	489	493	497	501	504	508	512
2.8	489	493	497	501	505	509	513	516	520
2.9	497	501	505	509	513	516	520	524	528
3.0	504	508	512	516	520	523	527	531	535
3.1	510	514	518	522	526	530	533	537	541
3.2	515	519	523	527	531	535	539	543	546
3.3	520	524	528	532	536	540	544	548	551
3.4	525	529	533	537	541	545	548	552	556
3.5	528	532	536	540	544	548	552	556	559
3.6	531	535	539	543	547	551	555	559	562
3.7	534	538	542	546	550	554	557	561	565
3.8	535	539	543	547	551	555	559	563	566
3.9	536	540	544	548	552	556	560	564	567
4.0	537	541	545	549	553	556	560	564	568

Table 17. Predicted merchantable volumes 100 years post-harvest for Pl/Sx site index 20 stands.

	Effective Total Age								
MSQ	10	11	12	13	14	15	16	17	18
1.0	206	210	214	217	221	225	228	232	235
1.1	226	230	233	237	241	244	248	251	254
1.2	245	249	252	256	260	263	267	270	273
1.3	263	267	270	274	278	282	285	288	292
1.4	281	284	288	292	296	299	303	306	309
1.5	298	301	305	309	312	316	320	323	326
1.6	314	318	321	325	329	332	336	339	342
1.7	329	333	337	341	344	348	351	355	358
1.8	344	348	352	356	359	363	366	370	373
1.9	359	362	366	370	374	377	381	384	387
2.0	372	376	380	383	387	391	394	398	401
2.1	385	389	393	396	400	404	407	411	414
2.2	398	401	405	409	412	416	419	423	426
2.3	409	413	417	420	424	428	431	434	438
2.4	420	424	428	431	435	439	442	445	449
2.5	430	434	438	441	445	449	452	456	459
2.6	440	444	447	451	455	459	462	465	469
2.7	449	453	456	460	464	468	471	474	478
2.8	457	461	465	468	472	476	479	483	486
2.9	465	469	472	476	480	483	487	490	493
3.0	472	476	479	483	487	490	494	497	500
3.1	478	482	486	489	493	497	500	503	507
3.2	484	487	491	495	499	502	506	509	512
3.3	489	492	496	500	504	507	511	514	517
3.4	493	497	500	504	508	512	515	518	522
3.5	497	500	504	508	512	515	519	522	525
3.6	500	503	507	511	514	518	522	525	528
3.7	502	506	509	513	517	521	524	527	531
3.8	504	507	511	515	518	522	525	529	532
3.9	505	508	512	516	519	523	526	530	533
4.0	505	509	512	516	520	523	527	530	533

APPENDIX IV - EXAMPLE CALCULATION

Introduction

This example is based on data collected on four blocks in the Fort St. John TSA in August 2002. It follows the procedures outlined in Section 4 assuming:

1) The four blocks represent the target population.
2) Target stocking standard was 1,200 for all blocks.
3) Blocks were surveyed 15 years after harvest. In reality, not all blocks were surveyed 15 years after harvest so adjustments had to be made to crop tree heights. For example, if a block was actually surveyed 13 years after harvest, two years average crop tree leader growth was added to average crop tree height to approximate crop tree height 15 years after harvest. It was assumed that MSQ would be the same 15 years after harvest as at the time of the survey.
4) Different site index values than those recorded in the surveys. The site index values recorded in the surveys are based on SIBEC data and in comparison to the crop tree heights and ages for most blocks appear low. New site index values were chosen for this example to approximate site indices closer to the true values.[16]

Choose a Post-harvest Age for PMV

For this example 90 was chosen as the target post-harvest age.

Post-Stratify the Surveyed Area

Three strata were identified based on species, site index, SR versus NSR, and TSS (Table 18)

Table 18. Description and stratification of Fort St. John blocks surveyed in August 2002.

CP/Block	Inventory label[a]	Area (ha)	Stratum Species	Stratum Site index	Stratum SR/NSR	Stratum TSS
306-2	Pli9Bl1-11-2.2-15-7-4233/1	19.9	Pl	15	SR	1,200
111-3	Sx10-13-2.8-15-6-1870/1	16.6	Sx	20	SR	1,200
111-4	Sx9Pli1-13-2.6-15-5-3021/1	16.8	Sx	20	SR	1,200
306-2	Sx7Bl2Pli1-12-2.1-15-6-5200/1	29.8	Sx	20	SR	1,200
304-6	Sx10-14-3.1-18-6-1539/1	57.4	Sx	22	SR	1,200

[a] Inventory label, including SIBEC based site index from actual survey data. Site index values listed under Stratum are approximate site indices based on height and age data.

[16] In future surveys it is recommended that growth intercept equations be used to determine site indices rather than SIBEC estimates.

Determine Effective Age, MSQ, and PMV

All of the survey plots were assigned to one of the three strata, and stratum average crop tree heights and mean stocked quadrants were calculated. The average crop tree height and site index were then used to determine the effective age using one of the tables in Appendix II. The effective age and MSQ are then used to determine PMV for site index 20 using one of the tables from Appendix III. Finally, the site index 20 PMV is adjusted to reflect the site index for the stratum (Table 19).

Table 19. Calculated effective ages, MSQs and PMVs for each stratum.

Species	Stratum Site index	SR/NSR	TSS	Avg Site Tree Ht	Effective Age	MSQ	PMV_{20} (m^3/ha)	Site index Adjustment	PMV (m^3/ha)
Pl	15	SR	1,200	3.0	14	4.0	463	0.6	278
Sx	20	SR	1,200	3.2	17	4.0	524	1.0	524
Sx	22	SR	1,200	3.1	15	4.0	515	1.2	618

Compare PMVs and TMVs

For this example TMVs were determined by:

1) Determining the PMV for MSQ = 4.0, effective age = 17, and site index = 20.
2) Multiplying the PMV from step 1 by 0.9 and by the appropriate site index adjustment for the stratum.

In this example, the total predicted merchantable volume exceeds the target by 6,736 m^3 or 48 m^3/ha (Table 20).

Table 20. PMVs and TMVs for each stratum and the population totals.

Species	Stratum Site index	SR/NSR	TSS	PMV (m^3/ha)	TMV (m^3/ha)	Area (ha)	PMV (m^3)	TMV (m^3)
Pl	15	SR	1,200	278	256	19.9	5,528	5,094
Sx	20	SR	1,200	524	472	63.2	33,117	29,805
Sx	22	SR	1,200	618	566	57.4	35,473	32,484
Total						*140.5*	*74,118*	*67,383*

Appendix 8: Noxious Weeds

Noxious Weeds

Prohibited Noxious Weeds

Must be eradicated. This entails destruction of all reproductive parts; therefore stops the ability to spread. These weeds possess highly competitive characteristics, inherent means for rapid spread, and may pose difficulties for control. These weeds are known to be very serious problems in other countries or provinces, but are not well established here.

Common Crupina (*Crupina vulgaris*)
Diffuse Knapweed (*Centaurea diffusa*)
Dodder (*Cuscuta spp*.)
Hound's-tongue (*Cynoglossum officinale*)
Giant Burdock (*Arctium spp*.)
Jointed Goatgrass (*Aegilops cylindrica*)
Leafy Spurge (*Euphorbia esula*)
Rush Skeletonweed (*Chondrilla juncea*)
Spotted Knapaweed (*Centaurea maculosa*)
Tansy Ragwort (*Senecio jacobaea*)
Velvetleaf (*Abutilon theophrasti*)
Yellow Starthistle (*Centaurea solstitialis*)
Green Foxtail (*Setaria viridis*)
Kochia (*Kochia scoparia*)
Oxcyc Daisy (*Chrysanthemum leucanthemum*)
Tartary Buckwheat (*Fagopyrum tataricum*)
Russian Thistle (*Salsola kali*)
Marsh Plume Thistle *(Cirsium palustre)*

Primary Noxious Weeds

Must be controlled. While this does not entail eradication, weeds in this category must be prevented from forming viable seed. These weeds have the potential to spread rapidly and cause major crop losses.

Canada Thistle (*Cirsium arvense*)
Perennial Sow Thistle (*Sonchus arvensis*)
Common Toadflax (*Linaria vulgaris*)
Dalmation Toadflax (*Linaria dalmatica*)
Scentless Chamomile (*Mairicaria maritima*)
Annual Sow Thistle (*Sonchus oleraceus*)
Wild Mustard (*Sinapsis arvensis*)
Nightflowering Catchfly (*Silene noctiflora*)
White Cockle (*Lychnis alba*)

Invasive Species of Concern

Orange Hawkweed (*Hieracium aurantiaeum*)
Cypress Spurge (*Euphorbia cyparissias*)

Other invasive plants may be added to this list as made know by the District Manager.

Appendix 9: List of Species at Risk – Fort St. John Forest District

Latin Name	Common Name	Global Rank	Regional Rank	COSEWIC Status	Provincial Listing	IWMS Species
BIRDS						
Accipiter gentilis atricapillus	Northern Goshawk	G5	S4B,S4N	None	YELLOW	Yes (Vol. 1)
Ammodramus leconteii	Le Conte's Sparrow	G4	S3S4B,SZN	None	BLUE	No
Ammodramus nelsoni	Nelson's Sharp-tailed Sparrow	G5	S2B,SZN	Not At Risk (1998)	RED	Yes (Vol. 2)
Ardea herodias herodias	Great Blue Heron (interior subspecies)	G5T5	S3B,S1N	None	BLUE	Yes (Vol. 2)
Asio flammeus	Short-eared Owl	G5	S3B,S2N	Special Concern (1994)	BLUE	Yes (Vol. 2)
Bartramia longicauda	Upland Sandpiper	G5	S1S3B,SZN	None	RED	No
Botaurus lentiginosus	American Bittern	G4	S3B,SZN	None	BLUE	Yes (Vol. 1)
Buteo platypterus	Broad-winged Hawk	G5	S2S3B,SZN	None	BLUE	No
Coturnicops noveboracensis	Yellow Rail	G4	SA	Special Concern (NOV 2001)	ACCIDENTAL	No
Cygnus buccinator	Trumpeter Swan	G4	S3S4B,S4N	Not At Risk (1996)	BLUE	Yes (Vol. 1)
Dendroica castanea	Bay-breasted Warbler	G5	S2B,SZN	None	RED	Yes (Vol. 2)
Dendroica tigrina	Cape May Warbler	G5	S2B,SZN	None	RED	Yes (Vol. 2)
Dendroica virens	Black-throated Green Warbler	G5	S3B,SZN	None	BLUE	Yes (Vol. 2)
Dolichonyx oryzivorus	Bobolink	G5	S3B,SZN	None	BLUE	Yes (Vol. 1)
Grus americana	Whooping Crane	G1	SA	Endangered(Nov 2000)	ACCIDENTAL	No
Grus canadensis	Sandhill Crane	G5	S3S4B,SZN	Not At Risk (1979) G. canadensis tabida assessed	BLUE	Yes (Vol. 1 & 2)
Melanitta perspicillata	Surf Scoter	G5	S3B,S4N	None	BLUE	No
Oporornis agilis	Connecticut Warbler	G4	S2B,SZN	None	RED	Yes (Vol. 2)
Vireo philadelphicus	Philadelphia Vireo	G5	S3S4B	None	BLUE	No
Wilsonia canadensis	Canada Warbler	G5	S3S4B	None	BLUE	No

Latin Name	Common Name	Global Rank	Regional Rank	COSEWIC Status	Provincial Listing	IWMS Species
MAMMALS						
Bison bison bison	Plains Bison	G4TU	S3	None	BLUE	No
Gulo gulo luscus	Wolverine, *luscus* subspecies	G4T4	S3	Special Concern (1989) western population only	BLUE	Yes (Vol. 2)
Martes pennanti	Fisher	G5	S2	None	RED	Yes (Vol. 1)
Myotis septentrionalis	Northern Long-eared Myotis	G4	S2S3	None	BLUE	No
Ovis canadensis	Bighorn Sheep	G4G5	S2S3	None	BLUE	Yes (Vol. 2)
Rangifer tarandus pop. 14	Caribou (boreal population)	G5T?	S3	Threatened (MAY 2002)	BLUE	No
Rangifer tarandus pop. 15	Caribou (northern mountain population)	G5T4	S3S4	Special Concern (MAY 2002)	BLUE	Yes (Vol. 2)
Ursus arctos	Grizzly Bear	G4	S3	Special Concern (MAY 2002)	BLUE	Yes (Vol. 1)
FISH						
Hiodon alosoides	Goldeye	G5	S3S4	None	BLUE	No
Notropis hudsonius	Spottail Shiner	G5	S1S2SE	None	RED	No
Salvelinus confluentus	Bull Trout	G3	S3	None	BLUE	Yes (Vol. 1)
PLANTS						
Alopecurus alpinus	alpine meadow-foxtail	G5	S2S3	None	BLUE	No
Anemone canadensis	Canada anemone	G5	S2S3	None	BLUE	No
Arnica chamissonis ssp. *incana*	meadow arnica	G5T?	S2S3	None	BLUE	No
Artemisia longifolia	long-leaved mugwort	G5	S2	None	RED	No
Atriplex nuttallii	Nuttall's orache	G5	S1	None	RED	No
Calamagrostis montanensis	plains reedgrass	G5	S1	None	RED	No
Carex bicolor	two-coloured sedge	G5	S2S3	None	BLUE	No
Carex misandra	short-leaved sedge	G5	S2S3	None	BLUE	No
Carex rupestris ssp. *rupestris*	curly sedge	G5T?	S2S3	None	BLUE	No
Carex torreyi	Torrey's sedge	G4	S2S3	None	BLUE	No
Carex xerantica	dry-land sedge	G5	S2S3	None	BLUE	No
Draba glabella var. *glabella*	smooth draba	G4G5T4	S2S3	None	BLUE	No

Latin Name	Common Name	Global Rank	Regional Rank	COSEWIC Status	Provincial Listing	IWMS Species
Draba lactea	milky draba	G4	S2S3	None	BLUE	No
Draba porsildii	Porsild's draba	G3G4	S2S3	None	BLUE	No
Epilobium hornemannii ssp. *behringianum*	Hornemann's willowherb	G5T4	S2S3	None	BLUE	No
Epilobium leptocarpum	small-fruited willowherb	G5	S2S3	None	BLUE	No
Eriophorum vaginatum ssp. *vaginatum*	sheathed cotton-grass	G5T?	S3	None	BLUE	No
Glyceria pulchella	slender mannagrass	G5	S2S3	None	BLUE	No
Gymnocarpium jessoense ssp. *parvulum*	Nahanni oak fern	G5T4	S2S3	None	BLUE	No
Helictotrichon hookeri	spike-oat	G5	S2S3	None	BLUE	No
Juncus arcticus ssp. *alaskanus*	arctic rush	G5T?	S2S3	None	BLUE	No
Lomatium foeniculaceum var. *foeniculaceum*	fennel-leaved desert-parsley	G5T5	S1	None	RED	No
Lomatogonium rotatum	marsh felwort	G5	S2S3	None	BLUE	No
Luzula nivalis	arctic wood-rush	G5	S2S3	None	BLUE	No
Luzula rufescens	rusty wood-rush	G5	S2S3	None	BLUE	No
Minuartia austromontana	Rocky Mountain sandwort	G4	S2S3	None	BLUE	No
Oxytropis jordalii ssp. *davisii*	Davis' locoweed	G4T3	S3	None	BLUE	No
Pedicularis parviflora ssp. *parviflora*	small-flowered lousewort	G4T4	S3	None	BLUE	No
Penstemon gracilis	slender penstemon	G5	S2	None	RED	No
Polemonium boreale	northern Jacob's-ladder	G5	S2S3	None	BLUE	No
Polemonium occidentale ssp. *occidentale*	western Jacob's-ladder	G5?T5?	S2S3	None	BLUE	No
Polygala senega	Seneca-snakeroot	G4G5	S1	None	RED	No
Polypodium sibiricum	Siberian polypody	G5?	SH	None	RED	No
Ranunculus pedatifidus ssp. *affinis*	birdfoot buttercup	G5T5	S2S3	None	BLUE	No
Ranunculus rhomboideus	prairie buttercup	G4	S1	None	RED	No
Rosa arkansana var. *arkansana*	Arkansas rose	G5T4T5	S2S3	None	BLUE	No

Latin Name	**Common Name**	**Global Rank**	**Regional Rank**	**COSEWIC Status**	**Provincial Listing**	**IWMS Species**
Rumex paucifolius	alpine sorrel	G4	S2S3	None	BLUE	No
Salix petiolaris	meadow willow	G5	S2S3	None	BLUE	No
Selaginella rupestris	rock selaginella	G5	S1	None	RED	No
Senecio plattensis	plains butterweed	G5	S2S3	None	BLUE	No
Silene drummondii var. *drummondii*	Drummond's campion	G5T5	S3	None	BLUE	No
Silene taimyrensis	Taimyr campion	G4?	S2S3	None	BLUE	No
Solidago nemoralis ssp. *longipetiolata*	field goldenrod	G5T5	S2S3	None	BLUE	No

***G** = global **N** = national **S** = provincial*
1 = critically imperiled
2 = imperiled
3 = vulnerable
4 = apparently scarce
5 = secure
? = unranked
U = unrankable (due to lack of information)

Appendix 10: Criteria For Establishing Areas For Protection

CRITERIA FOR ESTABLISHING AREAS FOR PROTECTION

Ecological Reserves

Definition: Ecological reserves are areas selected to preserve representative and special natural ecosystems, plant and animal species, features and phenomena. Scientific research and educational purposes are the principle uses of ecological reserves.

Benefits:

- Maintenance of biological diversity
- Provide outdoor laboratories and classrooms for studies
- Benchmarks against which environmental changes can be measured

Criteria for Establishing Ecological Reserves:

Prior to 1990:

- Members of the public submitted proposals for ecological reserves to BC Parks for review and consideration of significance of the proposed area under the Ecological Reserve program.
- A multi-agency review occurred to ensure no land-use conflicts.
- If there were no land-use conflicts, then the proposed area was designated by provincial order-in-council under the Ecological Reserves Act. Once designated the land is legally and permanently set aside to serve their intended long-term function.

1990 and Beyond:

- The LRMP process in British Columbia was used to determine land-use designations over set geographical areas. The selection and designation of protected areas and the type of designation that they would receive (i.e. Park, Ecological Reserve or Protected Area) was included in this process.
- The Lieutenant Governor in Council may, by order, establish the proposed area(s) as an ecological reserve.

Refer to website for more information:
http://wlapwww.gov.bc.ca/bcparks/eco_reserve/ecoresrv/ecoresrv.htm

Wildlife Habitat Areas (WHA's)

The following information was taken from the above sources and should be referenced if used in the SFMP. Please note that Version 2 of the *Identified Wildlife Management Strategy* is currently in publication and will be released shortly. This version will likely include modifications to the process outlined below.

Definition: *Wildlife Habitat Areas* are mapped areas of habitat which are biologically limiting to a species or are remaining examples of identified plant communities. They are established to protect critical habitat elements for one or more species of Identified Wildlife. *Identified Wildlife* are considered to be sensitive to habitat alteration associated with forest and range practices and are considered to be at risk (i.e. endangered, threatened, vulnerable, or regionally important).

Benefits:

- Preservation of elements of biodiversity that are not addressed through other components of the Forest Practices Code.
- Protection of known occurrences of Identified Wildlife species and their critical habitat.
- An important component of the province's commitment to meeting the *National Accord for the Protection of Species at Risk.*

Criteria for Establishing Wildlife Habitat Areas (9 steps):

1) Site is proposed: A WHA proposal is submitted to the Regional Rare and Endangered Species Biologist (RES, or designate) of MWLAP for review and consideration. Any person or organization can propose a site.
2) Initial biological review: The RES reviews the proposal, ensuring that it meets the biological criteria for the species or plant community in question. Indications of occupancy by the species, presence of the habitat feature, and/or suitability of the habitat must be confirmed. Species most at risk and the most beneficial locations from a conservation biology perspective are first priority. Proposals that survive this evaluation proceed to the next step.
3) Mapping draft boundaries, consultation and review: The Regional WHA Committee coordinates review, consultation, and mapping of draft boundaries. Criteria used for selecting the site and designing the boundary will include ecological considerations, operational feasibility, windfirmness and other standard boundary criteria.
4) Preparation of map and documentation: Data forms and maps are assembled and documentation is sent to the WHA Technical Committee.
5) Review by WHA Technical Committee: Proposal is evaluated in terms of the conservation of the species, socio-economic impacts, and cumulative impacts.
6) Decision is made: The Chief Forester and Deputy Minister of Water, Lands and Parks (or designate) will make a decision about the proposed WHA.
7) Notice of decision and impact tracking: Proponents, tenure holders, and regional agencies are notified of the decision, and approved WHA's are published in the B.C. Gazette.
8) Final mapping: Maps are digitized.
9) Add boundaries to district and regional maps.

Refer to the *Identified Wildlife Management Strategy Volume 1* (February 1999) or the website for more information: http://wlapwww.gov.bc.ca/wld/identified/index.htm

Ungulate Winter Range

Definition (from extracts of the FPC, OPR): Ungulate Winter Range means an area that is identified as being necessary for the winter survival of an ungulate species by any of the following:

a) A higher level plan;
b) The Chief Forester and Deputy Minister of Environment, Lands and Parks under section 69;

c) A wildlife management plan or strategy approved before October 15, 1998
   i. by
      a) The District Manager or Regional Manager, and
      b) The Designated Environment Official
   ii. by the Chief Forester, or
   iii. by the ministers,

but a wildlife management plan or strategy approved under this paragraph expires on October 15, 2003, unless
   i. modified under paragraphs a) or b), or
   ii. confirmed before that date under section 69

Biological Principles behind establishment of UWR (not all inclusive):

- should be well distributed across the range of the species, so local populations are not extirpated,
- should provide areas of habitat that will sustain sufficient numbers of the ungulate species through severe winter conditions that local populations will be able to quickly recover, and
- should be located on sites that show evidence of high winter range value for the locality, as determined by evidence of past use or by topographic and vegetative characteristics defined for the locality by experienced biologists.

Ungulate Winter Range Criteria

To be acceptable as an ungulate winter range the mapped area must meet at least one of the following criteria:

- a combination of topographic and vegetative features defining high-quality winter range as appropriate for the species and the locality, as determined by regional wildlife or habitat staff of MELP;
- a documented history of winter use, as determined by regional wildlife or habitat staff of MELP; or
- in localities that are regularly occupied by an ungulate species during the winter but that do not have sufficient high-quality winter range as defined under point 1 above, a combination of topographic and vegetative features that provide the most suitable habitat for winter range.

Typical topographic and vegetative features to be used in delineating winter ranges are:
- slope
- aspect
- elevation
- topographic shading
- presence of rock outcrops or cliffs
- forest cover type (species composition, height, age, volume or basal area, canopy closure or overstorey)
- species composition and abundance of understorey vegetation
- species composition and abundance of arboreal and terrestrial lichens
- stand heterogeneity
- size and configuration of area

- adjacency of other important habitats such as early winter and spring ranges
- proximity to other winter ranges

Reference:

Memorandum of Understanding (between the Ministry of Forests and the Ministry of Environment, Lands and Parks) on Confirmation and Establishment of Ungulate Winter Ranges previously included in Timber Supply Reviews (May 11, 2000

Appendix 11: Procedure for Selecting Sample Trees in Operational Cruising for Use in Site Index Calculations

Procedure for Selecting Sample Trees in Operational Cruising for Use in Site Index Calculations

Cruiser must first determine the leading species in the plot based on live basal area. In variable radius (prism) plots this can easily be done by determining the species with the highest live stem count as each tree represents equal basal area. In fixed area plots leading species can be approximated by a live stem count in the field as well (has been shown to be accurate 90% of the time).

Once leading species has been determined, select the largest diameter, live, leading species tree within a 0.01 ha area (5.64m radius plot). This tree must be suitable to use as a height and age sample. If the selected tree is not suitable, use the 2nd largest diameter, live, leading species tree within the 0.01 ha area.

Examples of trees that are not suitable for height samples include:

- broken top
- significant dead top
- fork or crook that significantly affects height growth
- abnormally high amount of scarring or other damage that may have affected height growth (small to moderate scarring is still suitable to use as a sample)

Examples of trees that are not suitable for age samples include:

- rotten cores
- residual trees (Mature veterans in an immature stand - please note these trees should still be recorded as TC 5's on the cruise card)

In situations where there is a secondary coniferous species that contributes greater than or equal to 20% of the basal area in an individual plot, the above procedures should be repeated for the secondary coniferous species as well.

All sample tree information (both leading and secondary species information) must be keypunched into the Card Type 3 in the compilation program.

If there are no trees within the 5.64m radius plot, select the most suitable tree (following the standards listed above) within the cruise plot as the sample tree to determine the Maturity Class for the plot for use in the appraisal cruise. **Sample trees taken from outside the 5.64 m radius must not be keypunched** in the Card Type 3 in the compilation program.

Appendix 12: Stream Crossings and Seasonal Bridge Installation and Removal Procedures

GUIDELINES FOR
STREAM CROSSINGS AND
SEASONAL BRIDGE INSTALLATION AND REMOVAL

Purpose:

The intent of this document is to provide operators with best management practices for various options pertaining to stream crossings, culvert installations and temporary bridge installation, for fish bearing and non-fish bearing streams. The supervisor or equipment operator will make the decision on what crossing method is appropriate based on the site specific conditions and timing, while keeping the main objectives in mind.

It is the proponent's responsibility to identify concerns regarding fish and fish habitat and refer these to the appropriate authority.

Objectives:

- Minimize impact to stream bank integrity by utilizing the least impact stream crossing structure, when feasible, and to implement bank stabilization countermeasures where necessary. This would include, riprap, straw matting, grass seeding, etc.
- Maintain fish passage.
- Minimize the risk of damage to fish and fish habitat.
- Maintain water quality by preventing the introduction of sediment and other deleterious material into the stream.

The following are suggested construction methods, winter and summer stream crossing planning matrix and other guidelines that are associated with stream crossings.

CLASS:	**Seasonal**
TYPE:	Single span, steel stringer
STREAM CLASS:	S2 to S6 (see *Summer and Winter Stream Crossing Approval Matrices*)
ABUTMENTS:	Log (minimum diameter 300 mm) or timber (minimum 200 mm X 200 mm)

Where necessary, an area will be leveled-off on the stream bank to accommodate sills. Log cribbing may also be used to supplement abutments where leveling is required.

Abutment walls (where appropriate, lined with geotextile fabric) will be erected to prevent approach fills from sloughing into streams.

Bridge Installation:

(See diagram showing placement and removal.) The fording of the stream by heavy equipment to facilitate bridge placement will be minimized (generally, no more than two crossings). Access to the stream will protect stream bank integrity and not initiate or cause erosion. An excavator may be used to construct access trails through riparian areas and down stream banks provided equipment is operated from the banks.

Seasonal winter bridges may be installed anytime after freeze-up, generally no earlier than October 15th in any year.

All seasonal summer bridges may be installed after the spring freshet. Fording of the stream by heavy equipment to facilitate bridge construction will be restricted to the timing window identified in this document for all streams S1 through S4 (inclusive) without prior approval by MWLAP. **Fording of these streams outside the window will require notification to MWLAP.**

Bridge Removal:

The fording of the stream by heavy equipment to facilitate bridge removal will be minimized (generally, no more than two crossings). Deactivation of approaches will involve re-contouring stream banks to their pre-construction condition (as appropriate) to prevent erosion and seeding with appropriate vegetation (any disturbed areas). All excavated material and debris from the site will be placed in a stable area above the normal high water mark and protected from erosion.

Seasonal winter bridges will be removed by the first day of spring freshet, usually no later than March 15th in any year. Extensions to this date may be approved by MWLAP upon application.

Seasonal summer bridges will be removed as soon as possible. Fording of the stream by heavy equipment to facilitate bridge removal will be restricted to the timing window identified in this document for all streams S1 through S4 (inclusive) without prior approval by MWLAP. If not threatened by higher flows, and if still required, seasonal bridges may stay in place for the winter. They will be removed by the first day of spring freshet, usually no later than March 15th in any year without consulting MWLAP. Extensions to this date may occur but will be dependent on site-specific conditions that may vary year to year.

General Seasonal Bridge Environmental Protection Measures:

- Seasonal winter bridges will clearly span the stream channel, or as otherwise approved by the appropriate authority.
- Seasonal summer bridges will clearly span the stream channel with provisions for somewhat higher than normal flows and debris.
- Bridge approaches will not enter the stream channel of the stream without approval from the appropriate authority. Monitoring of weather conditions and associated stream flows will be ongoing with provisions in place for timely removal of the bridge span, abutments (sills) and approach fills prior to high water stream flow events.
- Seasonal bridges will be adequately supported so that the stream banks are protected.
- Any rock used as riprap will be clean (free of fines and dirt), durable, angular in shape and suitably graded and sized to resist movement by stream flows. Riprap placement will not adversely impact fish, fish habitat, or fish passage.
- Seasonal bridge construction and removal will be accomplished in a manner that does not cause stream bank erosion or contribute silt or dirt to the stream.

Stream Crossing Planning and Methodology:

- Notification of the proposed location and construction of a bridge or major culvert will be by way of forest development plans, forest operation schedule, site level plan, road authorization, and/or specific notifications to MWLAP.
- Participants will plan and construct stream crossings using the *Summer and Winter Stream Crossing Planning Matrices* (attached.) as a guide. Stream crossings qualified by a "maybe" will be applied where site conditions permit and where the stated objectives can be met. Alternate proposals and/or measures proposed by Participants will be considered where specifically proposed.
- Minimum culvert (CMP or steel pipe) diameters installed will be 400 mm.
- Where other appropriate alternatives exist (e.g. as per the *Summer and Winter Stream Crossing Planning Matrices*), culverts will not be installed in streams classed S1 through S3, inclusive.
- Instream work required to install bridges or culverts on S1 through S4 streams will be restricted to the *Least Risk Instream Work Windows* for resident fish species in streams (as identified by MWLAP) as outlined in the *Riparian Management Area Guide Book.* Alternate proposals and/or measures proposed by participants will be considered where specifically proposed.
- Aspen and cottonwood will not be used in the construction of any fills in or adjacent to streams that will be in place during unfrozen conditions. These species contain a leachate that may be toxic to aquatic life.
- Snowfills shall be constructed of clean snow only. Placements of clean logs or temporary steel pipes to facilitate movement of water under the snowfill will be considered appropriate (refer to *Winter Stream Crossing Planning Matrix*). Where a large number of logs are required in the construction of the crossing it is recommended that the logs be banded to facilitate removal. Snowfills (including any pipe or logs and unintentional dirt deposited from logging traffic) will be removed with an excavator during post-logging road deactivation, placed above the high water mark of the stream and protected from erosion.
- Ice bridges may be constructed (see *Winter Stream Crossing Approval Matrix*) on major rivers and streams with appropriate depth and winter flows. Ice bridges will not interfere with or impede winter flows in any stream or river. Ice bridges will be maintained and monitored throughout their use.
- Clean, limbed and topped coniferous logs with the root boles removed may be used to reinforce ice bridges.
- Ice bridges will be located to minimize approach grades. Where possible, bridge approaches shall be constructed of clean snow and ice to a sufficient thickness to adequately protect riverbanks.

Timing Windows:

Instream work can result in harmful effects to fish and fish habitat, including the harmful alteration or destruction of spawning habitat, introduction of sediment and the destruction of fish eggs and juveniles prior to emergence from gravel. Therefore, such work must be undertaken during times or periods when such harmful effects will be minimized. Timing windows may be better referred to as windows of least risk regarding fish and fish habitat. Instream timing windows (windows of least risk) for the Fort St. John TSA are as follows:

Fish Affected	Approved InStream Time Window
Both spring and fall spawners	July 15 - August 15
Fall spawners (bull trout, kokanee and mountain whitefish)	June 15 - August 15
Spring spawners (rainbow trout, arctic grayling)	July 15 - March 31
Anadromous salmon	DFO has site-specific time windows if needed

- If fish species information for a particular stream is not available, the instream timing window for both spring and fall spawners will be used.
- Stream inventory data for fish presence/absence are critical to establishing the widest possible timing windows.
- These timing windows must be applied to all construction in fish streams, as well as tributaries that have a high risk of depositing sediment into fish streams.

Variances to Timing Windows:

- Where a proponent wishes to conduct in-stream work outside the approved timing window, a variance must be requested from the MWLAP in writing. Requests will be evaluated on a case by case basis.
- Notwithstanding the above, if any one of the following conditions is met, then the timing window extends from January 1 through December 31 of any given year.
    1. On fish streams, the stream channel is dry and the construction, modification or deactivation activity will not result in the introduction of sediment into fish habitat.
    2. Winter crossings of fish streams located on cutblocks where appropriate winter crossings methods are identified in a Forest Practices Code approved plan (i.e. SLP, FDP,FOS, SFMP).
    3. On fish streams, the structure does not encroach below the high water mark, no work is proposed within the stream channel and the risk of sediment delivery to the stream is low.
- Any request for variance must be submitted, in writing, to MWLAP.
- Any approval for a variance from the timing windows and measures outlined in this document must be kept on site.

SUMMER STREAM CROSSING PLANNING MATRIX

Stream Class	**S1**	**S2**	**S3**	**S4**	**S5 no fish**	**S6 no fish**
Width	**> 20 m**	**> 5-20 m**	**1.5 – 5 m**	**< 1.5 m**	**> 3 m**	**< 3 m**
Temporary bridge (no instream work)	Yes	Yes	Yes	Yes	Yes	Yes
Temporary bridge (with instream work)	Yes (*1*)	Yes (*2*)	Yes (*2*)	Yes (*2*)	Yes (*3*)	Yes
Seasonal (*4*) bridge (no instream work)	No	Maybe (*1)	Yes	Yes	Yes	Yes
Seasonal (*4*) bridge (with instream work)	No	Maybe (*2*)	Yes (*2)	Yes (*2*)	Yes (*3*)	Yes (*3*)
Engineering culvert with earthfill	n/a	No	Maybe (*2)	Maybe (*2*)	Yes (*3*)	Yes (*3*)
Culverts less than 2,000 mm	n/a	n/a	n/a	Yes (*3*)	Yes	Yes
Ford	No	No	Yes (*5)	Yes (*6*)	Yes (*6*)	Yes (*6*)

I Site specific approval required from the appropriate authority.

2 Site specific approval required from the appropriate authority. Instream work may be restricted to specific time period. (Refer to timing windows identified in this document.)

3 Instream work may be restricted to specific time period. (Refer to Timing Windows identified in this document).

4 Clear span, no approaches within the stream channel, monitored/removed at high flows.

5 Light (LGP, pickup or less) traffic only; site specific notification required.

6 Refer to MLWAP authorization letters for details.

Note: Instream work does not include fords.

WINTER STREAM CROSSING PLANNING MATRIX

Stream Class	S1	S2	S3	S4	S5 – no fish	S6 – no fish
Width	**> 20 m**	**> 5-20 m**	**1.5 – 5 m**	**< 1.5 m**	**> 3 m**	**< 3 m**
Temporary or seasonal clear span bridge (no instream work)	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal bridge (with instream work)	Yes (*4*)	Yes (*4*)	Yes (*4*)	n/a	Yes (*4*)	n/a
Seasonal bridge (with instream work, and snow fill or ice approaches)	Yes (*4*)	Yes	Yes	Yes	Yes	Yes
Ice bridge – heavy loads	Yes	Yes (*1*)	No	No	n/a	n/a
Ice bridge – light loads (*2*)	Yes	Yes	Maybe (*4*)	n/a	Yes	n/a
Snowfill – artificial or natural, with pipe or log bundles (*3*)	n/a	No	Yes	Yes	Yes	Yes
Snowfill – artificial or natural (no flow, dry or frozen solid)	n/a	No	Yes	Yes	Yes	Yes
Temporary pipe/culvert with earthfill	n/a	No	No	Yes	Yes (*4*)	Yes

I If depth > 1 metre, width > 15 metre and winter mean daily flows > 0.5 m^3/sec

2 Weight restriction. (1 ton or less). For heavier loads, special approval is required from the participants engineering supervisor.

3 If stream flow.

4 Not first option.

Note: Instream work does not include fording for construction purposes.

Installation & Removal Guidelines for In-Block Equipment Crossings on Streams

General:

- Equipment crossing locations must be approved by a participants supervisor before construction.
- During summer activities or unfrozen ground conditions, measures must be taken to protect the approaches to the crossing. Coniferous logs can be used as a mat to protect the ground adjacent to the crossing.
- Where possible, clean, non-merchantable wood should be used for constructing crossings and approaches (dry trees or undersize). Deciduous trees can be used under frozen conditions only.
- Where possible rub trees (stubbed) should be created on each side of the approach to the crossing. This will help minimize the amount of debris carried to the crossing and help minimize the width of the crossing.

- Care must be taken during installation and removal to maintain the natural stream banks and vegetation.
- Where snow fills are used as a temporary crossing structure, they must be installed at least one day prior to skidding across them to allow the snow sufficient time to set up.
- Crossing structures must be monitored by the logging contractor during use to ensure the objectives are being met (i.e. stream banks are not being damaged, sediment and other deleterious material is not being introduced to the creek).

Suggested methods of construction:

1. Temporary Bridge – Spans streams bank to bank. Construction materials can include coniferous logs/timbers/steel.
2. Culvert with Log Fill – Permits free flow of water, logs fill and/or bridge the channel (depending on log orientation) to protect stream bank stability. Deciduous logs may be used during frozen conditions only.
3. Log Fill – Permits water flow, logs fill and/or bridge the channel (depending on log orientation) to protect stream bank stability. Where a large number of logs are required in construction of the crossing it is recommended that the logs be banded to facilitate removal. Deciduous logs may be used during frozen conditions only.
4. Clean snow/ice fill – Snow and/or ice fill channel protecting stream bank stability.

Removal Guidelines:

1. Prior to spring freshet materials used for the crossing structure and approaches must be removed in a manner that protects the stream channel and banks. Crossing materials will be removed from site, skidded to slash piles or left as coarse woody debris, if appropriate.
2. Any logging debris (including limbs) must be removed from the channel and crossing site, and placed a minimum of 5 metres from the channel or 5 metres above the high water mark whichever distance is greater. Care must be taken to minimize disturbance to the natural stream channel.

IN-BLOCK EQUIPMENT CROSSING PLANNING MATRIX

Stream Class	**S3**	**S4**	**S5 – no fish**	**S6 – no fish**
Width	1.5 – 5 m	< 1.5 m	> 3 m	< 3 m
Temporary bridge (without instream work)	Yes	Yes	Yes	Yes
Culvert with log fill	No	Maybe (*1*)	Yes	Yes
Snowfill, artificial or natural/log fill	Yes	Yes	Yes	Yes
Clean artificial or natural snow/ice fill	Yes	Yes	Yes	Yes

I Specific approval required.

2 Frozen conditions only

Revised February 23, 2004

Appendix 13: ROS Polygon Delineation Standards

ROS Polygon Delineation Standards

<table>
<tr><th rowspan="3">ROS Class</th><th colspan="6">Factors</th></tr>
<tr><th colspan="2">Remoteness</th><th colspan="2">Naturalness</th><th colspan="2">Social Experience</th></tr>
<tr><th>Distance from road (km)</th><th>Size (ha)</th><th>Motorized Use</th><th>Evidence of Humans</th><th>Solitude/Self-reliance</th><th>Social Encounters</th></tr>
<tr><td>Primitive
(P)</td><td>>8</td><td>>5000 ha</td><td>• occasional air access, otherwise no motorized access or use in the area</td><td>• very high degree of naturalness
• structures are extremely rare
• generally no site modification
• little on-the-ground evidence of other people
• evidence of primitive trails</td><td>• very high opportunity to experience solitude, closeness to nature; self-reliance and challenge</td><td>• very low interaction with other people
• very small party sizes expected</td></tr>
<tr><td>Semi-Primitive Non-Motorized
(SPNM)</td><td>> 1</td><td>> 1000 ha</td><td>• generally very low or no motorized access or use
• may include primitive roads and trails if usually closed to motorized use</td><td>• very high degree of naturalness
• structures are rare and isolated except where required for safety or sanitation
• minimal or no site modification
• little on-the-ground evidence of other people</td><td>• high opportunity to experience solitude, closeness to nature, self-reliance and challenge</td><td>• low interaction with other people
• very small party sizes expected</td></tr>
<tr><td>Semi-Primitive Motorized
(SPM)</td><td>> 1</td><td>> 1000 ha</td><td>• a low degree of motorized access or use</td><td>• high degree of naturalness in the surrounding area as viewed from access route
• structures are rare and isolated
• minimal site modification
• some on-the-ground evidence of other people
• evidence of motorized use</td><td>• high opportunity to experience solitude, closeness to nature, self-reliance and challenge</td><td>• low interaction with other people
• small party sizes expected</td></tr>
<tr><td>Roaded Natural
(RN)</td><td>< 1</td><td>N/A</td><td>• moderate amount of motorized use within the area
• may have high volume of traffic through the main travel corridor</td><td>• moderate degree of naturalness in surrounding area
• structures may be present and more highly developed
• moderate site modification
• some on-the-ground evidence of other people
• some on-site controls
• typically represent main travel corridors and recreation areas that have natural-appearing surroundings</td><td>• moderate to high opportunity to experience solitude, closeness to nature, self-reliance and challenge</td><td>• moderate interaction with other people
• small to large party sizes expected</td></tr>
<tr><td>Roaded Modified
(RM)</td><td>< 1</td><td>N/A</td><td>• moderate to high degree of motorized use for both access and recreation</td><td>• low degree of naturalness
• moderate number of more highly developed structures
• highly modified in areas; generally dominated by resource extraction activities
• on-the-ground evidence of other people and on-site controls</td><td>• low to moderate opportunity to experience solitude, closeness to nature, self-reliance and challenge</td><td>• moderate to high interaction with other people
• moderate to large party sizes expected</td></tr>
<tr><td>Rural
(R)</td><td>< 1</td><td>N/A</td><td>• high degree of motorized use for both access and recreation</td><td>• very low degree of naturalness
• complex and numerous structures, high concentrations of human development and settlements associated with agricultural land
• obvious on-the-ground evidence of other people and on-site controls</td><td>• low opportunity to experience solitude, closeness to nature, self-reliance and challenge</td><td>• high interaction with other people
• large party sizes expected</td></tr>
<tr><td>Urban
(U)</td><td>< 1</td><td>N/A</td><td>• very high degree of motorized use for both access and recreation</td><td>• very low degree of naturalness
• highly developed and numerous structures associated with urban development
• very high site modification
• obvious on-the-ground evidence of other people and on-site controls</td><td>• very low opportunity to experience solitude, closeness to nature, self-reliance and challenge</td><td>• very high interactions with other people
• very large party sizes expected</td></tr>
</table>

Appendix 14: WTP Calculation

LU	Forested Area		% Available for Harvest	Harvested with no WTR		Harvested with WTR		WTR	WTR %	Target with LU Objectives	Target No LU Objectives	SFMP targets	Comments
	Total	THLB		Area	%	Area	%						
Blueberry	484,522	319,555	66%	57,107	17.9%	1,681	1%	163	10%	6%	9%	6%	High intensity zone, accept higher risk to biodiversity
Halfway	155,063	71,299	46%	9,574	12.9%	704	1%	98	14%	3%	6%	3%	High intensity zone, increase to 3% (from 2%) to fall within Delong range of 3-15% in fire
Kahntah	233,653	120,656	52%	6,763	5.6%	272	0%	60	22%	3%	7%	7%	Medium intensity- use rating consistent with greater protection of biodiversity
Kobes	115,901	74,271	64%	14,433	19.2%	307	0%	26	8%	5%	8%	5%	High intensity zone, accept higher risk to biodiversity
Lower Beatton	94,349	51,167	54%	15,050	29.4%	0	0%	0	0%	5%	8%	8%	Medium intensity- use rating consistent with greater protection of biodiversity
Milligan	157,627	74,271	47%	3,145	4.2%	0	0%	0	0%	3%	6%	6%	Medium intensity- use rating consistent with greater protection of biodiversity
Tommy Lakes	401,001	107,677	42%	13,207	7.7%	2,802	2%	304	11%	2%	5%	3%	High intensity zone, increase to 3% (from 1%) to fall within Delong range of 3-15% in fire
Trutch	258,178	107,677	42%	2,288	2.1%	90	0%	40	44%	2%	5%	5%	Medium intensity- use rating consistent with greater protection of biodiversity
Sikanni	98,455	30,853	31%	0	0.0%	0	0%	0	0%	1%	4%	4%	Low intensity- use rating consistent with greater protection of biodiversity
Graham	219,455	54,687	25%	96	0.2%	0	0%	0	0%	1%	4%	4%	Low intensity- use rating consistent with greater protection of biodiversity
Crying Girl	62,085	29,931	48%	969	3.2%	1,788	6%	210	12%	3%	6%	6%	Medium intensity- use rating consistent with greater protection of biodiversity
Total All LU's	2,280,291	1,106,746	49%	122,631	11.0%	7,644	1%	901	12%	3%	6%		

Appendix 15: Public Review Strategy

Public Review Strategy

for

Fort St. John Pilot Project
Sustainable Forest Management Plan

submitted to the

Regional Manager
Prince George Forest Region
British Columbia Ministry of Forests

September 12, 2003

The purpose of this public review strategy is to identify when, where and how persons interested in or affected by the forest management of the Fort St. John Pilot have an opportunity to review and comment on the various components leading to the approval of the Sustainable Forest Management (SFM) Plan.

Public Advisory Group (PAG)
The Fort St John Pilot PAG has been providing recommendations into the SFMP through a series of meetings since 2001.

All PAG members have been provided copies of the proposed SFMP and will have an opportunity to provide comments and recommendations at the next scheduled PAG meeting on September 15, 2003.

The participants will notify the public advisory group on how the recommendations were addressed at the scheduled PAG meeting on September 22, 2003.

First Nations
The following First Nations have been provided copies of the proposed SFMP and have an opportunity to provide comments and recommendations:

Assumption
Blueberry River
Doig
Fort Nelson
Halfway River
Prophet River
Saulteau
West Moberly

Public Viewing of Sustainable Management Plan
Advertisements will be placed in the following newspapers to notify the public that the proposed SFMP is available for comment for 60 days ending on November 21 2003:
Alaska Highway News on September 22 and 26 and October 3, 10 and 17, 2003.
North Peace Express on September 21 and 28 and October 5 and 12, 2003.

Copy of advertisement.

NOTICE OF PUBLIC REVIEW OF SUSTAINABLE FOREST MANAGEMENT PLAN

The participants in the Fort St. John Pilot Project, which include the major forest industry companies and the Ministry of Forests BC Timber Sales who operate in the Fort St. John Timber Supply Area, have developed a Sustainable Forest Management (SFM) Plan to provide strategic direction to future forestry operations. This plan includes landscape level strategies to be implemented by the participants to address resource issues that may be impacted by their activities.

The SFM Plan is available for public review and comment from September 22nd, 2003 until November 21st, 2003. Revisions may be made to the SFM Plan as a result of comments received during the review period.

Copies of the SFM Plan are available for reviewing between 8:30 a.m. and 4:00 p.m., Monday to Friday, until November 21st, 2003 at the following locations:

B.C. Ministry of Forests: 9000-17th Street, Dawson Creek, B.C.
Canfor: 9312- 259 Road, Fort St. John, B.C.
Canfor : 4700-50th Street, Chetwynd, B.C.
Slocan-LP OSB Corp: 9912-100 Avenue, Fort St. John, B.C.

Written submissions received prior to 4 pm November 21st, 2003 are welcome, and should be sent to :

Warren Jukes, RPF
(250) 788-4355
Management Forester, Peace Region
Canadian Forest Products Ltd.
Box 180 Chetwynd, B.C. VOC 1J0

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Warren Jukes, RPF, Management Forester, Peace Region
Canadian Forest Products Ltd.
Box 180, Chetwynd, BC V0C 1J0
Phone (250) 788-4355

Written Comments Received

From: Silins, Uldis [mailto:Uldis.Silins@ualberta.ca]
Sent: Monday, November 03, 2003 1:25 PM
To: 'WJukes@mail.canfor.ca'
Subject: Fort St John Pilot SFMP - Silins Comments

Dear Warren:

Looked through the draft SFMP with a focus on 4.4, 6.7, 6.22, 6.33, 6.34, 6.35, 6.36, & 6.37

Most of this plan looks quite reasonable to me at first cut.

Though research may strengthen the approach in many of these area, many of the outstanding questions are potentially large undertakings with likely limited impact to the SFMP.

However, section 6.34 is (PFI & ECA) is closely tied to both allowable cut levels and the state of hydrologic recovery of older disturbances (something over which you have some degree of silvicultural control) and I do believe that some additional insights could be generated through research aimed at this indicator.

Some general areas of potential research aimed at the effectiveness monitoring spring to mind on this one.

1) General statements concerning role of spring snowmelt on peakflows and H60 analysis based on other climatic regions such as the interior may have less clear application in the eastern slopes and boreal regions around ft. st. John. Though the spring freshet is probably quite important in these areas, I suspect peakflows in this region are not strongly synchroized with with snowmelt. If true, H60 weighting may be less critical in this area (and others with simlar regional hydrology) than others in BC. Some research (precipitation, flood frequency analysis with a focus on seasonal timing of large events) might provide valuable insights to tune this approach.

2) Predicting hydrologic recovery of stands based on height growth is a good start, however, other ecologically based approaches that predict stand level leaf area index (LAI) may provide a better approach. As this issue is closely tied to regeneration, stocking, and juvenile growth ... some research here may kill several important birds with one stone. Several techiques to estimate LAI may yield reasonable results

3) Though only limited detail is presented in the SFMP on baseline PFI targets, some regional flood frequency analysis in relation to climatic variability may provide reasonable insights into regionally appropriate "PFI thresholds" in the Ft. St. John area.

Sorry again about my inability to make tomorrows meeting.

Uldis

Uldis Silins, Ph.D., RPF
Associate Professor - Forest Hydrology
751 - General Services Building
Dept. of Renewable Resources, University of Alberta
Edmonton, Alberta, CANADA. T6G 2H1
Tel: (780) 492-9083 Fax: (780) 492-4323
http://www.rr.ualberta.ca/forest_hydrology
E-Mail: uldis.silins@ualberta.ca

STAC MINUTES: November 4, 2003

Attendance:

Lorne Bedford	Hamish Kimmins	Dave Harrison	Chris Hawkins
Brad Seely	John Nelson	Jim Thrower	Pierre Vernier
John Innes	Ralph Wells	Fred Bunnell	
Roger St. Jean	Jeff Beale	Warren Jukes	Don Rosen

Gail Wallin (facilitator)

Meeting Objectives:

1. Feedback
2. Key research needs

SFMP presentation

- Q/As
- What worked in the plan, what didn't?
- **QA's**
  - **Hamish:** How do you establish who leads, how do you operationally do the Coordination?
    WG: ok at the strategic level, the real test will be in the making of the FOS.
  - **John Nelson:** Will there be a common data base (even for oil/gas)?
    WG: No not yet, but we are working towards that.
  - **Hamish:** Monitoring, what's your conceptual approach (CSA), stand approached, what do we do with it, how do we build knowledge?
    WG: currently monitoring plots structured on a 3km grid on DFA, 15yrs post-harvest and CMI plot sampling… also will look at WTP's, cwd and shrubs… how will it feed back to practices.

FEEDBACK on the PLAN (quotations and/or paraphrasing):

1. **John Nelson**: Quite impressed with it. Liked that the fact there was a rationale for all indicators. It's a very comprehensive plan. Maybe some improvements in forecasting
2. **Fred Bunnell**: Very impressive. Not in a knot over any stuff as written, but very comfortable with the Code Pilots' ability to change the strategies, regulation and the fact that it is an adaptive mgmt process. Need to get targets around mixedwood mgmt, don't want to unmix the mix too much. Improve the effectiveness and flexibility through zonation and intensity.

3. **Ralph Wells**: From a distance, the indicators were strongly linked to CSA, but he's seen some adjustment to them, which he thinks is good. What are the processes to adjust monitoring, and focus on specific questions?
4. **Chris Hawkins**: Its great. It identifies what you don't know too, and the public is not being duped. Must be careful about how quickly we unmix the mix.
5. **Hamish:** WG could use LEMS to decipher this. What do we mean by the term of un-mixing the mix?
6. **Lorne Bedford**: Opined that WG could have used the STAC more thoroughly. He likes what we have in here, we have a radical departure in silviculture but we've not actually used the U of A guys enough (V. Leiffers & P. Comeau particularly). Not much on soils in Code Pilot SFMP and thought there would be more.
7. **Brad Seely**: Very comprehensive in the Indicators. You might get false impression that we have the capacity to do the analyses, but describe better how you get from the higher level plan to the operations… i.e., how does the strategic link to the operations?
8. **Jim Thrower**: What's the mechanism to do the continuous improvement? Should we continue to use the indicators? How well are we monitoring the indicators?
   <u>**WG**</u>: Annually the WG monitors appropriate-ness and effectiveness.
9. **Fred Bunnell**: Forestry is addressing "wicked problems" (quoting from an old paper). What are the links to mgmt.? Assessing what would we do differently if we looked at things this way *vs.* that way? Work with the PAG extensively and intensively (i.e., go deep with them) and do it with a corporate mindset too. What are the planning tools that we are using & how do you explore the alternatives? There should be more done with WTP and intensity zoning—which runs into harvest scheduling and forest valuation.
10. **Hamish**: "What kinds of tools, synthesis and analysis will the FSJ PP use to bring all this together? I want comfort; I want scenario analysis with multi-values." Want use of planning and or exploratory tools.
    <u>**WG:**</u> we'll use tools like we have at UBC, and has been used for TFL 48 and in the Arrow IFPA.
11. **Ralph Wells**: Given the indicators, what kind of analyses (spatial *vs.* aspatial etc.) would support working with these indicators, or where are these indicators failing?

MONITORING

- SFMP short-term: Saskatchewan Gov't. Monitoring Board (Kimmins has a report that he'll send out). Essence is monitoring for so many values is a cost-hole (not sensible). Smart monitoring, checks that you are in compliance, but done in a way that collects data over time so that it monitoring the accuracy of predictive tools that are used in all levels of planning and risk mgmt.
- Going to get conflicting values for different indicators (FB), no way you can answer all of your questions, how do you sift the list to the most impt? Sometimes it boils down to monitoring to decipher which is the better of two options/alternatives (---Adaptive Management).

- SFMP short-term: Mixedwood Committee
  - Fred, What have we done to tap into the SFM network? Work with them (2nd time comment).
  - Brad, does not like the existing DC/CD mixedwood classification; need process based modelling
  - Hamish, what are the values of different mixes? It's a landscape level and a patch size frequency distribution. BETTER Inventory, combo of spatially explicit stand and landscape level models, and then we need interpretations of the wildlife models added in? To the degree that SORTIE is a light driven model that is good as it could be hooked up to a landscape level model. What are the eco questions that need to be answered? What are the tools that best fit those questions?
  - Chris, look at Mystic in SK. Age of old growth of aspen is something that needs to be looked at. Quoted the age- study they did in the Dawson Creek.
  - Jim, "In God we trust all others bring data!" quotation from Kim Iles. The FSJ forest inventory is not great--- this will affect our setting of targets. Models will always be wrong – know that. Monitoring can be turned into a prediction system (e.g., look at Weldwood, Hinton AB). Monitoring data later can be used to validate the prediction tools.
  - Dave Harrison, go back and take a look at the EFMPP process.
  - Lorne, the big question is what are we shooting for (with reforestation)?

- SFMP short-term: Silviculture & Soils
  - Lorne, Vic Lieffers and Phil Comeau should take a look at reforestation strategy.
  - Lorne, the SFMP is too light on soils
  - John Innes, not keen on seeing more on soils since there is a lot of regulation piled up in Victoria
  - Lorne, maybe more should be written on the linkage between site productivity and maintenance of soil quality (go get info from Slocan Radium & Tembec in SE BC).
  - John Innes, there is more to soil productivity than just SI.
  - Brad Seely, should look at soil OM (organic matter) 'cause that's where the soil nutrient capital is. Also suggested using a soil compaction measure.
  - Fred, suppose you know all this info---what are you going to do about this? Do I have the framework to go back and change mgmt?
  - Dave Harrison, go look at Ontario, and Dave MacNabb at UA.

- SFMP Short-term Planning:
  - Examine WTP patches to reduce costs, maximize ecological benefits.
  - Wondering if we can turn SFMN's BEEST program to an advantage for FSJ Pilot?
  - Ralph, don't depend on science to ask the questions.
  - Recognize the questions and values can be in conflict?

Description of Current Projects

- MKMA cumulative impacts
  - Axys Consulting, MSRM & UNBC
- John Innes SFMN project
  - Hi impact area north of FSJ (Doig & BRFN)
  - Moderate impact area (PRFN)
  - Low impact area (WMFN & SFN)
    - First identify what concerns the FN's (moose turning out to be the big one)
    - Second identify valued indicators
    - Spatial modelling (with John Nelson)
    - Air quality being done
    - All data is confidential
- Carbon sequestration project
  - Brad, uses Forecast model
- Ecological representation
  - Got to get into oil & gas info
  - What are we going to do with this representation information?
- Avian indicator models in TFL 48: hope to scale them up for FSJ area
- Bioregional indicators (tradeoffs between all sectors including agric, range, energy, forestry & urbanization).. This is a BEEST project will span from BC to SK
  - Fred, recommended WG get involved (Jeff & Warren)

<u>Future research initiatives</u>

1. **R** Access mgmt & zonation
   a. Managing costs, ecology, FN, opportunity costs, impacts of competing resource users and values, trade-offs (overlapping tenures). Need a pilot area. See ALPAC. See George Hoberg and Policy research.

2. How much conservation is enough? A conservation biology theme.
   a. John Innes, looking at boreal circumpolar affects of deforestation etc. Watch the process, and review outcomes.

3. Mixedwood values, impacts and effects.
   a. Review existing research and science.
   b. Track the dynamics of the mixedwood forest and habitat elements and the value of the forests
   c. New book on Boreal: Burton & Messier

4. **R** Natural disturbance; need to examine the robustness of the models
   a. Reporting timber supply forecast
   b. Is in fact natural disturbance the right thing to emulate
   c. NEBC is the area that is going to change the most with regards to climate change.
   d. Why use ND?

   e. Linkage between operations and the strategic direction from the timber forecast models.
   f. Does the SFMP have a response strategy (i.e., to guide the Forest Health & salvage strategies based on a look back at the ND conditions and targets, and then ask the question of what are the impacts of the natural disturbance occurring then?)
      i. Lead STAC Contact(s): CRAIG, RALPH WELLS, ANDISON, HARRISON

5. Stand level dynamics (need this to get to the values)
   a. Problem analysis --- identify the gaps (Gap or Strategic analysis).
   b. Review the data (psp's etc)
   c. Habitat elements
   d. Social elements
   e. Timber values
      i. Lead STAC contact(s): JIM Thrower

6. Strategic to Operations Practices implementation (make sure indicators are linked to ecosystem function and social functions)
   a. NSERC project
      i. Mixedwood & large cutblocks
      ii. Link this to the SFMP
      iii. Lead STAC Contact(s): BRAD, JOHN N. RALPH, FRED

7. Change wording on stand habitat elements: to effectiveness of biodiversity strategy.

8. Social & Economic
   a. Benefits to the community
   b. SFM network
   c. ROI
   d. Economic rent
      i. Lead STAC Contact(s): BOXALL, SHEPPARD, MIETNER, MANNESS

9. MONITORING Effectiveness of the public participation process
   a. Evaluation process
   b. Looking at existing tools

Where does STAC go from here?

Research Projects

- Access mgmt
- Natural disturbance
- Stand level dynamics (id questions)
- Biodiversity strategy (effectiveness of)
- Strategic to Tactical Operational Implementation
- Mixedwoods (operational trials on 10% of THLB)

Literature synthesis

- Conservation biology
- Mixedwoods
    - John Innes says something is coming out soon in Ecological Transcripts
    - STAC also indicating a new book by Burton & Messier is helpful.
- Strategic to Tactical Operational Implementation
- Economic & Social Indicators

Forecasting and Scenario Modelling

1. Analysis tools: questions, scale, problems & effectiveness

NEXT STEPS

1. Annual / Biannual meetings
    - SFM Investment Plan
    - Annual updates and reviews
2. Specific Project Teams
    - Research
    - Monitoring

Memo

J.S. Thrower & Associates Ltd.
103-1383 McGill Rd, Kamloops, BC V2C 6K7
Phone: (250) 314-0875 Fax: (250) 314-0871
www.jsthrower.com

CERTIFIED ISO 9001:2000

To: Warren Jukes
From: Jim Thrower
cc: Jeff Beale, Don Rosen
Date: November 7, 2003
Project: NA
File:
Re: Comments on indicators in the FSJ SFMP

Gents – thanks the opp to participate in the STAC. I find the process interesting and hope that I have at least some small part to contribute. As I mentioned to you at the meeting, I have a few detail-oriented comments related to the some of the indicators. I did not review them all but only ones that I thought might be related to inventory or growth and yield. This memo describes some of these comments. I expect you may have already thought about most of what I have noted here, and some of comments may in fact not be relevant and may only reflect my lack of understanding of the conditions and situation.

Warren, you asked the question of how well you put together section 3.3 on managed stand monitoring. I think it is good. You have described well the big picture, which is most important for that section.

A general comment regarding presentation of the material. I think the document could be improved by more structure in how the indicators are presented. For example, can they be grouped by value? Also, how do they relate to each other and the big picture.

Indicator	Comments
6.1 Forest Types Percent distribution of forest type > 20 yrs old by landscape unit (page 61)	• I understand that you are about one-third done a VRI phase I, and thus you are probably more than aware of the impacts and dangers of using the old inventory to set targets. • The current distribution of forest types will change, possibly quite dramatically, after the Phase I is complete. Thus you must consider this when developing indicators and targets using the old inventory. • Furthermore, your Phase I will change after you complete a Phase II. Most changes after Phase I will be in species

Indicator	Comments
	composition and most changes after Phase II will be in height, age, and volume. • You must also consider the linkage and compatibility of using species composition from stands moving into age class 2 (> 20 yrs) with the older stands. Species comp will be estimated in two different ways. Is this a problem? • These comments apply to any other indicators that use species composition for existing or future stands, or any other inventory attribute.
6.2 Seral Stages The minimum proportion of late seral forest by NDU and LU (page 65)	• Again, caution when you are basing targets on ages from the old inventory (which may not be very good). • The concern is that your ages – and thus age class distribution – will change after you adjust the inventory (when and if you complete a Phase II). • Thus if you have met the targets with the old inventory, you may not with a new inventory.
6.5 Snags/Cavity Sites Number of snags and or live trees/ha on prescribed areas (page 88)	• I suggest you use a different sampling method for this. • To use the "jargon", you are sampling for a rare element (in relation to normal plot sizes), and you probably will not get satisfactory results from regular silviculture plots. • Will you assess this indicator using the point estimate or a confidence interval?
6.6 Coarse Woody Debris Average CWD volume/ha on blocks logged in the DFA (page 92)	• Typos in the section on monitoring procedures when referring to the monitoring plot locations (referred to as 3-km "long" plots etc.). • You will need an appropriate sampling method for this. Probably some kind of line transect. VRI has a method, but may not be appropriate for you. • If you are visiting these CMI plot locations immediately after harvest, you should consider doing some prep work that will help when the plot is established at age 15 yrs.
6.8 Shrubs The proportion of shrub habitat (%) by LU (page 98)	• I couldn't really glean how you are going to measure this from the text. But again, this is an inventory attribute that could make you out of compliance with a little change in the inventory (update, adjustment, etc).
6.8 Caribou Proportion of area of forest greater than the b baseline target age by caribou management zone (page 110)	• Same comment, you are relying on the inventory age. • What happens when the ages are adjusted and you age class distribution changes?
6.17 Representative Examples of Ecosystems Proportion of area (%) of	• Again, relying on the species composition from the inventory, and this could change (dramatically) after the Phase I is complete. • Another consideration, current MSRM procedures are that

Indicator	Comments
forest stands by leading species by HDU in ain unmanaged conditions (page 121)	species composition is not changed in the Phase II process, but is should be, and maybe by the time you are ready for this.
6.28 Species Composition Relative change in plantation composition versus harvest composition for spruce and pine (page 149)	• Relying on the species composition from the inventory. • That target is for the proportion of Pl and Sx to equal the proportion from harvested areas; however, you have 20% variance thus this may not be an issue. • The species comp of trees planting will not be the comp at rotation or later in life. Is this ok? • Is it a good thing to compare species comp based on trees planted to the comp based on harvest volume? There are many reasons why these should be different for the same stand.
6.32 Site Index Site Index (page 157)	• Site index is probably not a very good indicator of soil productivity by itself when compared between regenerated and natural stands. • The target also is probably not very meaningful because it related the site index in regenerated stands to natural, and for a variety of reasons, you don't expect them to be the same. • Site index estimated from cruise data will give you some indication of how the natural stand grew over time, but wont tell you anything about the next stand – except that future growth will be higher (especially for Pl and often Sx). • Assigning site indices using the options of cruise data, forest cover data, and SIBEC will give you very different answers. • I think site index is a very important indicator that can be used for a check of the most important input into your forecasting of timber supply and stand dynamics of a wide range of elements. • We should probably discuss this in detail.
6.38 Mean Annual Increment Mean annual increment (page 174)	• I think this is a good indicator as you are using it, however, your target is not clear to me. • You need to have a benchmark from which to compare the indicator, and again, comparison to the natural stand may not be what you want to do. • You imply in the text that you will monitor MAI on managed and natural stands, but I don't see how. • Maybe you could compare the MAI from the CMI program with the predicted MAI in your timber supply process (as long as you maintain independence of the two estimates).
6.52 Timber Profile The proportion (%) of area of height class 2 pine	• Similar comment to previous related to the inventory, where the distribution of area by height class can change dramatically after a Phase I and a Phase II.

Indicator	Comments
types to total cutblock area, in blocks harvested (page 199)	• How would this change impact your target?
6.52 Cut Control The percentage of the actual periodic cut control relative to the target periodic cut control (page 199)	• I would think you would want more flexibility around this. • Your current target reflects the current licence, but what will happen when and if your licence changes (which is the rumour).

Gents - I hope some of these comments help. Please call if we can discuss more if needed.

Jim.

From: Lieffers, Vic [mailto:Vic.Lieffers@ualberta.ca]
Sent: Monday, November 17, 2003 9:03 AM
To: Taylor, Greg; 'Jukes, Warren'; 'Chris Hawkins'; 'Craig DeLong (E-mail)'; 'Hamish (J.P.) Kimmins'; 'Lorne Bedford'; 'RPF Jim Thrower PhD'; Silins, Uldis
Cc: Harrison, Dave; 'Jeff Beale (E-mail)'; Comeau, Phil
Subject: RE: Fort St John Pilot SFMP

Dear Greg,
You asked me to provide comments on the silviculture aspects of the pilot project. Alberta is currently in a fight about how to handle mixedwood forests. If you go down the track that you are proposing in this document, you will be in the same turmoil as in Alberta.

Sorry for not being more positive about it, but I think that you have an opportunity to steer this in a better direction at this time.

All the best,

Ft.St john silv.doc

Vic Lieffers

Text of Ft. St. john silv.doc
Overall, this proposal for Silviculture is simply rebuilding most of the existing regulatory system. The innovative part of this document is the idea of linking the regeneration to the growth and yield estimate for the landbase, using models. The bad part of this system is that the single species, even-aged, competition-free system that it espouses can be blamed for unmixing mixedwood forests. If you are taking the issue of managing based upon natural process at all seriously, the types of forests that this system will produce will be very different forest from what is in place naturally. The system proposed is also very expensive to produce and will almost certainly result in heavy use of herbicides. While it is reasonable to use the proposed system for some of the single species portions of the landscape, the mixedwood component is more or less ignored.

produce mixedwood structures such as aspen with an understory of white spruce. It also will likely not result in the yield benefits expected of mixedwoods. The reasons for going down this path, however, is likely partly related to the limitations of modeling only pure stands in the TASS model. If this is viewed as a temporary situation for management, at least develop a path for change and put in place a timeline for implementation.

P50 the landscape level assessment of regeneration success is a good idea. It will however, be difficult to assess. The technique laid out relies heavily on the site intercept technique. Hopefully it will develop a correct estimate of future volume.

P52 The idea of setting a survey time at year 15 has some merit as a good time to do an assessment of the future yield. It is, however, a very long time after cutting. If the stand is not stocked and not growing well at this time, there is likely not much that can be done except take a drop in AAC. I note that there is some earlier estimate of stocking, however but techniques are very vague P153..

Secondly, 15 years is far too late for regeneration assessment in aspen/poplar. If they have not suckered well by the 3rd year, they likely will not improve with time.

P53 This section on failure of regeneration suggests that all of the cause of failure is competition. In many circumstances, other factors may be the cause. I like the idea of not spending ridiculous amounts on trying to fix unfixable problems. On the other side of the coin, however, an earlier checkoff would provide an opportunity to fix a problem before so much time has been lost. The question is whether or not this needs to be formalized or if fear of future losses of AAC for this block (and presumably back calculated) is enough incentive to do the right thing.

Regarding the issue of free to grow, this is a conifer bias system and it is not clear on what basis the threshold were established between competition and future growth. These should have a better justification before they are enacted. Overly aggressive competition thresholds will ensure that mixedwood management will not be enacted. We will continue to have single species plantations with herbicide use as the logical economic means to achieve the standards. Are we sure that this is what we should be doing?

P54 It is not clear how delay indicators should be applied to mixedwoods. While conifers might be delayed in time to maturity if there is a hardwood overstory, there likely will be greater total yield, particularly if some of the innovative mixedwood systems are applied. Underplanting/understory protection can be used to take advantage of mixedwood structures and allow both species to co-exist and it is very likely that a greater total yield will result in mixtures.

P55 There is an initiative at the U of A to upgrade the capacity of the MGM model that might help in this task.
Also, I am also very surprised by the statement that there is likely to be little understory spruce to protect. What sorts of surveys have been done on the 'pure' aspen areas? Were inventories from leaf-on photography? On the other side of the coin, if there is protection of understory, the hardwood lost by doing understory protection, this needs to be made up elsewhere in the landbase. These types of techniques/landbase swapping can only be done if there is common planning in the management unit(s). My reading of the above issue is that the forestry companies/provincial government do not want to deal with this planning difficulty, here or elsewhere in this document.

P149. I think that even-aged management is probably suitable for the pine areas of the unit, but I am not so sure about the mixedwoods. Given that aspen matures earlier than the spruce, understory protection to take out the aspen earlier than the spruce is logical. The spruce can continue to grow to maturity. While this is a form of even-aged management, I am sure it is not envisioned here.

P151 Exactly how will natural range of variability help in developing Silviculture for SFM? This term is widely used as filler in such documents and I am skeptical that there is much intent of modeling the Silviculture after natural processes. If natural processes were considered, mixedwoods, understory spruce and uneven-age stands would be discussed much more in this document and the silviculture that goes along with these structures – understory protection, underplanting, strip cutting and appropriate ways to estimate competition threshold in mixedwoods would be important topics.

11/21/2003 FRI 09:45 FAX 250 772 5200 HALFWAY RIVER 1st NATION ☑001/004

HALFWAY RIVER FIRST NATION
P.O. BOX 59
WONOWON, B.C. V0C 2N0
PH: (250)772-5058 FAX: (250)772-5200

FACSIMILE TRANSMITTAL SHEET

TO: Jeff Beale
FROM: KELSEY McLeod
COMPANY: Slocan - LP OSB Corp.
DATE: Nov. 21, 2003
FAX NUMBER: 250-261-6468
TOTAL NO. OF PAGES INCLUDING COVER: 4
PHONE NUMBER: 250-261-6464.
SENDER'S REFERENCE NUMBER:
RE: Fort St. John Code Pilot Project
YOUR REFERENCE NUMBER:

☐ URGENT ☒ FOR REVIEW ☒ PLEASE COMMENT ☒ PLEASE REPLY ☐ PLEASE RECYCLE

NOTES/COMMENTS:

Hi Jeff:

I finally got finished the SFMP and everything looks good. I sent you the ([illegible]) abbreviation from the entire binder and I think that they should be included in the glossary for those people who are not familiar with the lingo. I could not find a few if you could fill those in and get back to me that would be great.

Thanks KELSEY

-----Original Message-----
From: Taylor, Greg
Sent: Friday, November 21, 2003 2:53 PM
To: 'Comeau, Phil'; Taylor, Greg
Cc: Lieffers, Vic; Lorne FOR:EX Bedford (Lorne.Bedford@gems2.gov.bc.ca)
Subject: RE: Multiblock Reforestation Strategy

thanks for your comments Phil in answer to some of your questions:
- at this time the strategy is is complete only for the conifer stands(>80% conifer) and the management of deciduous and mixed wood will require further work to implement the system
- the 150% of competition requirement for well growing trees is only the first criteria and this is further qualified in subsequent statements. These are based on the MOF Guidebook. Trees with aspen greater than 150% of their height can still qualify depending on the height and numbers of aspen
-Clause E is intended to give the forester a site specific opportunity to call a plantation free growing if it does not meet the criteria, however, the forester would be expected to explain some rationale for this
- the well growing standards for deciduous will be reviewed over the coming year and it is quite possible the height requirement will be modified as you suggest

-----Original Message-----
From: Comeau, Phil [SMTP:Phil.Comeau@ualberta.ca]
Sent: Tuesday, November 18, 2003 3:39 PM
To: 'Taylor, Greg'
Cc: Lieffers, Vic; Lorne FOR:EX Bedford (Lorne.Bedford@gems2.gov.bc.ca)
Subject: RE: Multiblock Reforestation Strategy

Hi Greg,

I have read over this portion of the strategy for assessing reforestation performance. Unfortunately I have only had a limited amount of time to look at it and to provide comments.

I have noted several comments and corrections in the attached pdf file.

I am concerned that, unless harvesting is restricted to pure conifer and pure deciduous stands, the proposed strategy will result in conversion of mixedwood stands to pure conifer and pure deciduous and shrinkage in the mixedwood stratum. Given the level of our current knowledge, it should be possible to propose a simple and realistic standard that can be applied to 2 or 3 mixedwood strata (conifer dominated (CD) (80 to 100 year spruce rotation); mixedwood (MWD) (90 to 120 year spruce rotation); decid. dominated mixedwood (DC) (a minor component of conifer)). In terms of growth and yield predictions - the Mixedwood Growth Model (MGM) appears to be reasonable for modeling unmanaged/natural stands and could be useful in helping to provide at least some initial yield estimates. For the MWD and the DC stratum- simply having an acceptable minimum number of live white spruce, that are at least 0.5 to 1.0 m tall at age 15 is likely to be sufficient. (I have noted several comments on page 49).

Page 50 - I think that using a landscape level approach to balancing the distribution of stand types is an excellent idea. This could provide a basis for moving into some alternative and perhaps more effective regimes for regenerating mixedwood stands (underplanting spruce 10 years before harvesting the overstory aspen, using some form of understory protection) - that involve converting aspen stands to mixedwood stands, in that you could allow some mixedwood stands to become aspen stands after harvesting, etc.

Page 277 - for conifers in the conifer strata requirement for trees to be 150% the height of shrubs and 100% the height of herbs and grasses at age 15 is probably not unrealistic. But, you might want to allow tolerance of willow in the same way as for aspen and cottonwood. Work that Vic has done leads me to question the approach being used to try to characterize aspen competition. It might be better and easier to assess aspen within a larger plot (3.99 ?), and consider that you may have a problem (for spruce, being managed for pure conifer production on a relatively short rotation) when numbers exceed something like 1000 well spaced aspen stems/ha. For pine you may want to accept lower densities of well spaced aspen. Item E - What are the standards for determining whether vegetation is impeding the growth of crop trees?

Page 280 - For deciduous crop trees a standard of 2.0 or 1.5 m minimum height at 15 year is extremely low and should not be a problem to achieve. Wouldn't a minimum height of 5 m or so be more realistic at age 15?

For information on MGM and validation of the model go to:
<http://www.rr.ualberta.ca/research/mgm/mgm.htm>

Please give me a call or send me an email if you would like to discuss any of my comments or if you would like some clarification.

-----Original Message-----
From: Taylor, Greg [mailto:gregtaylor@mail.canfor.ca]
Sent: Monday, November 10, 2003 4:22 PM
To: 'Vic.Lieffers@ualberta.ca'; 'Phil.Comeau@ualberta.ca'
Cc: Jukes, Warren
Subject: Multiblock Reforestation Strategy

In Fort St John Canfor is developing a Sustainable Forest Management Plan. As part of this plan a new strategy for assessing reforestation performance is proposed. Lorne Bedford is a member of our scientific and technical advisory committee and has suggested that I forward a copy of our strategy to you for comment. The strategy is contained in the attached document. It would be greatly appreciated if you could find the time to review this strategy. I will follow this email with a phone call and I am available at 250-787-3640 if you have any questions. Our final date for incorporating comment into the plan is Nov 21st.

Appendix 16: Fort St. John TSA Timber Supply Analysis Report

Fort St John Timber Supply Area

Timber Supply Analysis Report
In support of the
Fort St. John Forest Practices Code Pilot Project

October 2003

Completed by:

Robert Schuetz, RPF

INDUSTRIAL FORESTRY SERVICE LTD.

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In Support of the

Fort St. John Sustainable Forest Management Plan

1.0 Introduction

In support of the *Forest Practices Code Act, Fort St. John Pilot Project Regulation* (December 2001), a Sustainable Forest Management Plan (SFMP) for the Fort St. John Timber Supply Area (TSA) was undertaken by four licensees and Fort St. John British Columbia Timber Sales (BCTS). The purpose of the SFMP is to test alternative methods of meeting the objectives of the Forest Practices Code while improving the regulatory framework. Improvements are initiated through a shift from prescriptive management to results-based management.

The purpose of this report is to evaluate and quantify the potential impact of some of the management initiatives being forwarded by the proponents of the Ft St. John SFMP. To assist in the evaluation of these initiatives, Industrial Forestry Service Ltd. was contracted to undertake a timber supply analysis of the Fort St. John TSA. The analysis is supported by the proponents of the SFMP which include Canadian Forest Products Ltd., Louisiana Pacific Canada Ltd., Slocan Forest Products Ltd. and the BCTS.

2.0 Information Preparation for the Timber Supply Analysis

This analysis was completed over a 2 month period. This was possible only through close familiarity with the Ministry of Forests' (MOF's) recently completed timber supply review (June 2002) and an acceptance by the contract proponents that, as a starting point, the timber harvesting land base (THLB) determination, yield assumptions and management assumptions followed the analysis developed by the MOF through the Timber Supply Review process. The Ministry of Forests Timber Supply Review (TSR) Base Case was the starting point. Following a re-determination of the Fort St. John TSR Base Case, the Code Pilot proponents have included, deleted, and modified analysis assumptions in recognition of the varied management initiatives that are being tabled under the SFMP.

Timber supply analyses generally require three principle sources of information that are integrated into one cohesive forest estate model. This information involves an identification of the land base inventory, timber growth and yield data, and management practices. These three factors, along with a brief description of the model, are described in the sections that follow.

The information contained in this analysis was prepared for the purpose of addressing five specific scenarios. As some of the scenarios utilized management data that was considerably different from the TSR2 Base Case, considerable preparatory processing was required prior to the start of the analysis.

The management scenarios that were modeled in this analysis are:

- **Scenario 1** is a remake of the MOF's TSR2 Base Case scenario. This scenario provides the benefit of both calibrating the model to match the original TSR2 Base Case, and evaluating the impact of moving away from some "traditional" management assumptions.
- **Scenario 2** is an NDU Enhanced Scenario. In this scenario several changes are made in a move away from managing according to the Base Case:

a. The deciduous land base is expanded to include some stands that were previously considered problem forest types,

b. The non-contributing land base was cycled for natural disturbances at a rate of 1,105 ha/year (versus 5,000 ha/year used in Scenario 1),

c. Deciduous stands are cycled when they reach their maximum ecological age. (This was not done in Scenario 1 where deciduous stands were assumed to age indefinitely if they were not harvested),

d. Forest cover constraints that were based upon the Forest Practices Code (FPC) Biodiversity Guidebook were dropped in favour of Natural Disturbance Units (NDU),

e. Approximately 15 percent of deciduous-leading stands were assigned a 4-year regeneration delay,

f. Minimum deciduous harvest ages are modified to better reflect the ability to harvest deciduous stands at 120 m^3/ha.

- **Scenario 3** builds on Scenario 2 through the inclusion of equivalent clear cut area (ECA) constraints on large and small spatially defined watersheds in the TSA,
- **Scenarios 4** builds on Scenario 3 but modifies the forest cover constraints that were applied to NDUs. This was done by increasing the old-growth targets from a minimum percent area over 140 years of age, to include mean and maximum targets based upon the biodiversity emphasis option (BEO) recommended for Fort St. John landscape units.
- **Scenario 5** builds on scenario 4 but modifies the harvest schedule and the THLB in recognition of the Graham River Integrated Resource Management Plan (IRMP).

2.1 Land Base Determination

The Fort St. John TSA is defined by a series of inventory coverages that spatially describe many industrial, political, legal, economic and ecological management concerns across the entire land base. Map inventories representing many of these concerns are merged with the forest inventory to provide a spatially explicit graphical and tabular data-base. An Arc-Info Geographic Information System (GIS) was used to link these spatial coverages to the forest inventory. The resource inventories were largely identical to the inventories used in the TSR Base Case. However, several key inventories have been modified as a result of the progressive nature of forest management across B.C. Revised inventories that include woodlot areas, newly legislated protected areas, range leases, and inaccessible areas are only a few of the many layers that have been merged with the Fort St. John land base inventory files. A listing of the old and new inventories is provided in Table A3 in Appendix I.

Industrial Forestry Service Ltd. updated the inventory files for this analysis in August 2003. The current dataset includes many revisions to the data base completed by the Ministry of Forests approximately 1½ years earlier. The predominant changes to the Fort St John TSA data base involve the inclusion of a vegetative resource inventory (VRI) for approximately 12 percent of the TSAs area. Furthermore, landscape units have been expanded in size and reduced in number, and two new administrative inventories have been included into the analysis (i.e., NDUs and watersheds).

Figure 1 depicts the location of the Fort St. John TSA within the province of British Columbia. Table 1 describes the net-down process for the Fort St. John TSA through which the THLB and the non-contributing land base (NCLB) are defined. Three different THLBs have been identified for the Fort St. John TSA in this timber supply analysis.

- THLB 1 describes a THLB utilizing as closely as possible the net-down assumptions developed by the MOF and described in the Fort St. John Timber Supply Analysis Report. This THLB was used in Scenario 1 and is representative of the MOFs TSR2 base case.

- THLB 2 describes an enhanced THLB that maintains the same net coniferous area but greatly expands the deciduous THLB area by including the Slocan-LP OSB Corp merchantable deciduous forest types. This THLB was used in Scenarios 2, 3 and 4.

- THLB 4 includes the enhanced deciduous THLB described above, but excludes area in the Graham River Valley that is outside the cut-block clusters and riparian reserves that have been spatially identified in the Graham IRMP. This THLB was used in scenario 5.

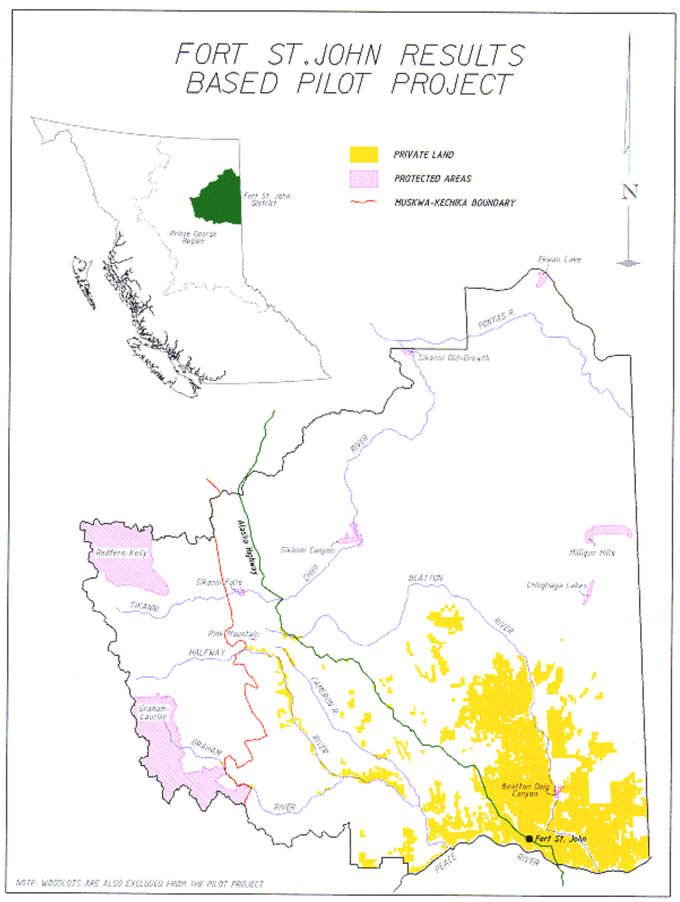

Figure 1 Map of the Fort St. John TSA

Table 1 Land Base Net Down

Classification	Gross Area (ha)	Net Area (ha)
Total TSA Area	**4,676,639**	
Non-forest	*2,018,108*	
Woodlots	*18,409*	*17,767*
Not Managed by BC For. Service	*555,181*	*215,596*
Non-commercial Cover	*173,065*	*148,977*
Area contributing to Forest Biodiversity		**2,276,190**
Range Leases	*13,388*	*9,370*
Parks and Reserves	*94,384*	*94,384*
Productive Forest Land Base		**2,172,436**
Reductions to Productive Forest		
Range and Wildlife Burn Areas	*30,795*	*30,623*
Inaccessible Areas	*24,297*	*15,691*
Inoperable	*20,356*	*18,347*
NonMerch Conifer	*344,063*	*339,100*
NonMerch Deciduous	*88,551*	*83,211*
Low Productivity Conifer	*554,305*	*328,261*
Low Productivity Deciduous	*171,228*	*149,174*
Recreation	*54,059*	*29,740*
ESA	*37,351*	*12,176*
WTP's	*95,586*	*52,921*
Reduction for NSR	*36,323*	*8,674*
Unclassified Roads,Trails and Landings	*14,348*	*9,351*
Lakes and Wetlands Riparian Areas	*15,087*	*7,181*
Streams Riparian Areas	*66,438*	*34,918*
Seismic Lines	*26,269*	*14,712*
Total Reductions		1,134,080
Timber Harvesting Land Base 1 **Coniferous - 733,206 hectares** **Deciduous - 305,150 hectares**		**1,038,356**
Deciduous Add-back		*124,289*
Timber Harvesting Land Base 2 **Coniferous - 733,206 hectares** **Deciduous - 429,439 hectares**		**1,162,645**
Reduction for Graham IRM Plan		*13,234*
Timber Harvesting Land Base 3 **Coniferous - 720,276 hectares** **Deciduous - 429,135 hectares**		**1,149,411**

2.1.1 Coniferous Land Base

Table 1 reveals that this net-down of the Fort St. John timber harvesting land base has resulted in a coniferous THLB that is almost the same size as the area determined by the MOF in TSR2. This coniferous THLB is utilized in all of the management scenarios but one. A small decline in the coniferous THLB occurs through the removal of merchantable areas inside the Graham River IRM Planning area.

Although only a very small difference in total coniferous area was determined through the net-down, the amount of area that was allocated to "small pine" versus the "traditional coniferous land base" has changed considerably. Approximately 18 percent of the area previously attributed to small pine has been redefined as traditional conifer. Approximately 6 percent of the coniferous land base now exists in the small pine THLB. Further detail in this regard is provided in Appendix I.

2.1.2 Deciduous Land Base

This analysis determined three deciduous THLBs. The first duplicates the net-down logic used in TSR2; the second defines an enhanced deciduous base; and the third marginally reduces the enhanced land base for the Graham IRMP. In this analysis, the first deciduous THLB is approximately 6 percent smaller than the land base derived in the MOF's analysis. An in-depth study into this discrepancy has not been carried out.

The second deciduous THLB is approximately 32 percent larger than the MOFs deciduous THLB. Slocan-LP OSB Corp has undertaken analysis that supports the inclusion of additional deciduous forest stands in an "enhanced deciduous THLB. This deciduous THLB adjustment is also partially supported by the MOF's own Phase II VRI analysis. The results of this analysis showed that deciduous volumes existing on the inventory files are believed to be underestimated in the Fort St. John TSA generally. Justification of this belief is not part of this analysis report.

The third and final deciduous THLB is reduced very slightly for deciduous stands within the Graham IRMP. This THLB was only used in Scenario 5.

The seral succession of deciduous-leading mixed-wood stands to coniferous-leading mixed-wood stands is not modeled in this analysis.

2.1.3 THLB Age Distribution

Figure 2 shows the current age class distribution of forested stands in the timber harvesting land base. Approximately 63 percent of the THLB is coniferous-leading stands. The remaining 37 percent are leading deciduous stands comprised of 'TSR2 defined' deciduous (26 percent) and stands previously defined as problem forest types (11 percent). The area in the Graham IRMP is mostly coniferous and makes up only 1 percent of the THLB area.

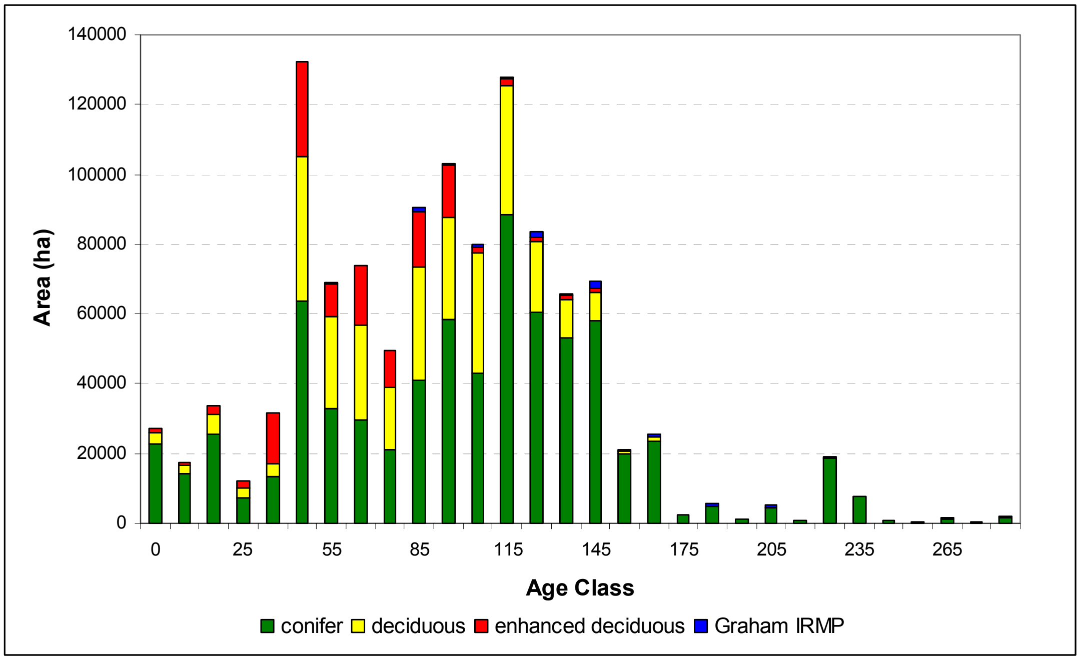

Figure 2 Fort St. John THLB Age Distribution

2.2 Growth and Yield

In this analysis, growth and yield relate to the rate at which stands increase in volume over time. Although the forest inventory for portions of the Fort St John timber harvesting land base was updated with the completion of a VRI, the analysis units and the yield tables representing each analysis unit remain largely unchanged from those developed and used by the MOF in the TSR2 analysis. The exception to this rule was the development of five additional analysis units and yield tables to represent the area and the growth and yield of the enhanced deciduous land base. Details on the amount of area in each analysis unit are provided in Appendix I, Table A19 .

The growth and yield of stands were determined by the MOF using two stand level models. Unmanaged stands were predicted using the VDYP model. Managed stands were predicted using the TIPSY model. It was assumed that deciduous-leading stands reverted back to an unmanaged state.

Figure 5 depicts the area-weighted average growth curve for deciduous stands and for unmanaged and managed coniferous stands.

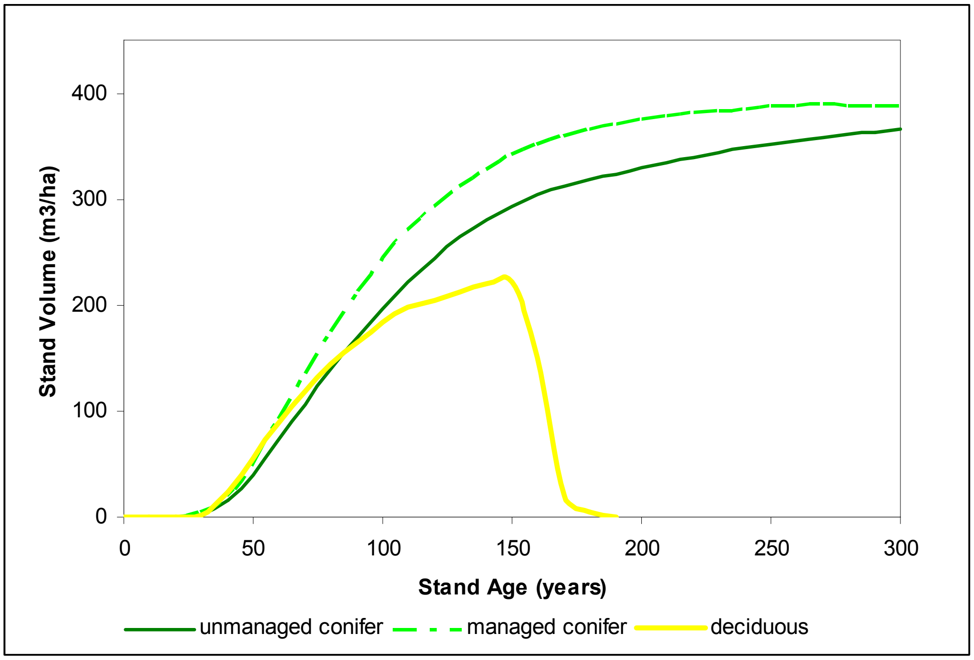

Figure 3 Average Yield Curves by Leading Species – Fort St. John TSA

2.2.1 Unmanaged Coniferous

Unmanaged conifer yield tables were unchanged from the yield tables used in TSR2. These unmanaged yield tables were produced using the MOF's Variable Density Yield Prediction model (VDYP). After harvesting, unmanaged coniferous stands convert to managed coniferous stands.

2.2.2 Managed Coniferous

Managed coniferous stands generally yield more volume per hectare than unmanaged stands. This is as a result of active forest management with respect to site preparation, seedling spacing, competition management, seedling quality and stand thinning. The managed stand coniferous yield tables used in this analysis remained unchanged from TSR2. Figure 5 shows that managed stands yield approximately 20 percent more volume than unmanaged stands after 100 years.

2.2.3 Deciduous

Deciduous yield tables remain largely unchanged from TSR2. However, two items are of note: 1) five new yield tables were added to the analysis to represent deciduous stands that were considered problem forest types. These stands were added back to an 'enhanced' deciduous land base. The analysis units representing these stands were only used in the scenarios (i.e., Scenarios 2-5) where an enhanced deciduous land base was modeled; 2) the yield tables of deciduous-leading stands were adjusted in Scenarios 2-5 such that after a certain age the merchantable volume fell to zero. The time at which this merchantable volume fall down occurs depended upon the leading species (i.e., 155 years for cottonwood and aspen, 115 years for birch). This was done to model the mortality and limited commercial and ecological life span of deciduous species. As a result of deciduous mortality, the average merchantable volume per hectare predicted for deciduous stands greater than 150 years age declines rapidly (see Figure 5). To minimize the loss of deciduous stands to mortality, a 'relative oldest-first' harvesting rule was applied in the model.

2.2.4 Mixed-wood

Mixed-wood stands were treated as per TSR2. The seral succession of deciduous-leading mixed-wood stands to coniferous-leading mixed-wood stands was not modeled. This omission occurred because growth and yield information on mixed-wood succession dynamics is lacking. Mixed-wood assumptions modeled in this analysis, presume that the total amount of mixed-wood area will remain relatively static. Figure 4 shows the amount of THLB by species composition. Roughly 27 percent of the THLB is comprised of mixed-wood stands.

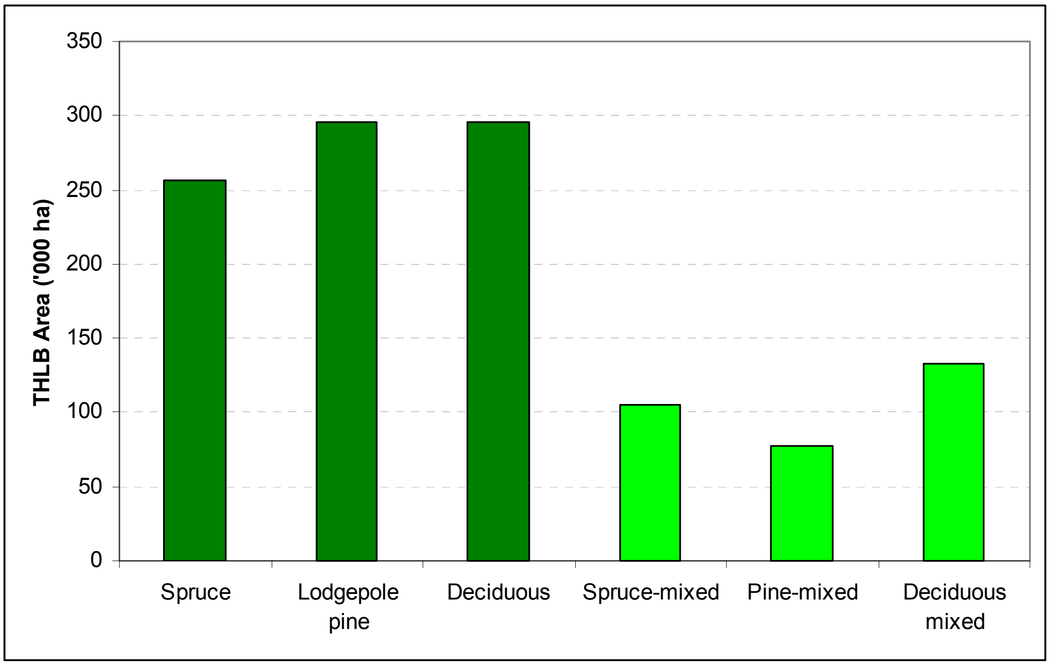

Figure 4 Species Distribution - Fort St. John TSA

2.3 Analysis Model

The forest estate model used in this analysis is the B.C. Ministry of Forest's forest estate model "FSSIM version 3.0". This is an aspatial model that harvests stands according to their availability and age, subject to varied resource management constraints. For the most part, stands are not selected for harvesting as a consequence of their location in the landscape.

In Scenario 5 (Graham IRMP), a degree of spatial integrity is maintained by spatially and temporally harvesting cut-block clusters. The area and timing of harvest was in reference to the design and harvest schedule proposed in the Graham River Integrated Resource Management Plan.

2.4 Management Practices

Management practices in the Fort St John TSA are largely guided by the Forest Practices Code of BC Act and associated regulations. The practices identified in this Act and Regulations that most directly influence short and long-term timber management is provided in Appendix I.

The scenarios examined in this analysis evaluate the change in some key management practices. A brief description of some of these key management assumptions follow:

- In all scenarios, three independent harvest forecast are modeled. One forecast for each of the traditional conifer land base, the deciduous land base and the small diameter pine land base.

- Silviculture management remains unchanged in all scenarios. Based upon TSR2 modeling assumptions, the treatment of stands pre and post-harvesting follows a system of clear-cutting with reserves, followed by stand re-establishment by either planting or natural regeneration.

- Forest health and unsalvaged losses remain the same in all scenarios. Losses are based upon the TSR2 expected average annual loss of 37,500 m^3/year of merchantable volume. This loss is applied only to the traditional coniferous land base and <u>all harvest flows graphed in this report are net of non recoverable losses.</u>

- Timber utilization remains unchanged in all scenarios and is based upon TSR2 assumptions regarding the size of trees and logs removed during harvest.

- Maintenance of scenic values occurs through an established visual landscape inventory and forest cover targets on this inventory. Visual quality objectives applicable to scenic areas remain unchanged in all scenarios.

- Cut-block adjacency was modeled in Scenario 1, by ensuring that the area within the IRM zone that does not meet green-up does not exceed a maximum of 40%. All other scenarios involved modeling according to natural disturbance units and have cut-block adjacency constraints removed.

- Caribou habitat values are maintained in all scenarios through forest cover targets (i.e., Kobes Creek, Graham and Hackney Hills) and through adjacency constraints (ie, Milligan Hills).

- Minimum harvest ages define the time it takes a stand to reach a merchantable condition with respect to volume/hectare. The minimum volume targets vary for coniferous based upon operability (e.g., licensees require 140 m^3/ha for operations on conventional ground and 250m^3/ha for operations on cable ground). Volume targets for deciduous are 120 m^3/ha. The minimum harvest ages used in this analysis remain unchanged between scenarios. The targets follow the values applied by the MOF in TSR2.

- Stand level biodiversity is maintained in all scenarios through a merchantable area reduction for wildlife tree patches (WTPs). WTP area reductions were applied based upon landscape unit name. This analysis utilizes far fewer landscape units then was used in TSR2. Hence the target values have been adjusted accordingly.

- Landscape level biodiversity is maintained through forest cover targets. This analysis diverges from the traditional FPC Act biodiversity guidebook's natural disturbance types (NDTs), and replaces those guidelines with recommended natural disturbance unit seral stage targets developed for the Prince George Forest Region. Only scenario 1 in this analysis utilizes NDTs. All other scenarios test the impact of managing for NDU landscape level old growth targets.

- The maintenance of water quality is managed by the establishment of a peak flow index applicable to defined watersheds. Each watershed has equivalent clear-cut area (ECA) forest cover targets. These watersheds and their associated targets are applied in Scenarios 3-5.

- Some forest lands are kept in an early seral stage through regular controlled burns for range and wildlife management. These areas do not contribute to timber supply, but can affect the amount of area outside burns required for old growth biodiversity.

- The Graham River Integrated Resource Plan was incorporated in Scenario 5. This IRMP spatially identified and scheduled cut-block clusters for harvesting over a very long planning horizon. THLB area adjacent to, but outside these clusters and associated riparian management zones, were excluded from any future harvesting opportunities.

2.4.1 Defined Management Areas

Management practices associated with several of the preceding bullets are summarized in the figures that follow. Additional information pertaining to the forest cover constraints applicable to each of these areas is provided in Appendix I. Figure 5 shows the area within management zones relative to the total productive forest. Note that defined management areas are not mutually exclusive of one another. Overlap between zones can exist.

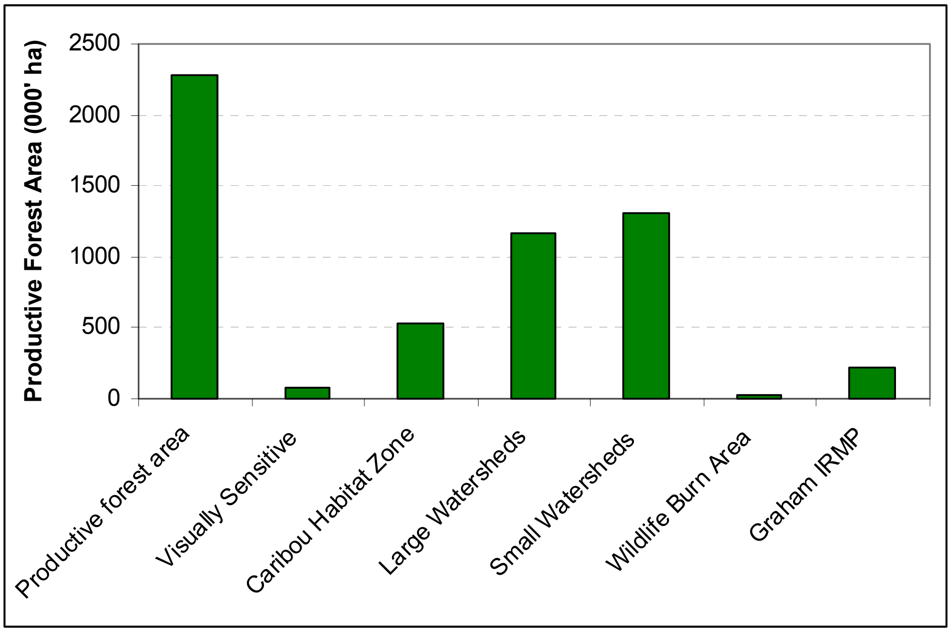

Figure 5 Defined Forest Management Areas

Visually Sensitive Areas

Visually sensitive areas cover only a very small portion (3.5 percent) of the TSA. These areas are classifications by their visual quality objectives (VQO), to which forest cover targets are applied. Figure 6 shows the relative distribution of VQO classifications across visually sensitive inventory area. Both the THLB and the non-contributing land base (NCLB) contribute to achieving visually quality objectives. Forest cover targets were applied at the VQO/landscape unit level.

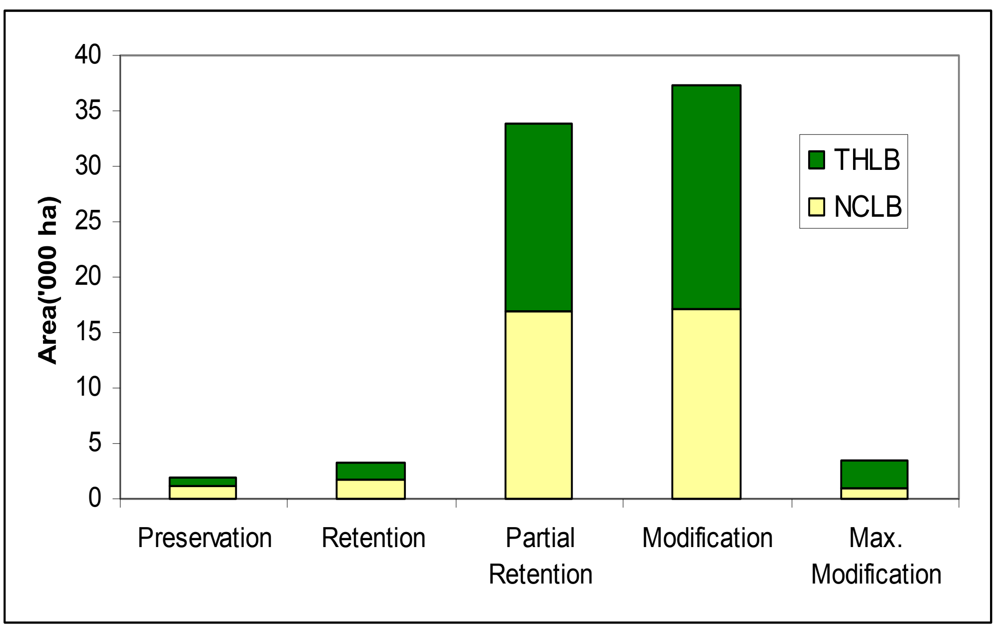

Figure 6 Visually Sensitive Areas

Caribou Habitat

Four caribou habitat zones have been spatially defined in this analysis. These zones cover approximately 24 percent of the TSA. Figure 7 describes these zones relative to one another. The Graham, Hackney Hills and Kobes Creek habitat areas are managed for old growth. The Milligan Hills area is managed for cut -block adjacency.

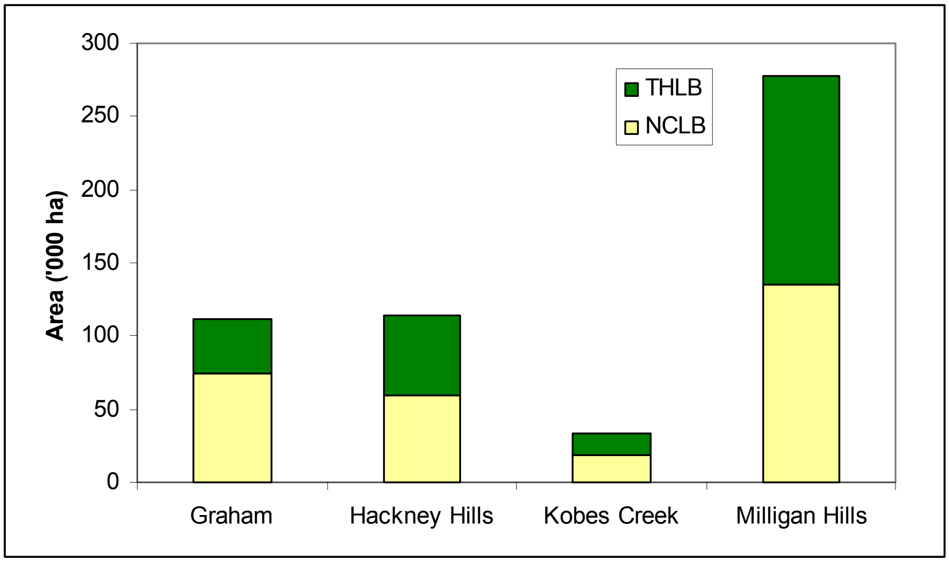

Figure 7 Caribou Habitat

BEC variants versus NDUs

A major change in management for biological diversity involves the incorporation of natural disturbance units as a planning tool across the Prince George Forest Region. NDUs are a relatively recent development in British Columbia's evolutionary progress to utilize best available information in the formulation of management planning guidelines. The Forest Practices Code biodiversity guidebook incorporated natural disturbance types utilizing biogeoclimatic ecosystem classifications for which old growth forest cover targets where determined. NDUs reflect a move towards the utilization of technically supportable guidelines utilizing spatially defined geographic areas and considerable research into natural disturbance patterns. This work was completed by the MOF at the Prince George Regional Office. The distribution of forested areas within NDTs and NDUs is shown in Figures 8 and 9.

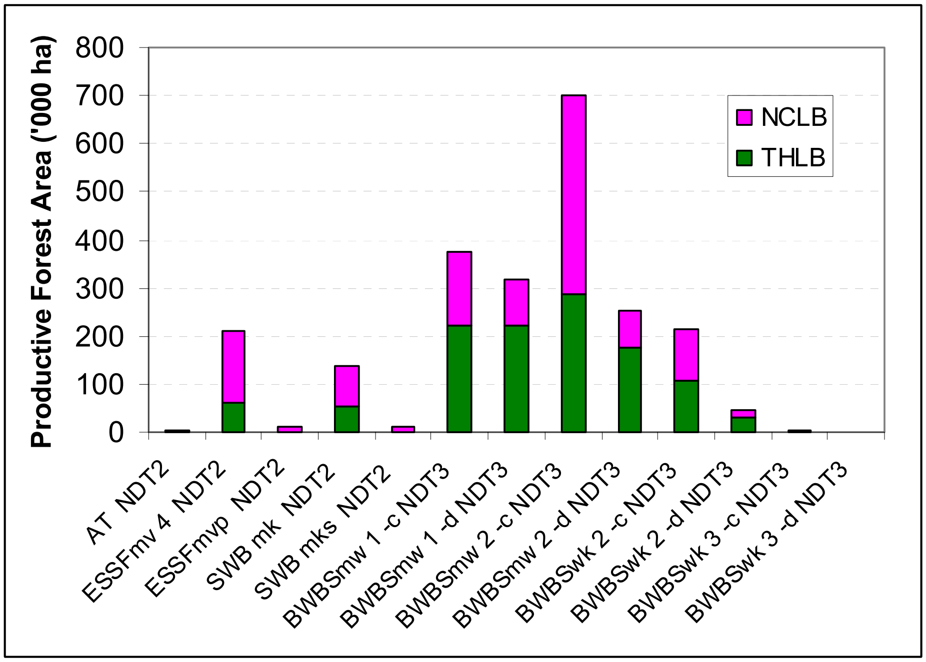

Figure 8 Forest Area by BEC, NDT - Fort St. John TSA

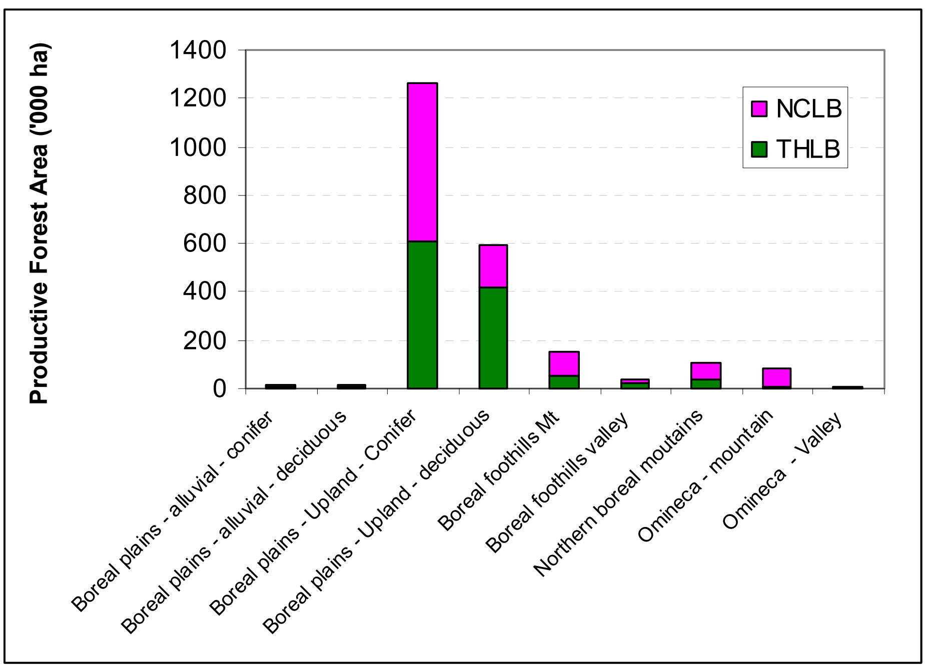

Figure 9 Forest Area by Natural Disturbance Unit – Fort St. John TSA

Watersheds and Equivalent Clear Cut Area (ECA)

As part of the Fort St. John SFMP project, watersheds have been delineated across most of the TSA. The watersheds vary in size from 900 hectares to over 170,000 hectares with many smaller watersheds existing within larger ones. Forest cover equivalent clear-cut area targets have been recommended for all of these watersheds. Figure 10 shows the broad extent to which watershed areas have been defined across the TSA.

Equivalent clear-cut area or "ECA" is used to estimate the average height required by plantations to achieve hydrologic recovery within a watershed. Most hydrologic impacts occur during periods of peak stream flow – usually during the springtime. After an area is harvested, both winter snow accumulation and spring melt rates' increase. As harvested areas are replanted and these plantations grow, the amount of snow accumulation and rate of snow melt are reduced. This reduction occurs as a result of the extent that the snow pack is exposed to solar radiation. The process is referred to as 'hydrologic recovery'. This analysis placed cumulative forest cover constraints on a watershed, thereby controlling the amount of forest land existing under a specified height. This should ensure that excessive timber harvesting in a watershed does not result in significant watershed damage.

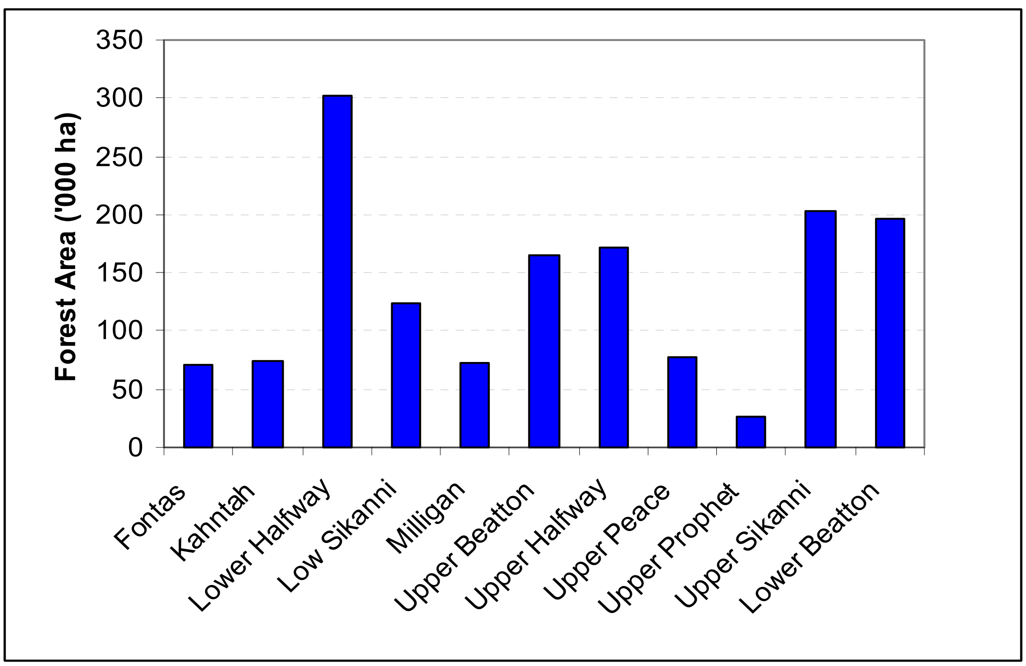

Figure 10 General Watershed Areas

Graham River Integrated Resource Plan

Forest management within the Graham River Valley has been refined for short and long-term management through a comprehensive integrated resource management plan. The acceptance of this plan by Graham River resource users led to the spatially explicit delineation of cut blocks and riparian corridors. A harvest schedule was proposed for these cut-blocks. Scenario 5 in this analysis incorporates this plan within the timber supply analysis. THLB area outside cut-blocks and riparian reserves were added to the non-contributing land base. The IRMP covers approximately 157,000 hectares in the TSA. From this area 24,022 hectares are identified in cut-block clusters or riparian areas as contributing to the THLB. The remaining area outside of clusters will not be harvested under this plan. Figure 11 defines this area and the associated harvest schedule.

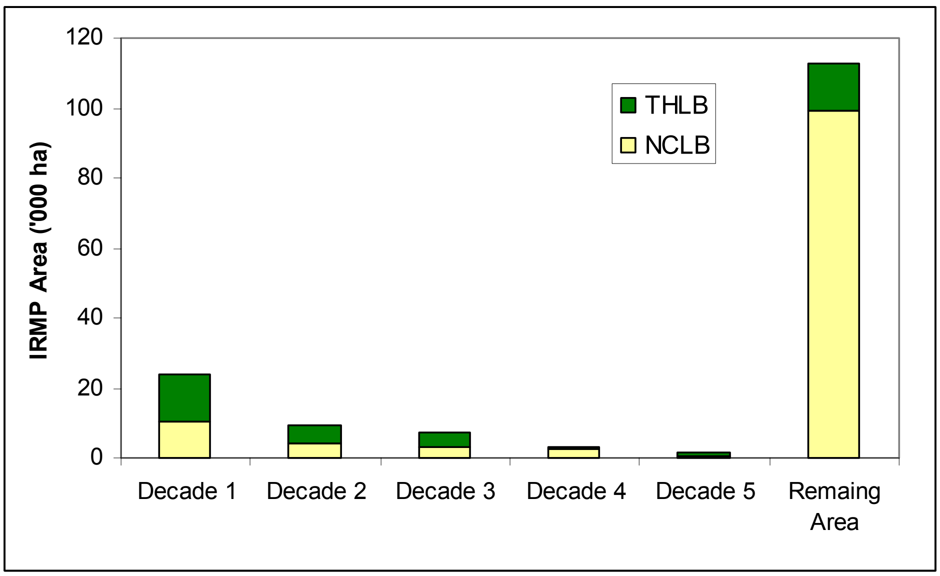

Figure 11 Graham River IRMP

3.0 Results

Five scenarios are examined in this analysis report. None of the scenarios are identified as a standard "Base Case", since the intent of this analysis was not to identify a sustainable harvest based upon current management practices, but to evaluate different management alternatives in support of a Sustainable Forest Management Plan.

3.1 Harvest flow

Harvest flow describes the sustainable harvest level for the TSA for the short, mid and long-term. The harvest flows shown in this report are net of non-recoverable losses and are supportable for a 400-year period. In each scenario, three harvest flows were determined. These are:

- A flat line non-declining traditional coniferous harvest level;
- A small-diameter lodgepole pine harvest level; and
- A deciduous harvest level that begins above the long-term sustainable harvest flow, and is followed by a maximum 10% per decade step down to the non-declining harvest level.

In each case an area-based disturbance target was directed at stands outside the THLB. This was done to cycle a certain level of mortality in the forested non-contributing land base

3.1.1 Scenario 1 – TSR2 Mimic

Forest estate modeling assumptions incorporated in this scenario follow very closely the land base and related assumptions developed by the Ministry of Forests for the Fort St. John Timber Supply Review (June 2002) Base Case Scenario. The harvest flow in Figure 12 shows a total initial harvest level of 2,750,000m^3/year. This harvest level is only 31,000 m^3 or 1.1 percent greater than the MOF's TSR2 Base forecast. The closeness of the result provides sufficient comfort to conclude that the forest estate model re-constructed for this analysis is capable of replicating TSR2 results, in light of changes to some inventories and various management assumptions.

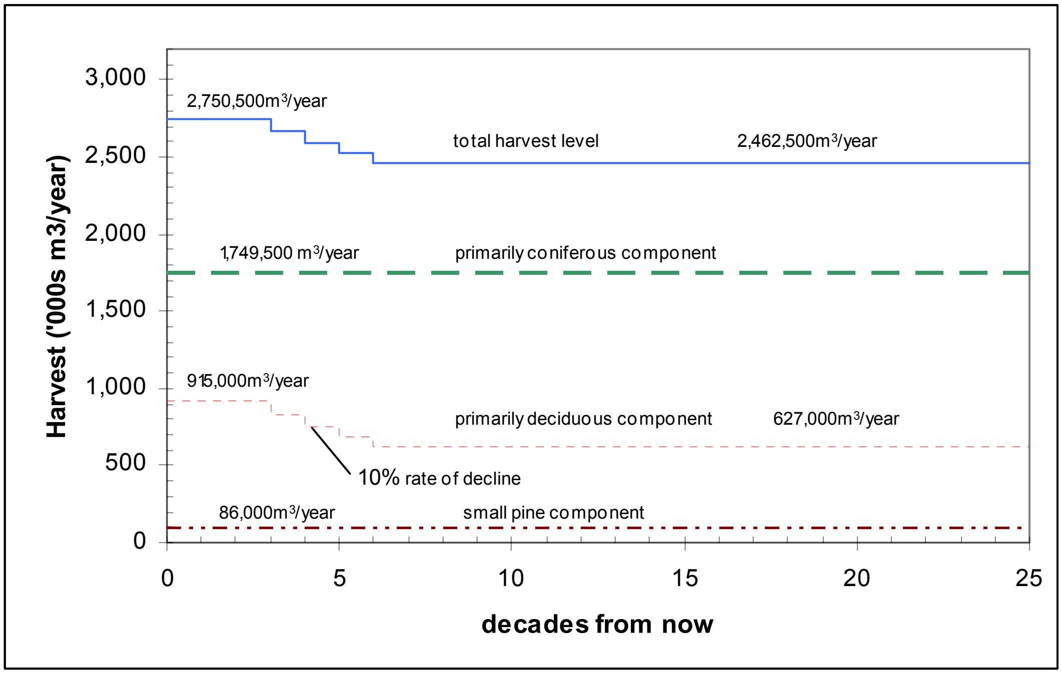

Figure 12 Scenario 1 harvest flow - TSR2 base case

Figure 12 also shows that the total TSA harvest has been apportioned to three defined land bases. The traditional coniferous land base can support a non-declining net harvest level of 1,749,500m^3/year. Although this is 3.3 percent greater than the harvest determined in TSR2, the difference can be generally explained by:

a) An increase in the traditional coniferous THLB by 1.5 percent (i.e., area has shifted from small pine to the traditional conifer THLB).

b) Grouping landscape units into larger contiguous management areas.

c) Small shifts in the amount of THLB associated with each analysis unit.

d) Use of a "relative oldest first" harvest rule in this analysis versus "random harvesting" in TSR2 (relative oldest first was used to better quantify the change in harvesting as a result of changes in management assumptions).

The small-pine harvest level has dropped significantly relative to the TSR2 results. A long-term harvest level of 86,000m^3/year is 22 percent less than the 110,000m^3/year reported in the TSR2 Report. A relatively significant portion of the area previously considered small-pine has shifted to the traditional conifer land base. The reason for the shift is a combination of the updated VRI forest inventory and slight variations in analysis unit programming logic.

The deciduous land base can continue to support an initial accelerated harvest of 915,000m^3/year for the next 30 years. This harvest then falls 10 percent per decade to the long-term harvest level of 627,000m^3/year (5,000m^3/year less than the TSR2 results). The difference in long-term harvest level is relatively small, in light of the 6 percent decrease in the deciduous THLB. Additional analysis, in regards to deciduous land base availability and yield and successional assumptions, needs to be undertaken; hence the results were deemed to be a reasonable representation of the sustainable deciduous harvest flow.

3.1.2 Scenario 2 NDU Analysis and an Enhanced Deciduous THLB

The participants of the Fort St. John results-based code pilot project have proposed a SFM plan that would manage forests according to a more natural range of variation then is currently advocated by the FPC biodiversity guidebook. The proposed plan would emulate patterns of natural disturbance at a landscape level, as opposed to management strategies directed at individual stands or cut-blocks. This scenario evaluates the move towards adopting natural disturbance indicators developed by the MOF's ecologist for the Prince George Region[1]. Several other changes to Scenario 1 were also incorporated in this scenario. To summarize these changes:

a) The deciduous land base was increased to include deciduous leading stands previously excluded from the THLB due to their being considered problem forest types. The inclusion of these stands increased the deciduous THLB by 41 percent (i.e., 124,290 ha) to 429,012.

b) Growth and yield from deciduous-leading stands was limited to a defined maximum age (155 years). Stands exceeding this age (if not harvested) reverted back to an immature unmanaged stand.

c) The non-contributing land base in both Scenario 1 and this scenario is cycled to reflect stand mortality from disturbance. Scenario 1 cycled the NCLB at a rate of 5,000 ha per year. Scenario 2 cycled stands based upon stand replacement disturbance cycles by NDU. Scenario 2 cycled the NCLB at a rate of approximately 1,105 ha per year.

d) The estimated loss to the THLB through the construction of future roads, trails and landings was increased from 0.6 percent in Scenario 1 to 6.4 percent.

Figure 13 shows the harvest flows that result from these changes. The initial TSA harvest level of 2,816,500m^3/year is 2.4 percent greater than in Scenario 1. Specifically, the traditional coniferous harvest has decreased from 1,749,500 to 1,693,500m^3/year; the small pine harvest has decreased from 86,000 to 83,000m^3/year; the deciduous allotment has increased from 915,000 to 1,040,000 m^3/year, and remains at this level for an additional 30 years before sinking to a long-term sustainable level.

Too many changes where made in the transition from Scenario 1 to Scenario 2 to fully analyze the incremental effect of each change. The increase in the deciduous THLB undoubtedly had a positive effect on the total deciduous harvest level. Increasing the estimated losses to future roads will have a negative effect on the long-term harvest level. The effect of managing for NDUs was unknown. Further analysis was undertaken. The stepwise change from NDT management to NDU management (i.e., whereby minimum NDU targets were applied to Scenario 1 in

[1] Natural Disturbance Units of the Prince George Forest Region: Guidance for Sustainable Forest Management, 2002. DeLong, Unpublished 2002

replace of NDT targets) revealed that this change had a very minor (e.g., <1%) positive impact on sustainable harvest levels.

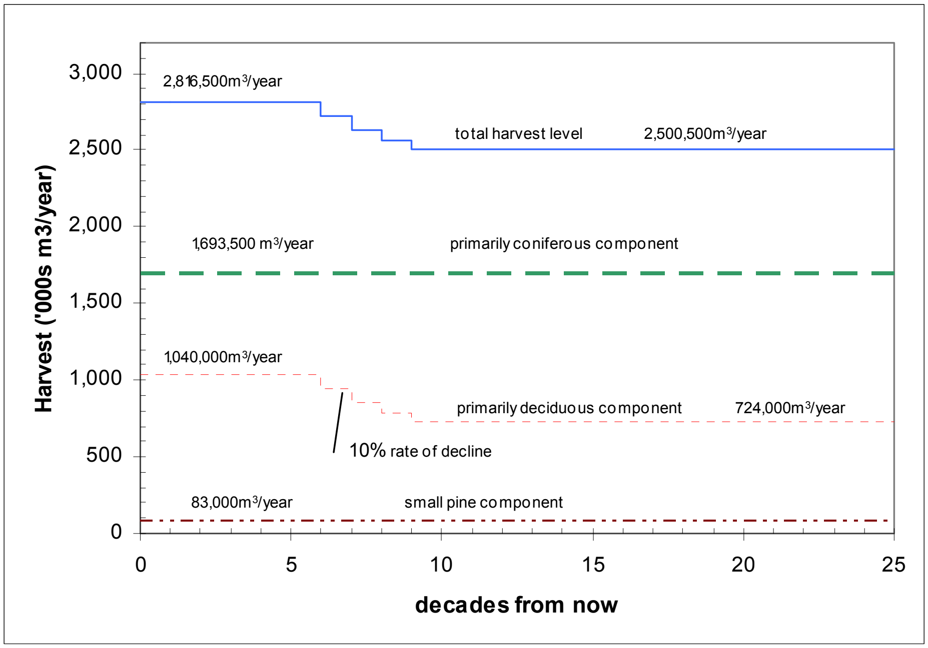

Figure 13 Scenario 2 harvest flow – Minimum NDUs

3.1.3 Scenario 3 – Watersheds

Incorporating watersheds into the harvest simulation was done incrementally by building on Scenario 2. Over 80 defined watersheds covering 1,564,164 hectares of forest land were modeled using equivalent clear cut area constraints. Greenup targets of 3, 5, 7 and 9 metres were applied to each watershed. Many of the watersheds were relatively small and overlapped with larger watersheds, thus more than one ECA target may have been applied to a forest stand. Further detailed information is provided in Appendix I, Section 2. The short and long-term timber supply impact of managing for watersheds using ECA is nil. The harvest flow described in Figure 13 is fully supportable, with the inclusion of watershed ECA targets in the timber supply model.

3.1.4 Scenario 4 – Biodiversity Emphasis Options

Previous to this point in the analysis, the constraints applied to the NDU/landscape unit areas were the minimum old growth targets (e.g., old growth is defined as stands ≥140 years) suggested in the Prince George Region natural disturbance unit document. The exception was deciduous leading stands in the Omineca NDU where the minimum NDU constraint was defined as the maintenance of 10% forest area above 120 years of age. This old growth target was determined through consultation with Craig Delong, the MOF's regional ecologist.

Biodiversity emphasis options (BEOs) have been proposed for landscape units within the TSA. The effect of these proposed BEOs was tested by applying the range of variability applicable to NDU old growth targets according to the biodiversity emphasis assigned to each landscape unit. High BEO landscape units were assigned the maximum old growth targets applicable for the NDU. Intermediate BEO landscape units were assigned mean old growth targets, and low BEO landscape units were assigned minimum NDU old growth targets.

The effect of this BEO assignment on the harvest flow is shown in Figure 14. BEOs have a very small effect on the TSA harvest levels. In the short-term the harvest flow falls only 0.2 percent. In the long-term the fall-down is slightly greater than 1 percent.

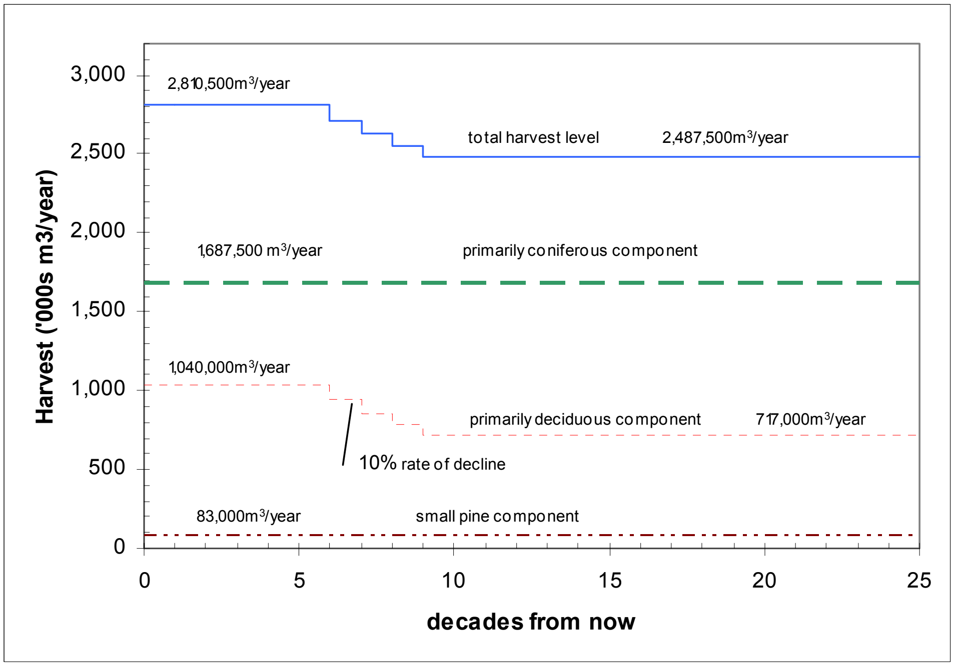

Figure 14 Scenario 4 harvest flow - Biodiversity Emphasis Options

3.1.5 Scenario 5 – Graham River Integrated Resource Management Plan

An integrated resource management plan (IRMP) was developed by Canfor for the Graham River Valley. A harvest plan was constructed with consideration given to scenic values, wildlife, recreation, hunting/fishing, and timber production. The geographic area is defined as the Crying Girl landscape unit and the Graham River landscape unit where it exists within the Omineca NDU. Within this area, clusters of cut-blocks were spatially delineated and a harvest schedule was prescribed. Riparian zones, inside and adjacent to clusters, were also defined. A maximum 10 percent of the area within riparian zones is considered available for harvest. All other area outside clusters and outside riparian zones was excluded from future harvesting.

The Graham IRM plan has a significant impact on the THLB for the entire TSA. The THLB was reduced by 13,234 ha (1.1%) for operable area adjacent to, but outside riparian areas and clusters.

The resultant harvest flow is provided in Figure 15. The initial net harvest level in for Scenario 15 is 2,769,500m^3/year for the TSA. This is sustainable for 60-years before beginning four declines of 10 percent per decade. In 90 years the long-term sustainable harvest level of 2,445,500m^3/year is achieved.

In Scenario 5, the coniferous and small pine harvest levels drop 2.2 and 5.1 percent respectively. This occurs primarily as a result of lost timber production opportunities in areas outside the IRMP harvest plan. The deciduous harvest level is not affected in the short or mid-term. A very small deciduous harvest reduction is forecast for the long-term. Very little of the Graham Valley has merchantable deciduous stands.

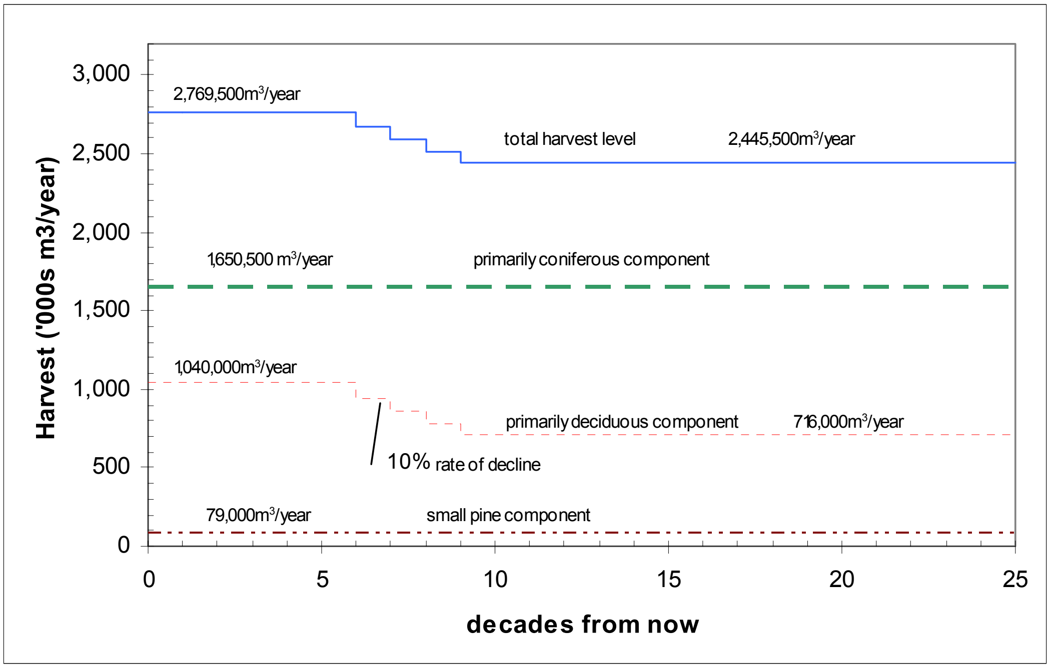

Figure 15 Scenario 5 harvest flow - Graham River IRMP

3.1.6 Scenario 5 - Additional Sensitivity Analysis

Additional sensitivity analysis was completed on Scenario 5. The sensitivity centered around 2 management assumptions:

a) All scenarios to this point included black spruce as contributing to biodiversity. Within the Fort St. John TSA, extensive areas of black spruce exist. These areas significantly mitigate the impact of forest cover constraints on the THLB. The timber supply impact of removing these expanses of black spruce from contributing to forest cover old growth targets was assessed.

b) All scenarios utilized a relative oldest first harvest rule. This was contrary to the TSR, which utilized a random harvest rule. The relative oldest first rule was chosen because it removed the possibility of a change in the analysis results, simply due to a change in the order of the input files.

The results for scenario 5(a) and scenario 5(b) are provided in Figures 20 and 21 respectively. Excluding black spruce (and range/wildlife burn areas) from contributing to biodiversity reduces the NCLB by 355,000 hectares or 32 percent. This has a significant impact on the timber that would otherwise contribute to biodiversity.

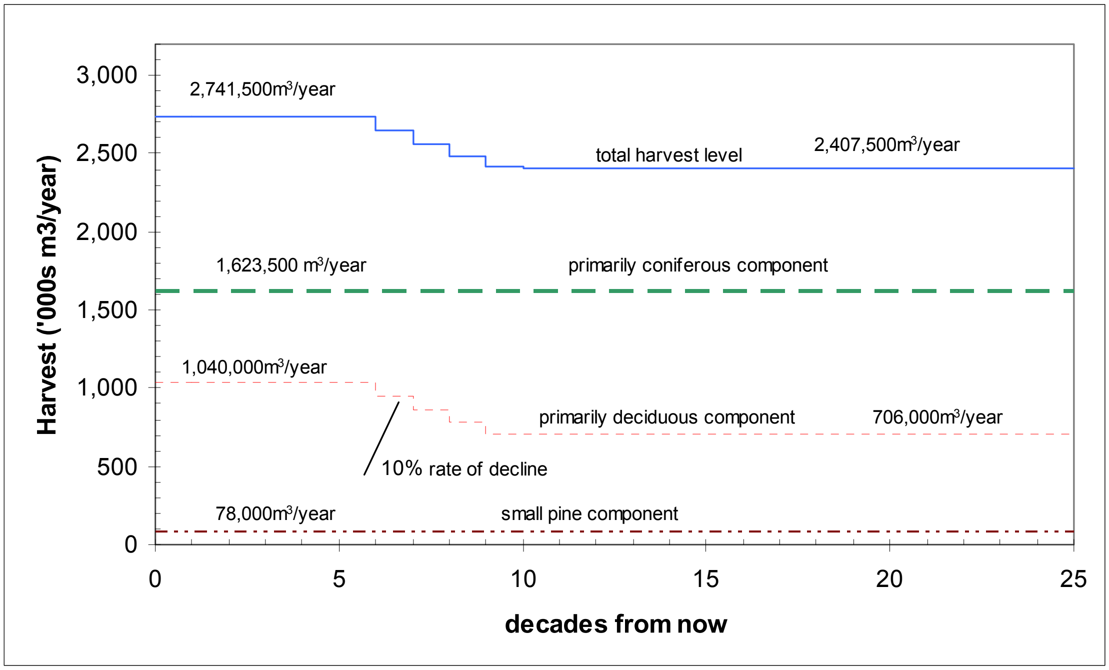

Figure 16 Scenario 5(a) harvest flow - Black Spruce Excluded from NCLB

A random harvest rule results in a very significant change to the sustainable harvest level for the TSA. Using this harvest rule, the total short-term harvest is sustainable for only 30 years, at a level of 2.38 million m^3/year. This is a 14 percent reduction from the original Scenario 5 which used a relative oldest first rule. After 7 decades, a long term harvest flow of 1.99 million m^3/year is reached..

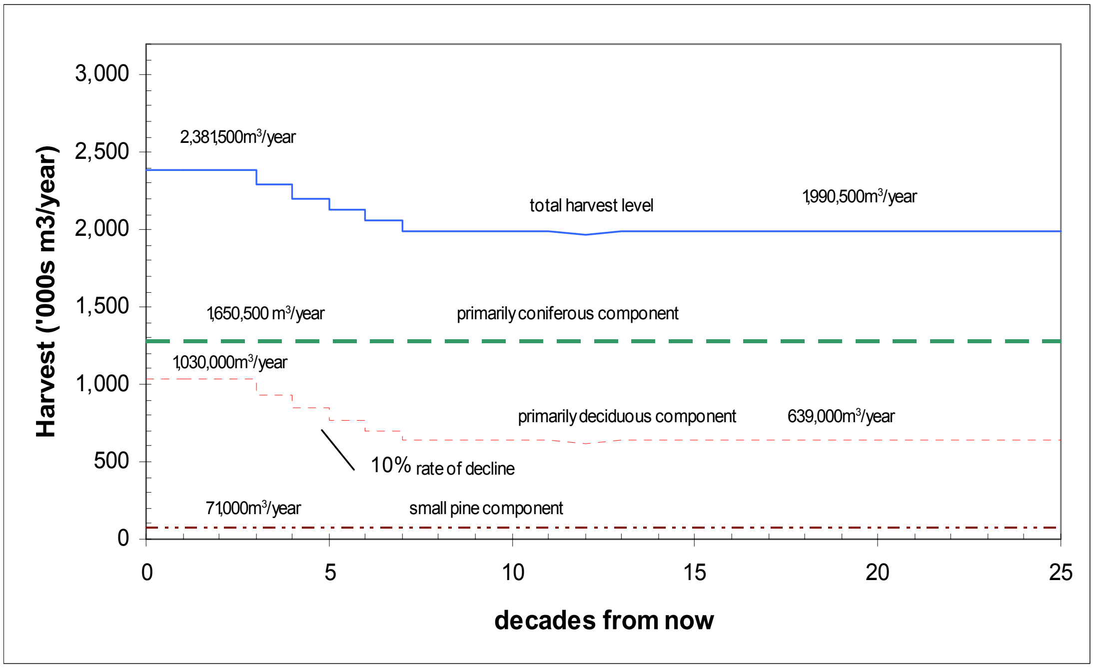

Figure 17 Scenario 5(b) harvest flow - Random Harvest Rule

3.1.7 Harvest flow summary information

Table 2 provides a tabular comparative summary of the harvest flow results for the preceding scenarios.

Table 2 Harvest flow results summary

Scenario	Description	THLB Area (ha)		Annual Harvest Levels (m3/year)					Percent change from S1 (short term)
				Leading Conifer	Leading Deciduous		Total		
		Conifer	Deciduous		Short Term	Long term	Short term	Long-term	
n/a	MOF TSR2	733,221	325,318	1,804,000	915,000	632,000	2,719,000	2,425,000	-1.15
S1	TSR2 mimic	733,206	305,150	1,835,500	915,000	627,000	2,750,500	2,462,500	0.00
S2	NDU	733,206	429,440	1,776,500	1,040,000	724,000	2,816,500	2,500,500	2.40
S3	Watersheds	733,206	429,440	1,776,500	1,040,000	724,000	2,816,500	2,500,500	2.40
S4	BEO	733,206	429,440	1,770,500	1,040,000	717,000	2,810,500	2,487,500	2.18
S5	Graham IRMP	720,267	429,144	1,729,500	1,040,000	716,000	2,769,500	2,445,500	-0.69
S5a	Graham – No Sb	720,267	429,144	1,701,500	1,040,000	706,000	2,741,500	2,407,500	-0.30
S5b	Graham - Random	720,267	429,144	1,721,500	1,030,000	639,000	2,751,500	2,360,500	0.00

The harvest flow results shown in Table 2 reveal that the Fort St. John TSA is very resilient to changes in management direction. This is a directed function of 2 overriding features: 1) the existing age class distribution indicates that approximately 73 percent of the THLB is merchantable and a large portion of this area can support both harvesting and old growth biodiversity; 2) the THLB includes only about 50% of the forested land base. Even with disturbance cycling, the non-contributing land base can support most of the short and long-term forest cover requirements that would otherwise constrain a harvest flow.

The sections following provide additional information about the consequences of harvest activities on the growing stock, and age class distributions across the TSA. For the sake of brevity, only the results for Scenario 5 are provided. Analysis of these results indicates that in most cases, only minor changes occur between the scenarios.

3.2 Growing Stock

For Scenario 5, Figure 18 shows the change in the THLB growing stock over time. Incorporating the expanded deciduous land base, the total THLB growing stock begins at about 180 million cubic metres and then declines rapidly over the next 10 decades. The THLB total growing stock stabilizes at about 95 million cubic metres. Most of this volume is coniferous. Figure 18 also shows the total growing stock for coniferous leading and deciduous leading stands. The TSA will eventually support a coniferous inventory of 73 million cubic metres and a deciduous inventory of 22 million cubic metres.

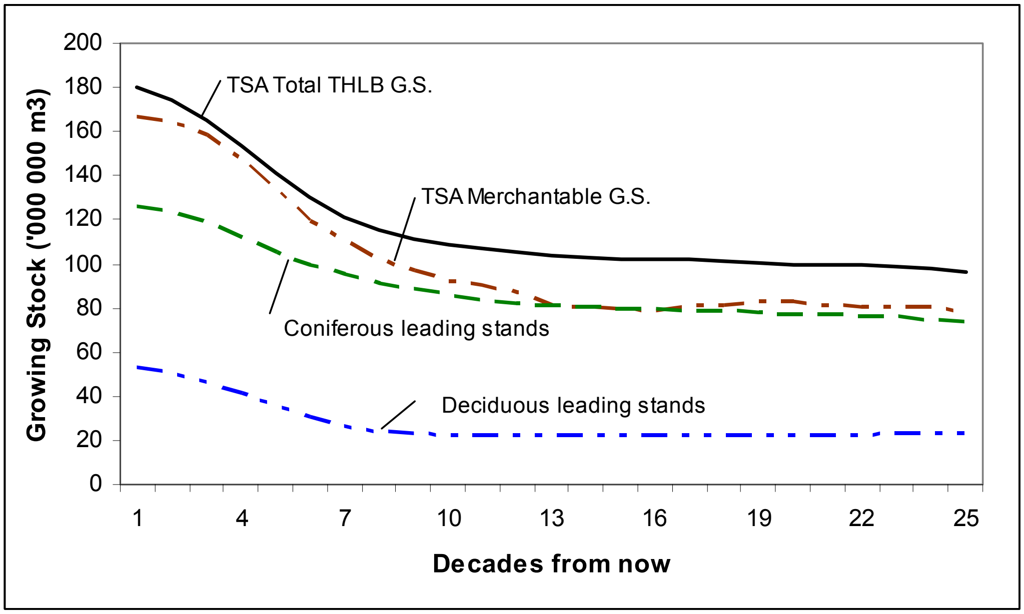

Figure 18 Change in growing stocks - Scenario 5 Fort St. John TSA

Yield tables for the non-contributing land base were not created in this analysis. However, when an area-weighted unmanaged stand yield table representing the THLB was applied to the NCLB, the result shown in Figure 19 is representative of the total expected change in the inventory for all productive forest stands in the TSA as-a-whole. Approximately 50 percent more growing stock exists across the TSA then is currently represented by the THLB. Although many of these stands are cycled (i.e., die through mortality and/or disturbance) the overall growing stock rises over time to about 500 million cubic metres. It is important to note that large catastrophic events are not modeled. Mortality equivalent to 1100 ha per year and periodic range and wildlife burns are modeled.

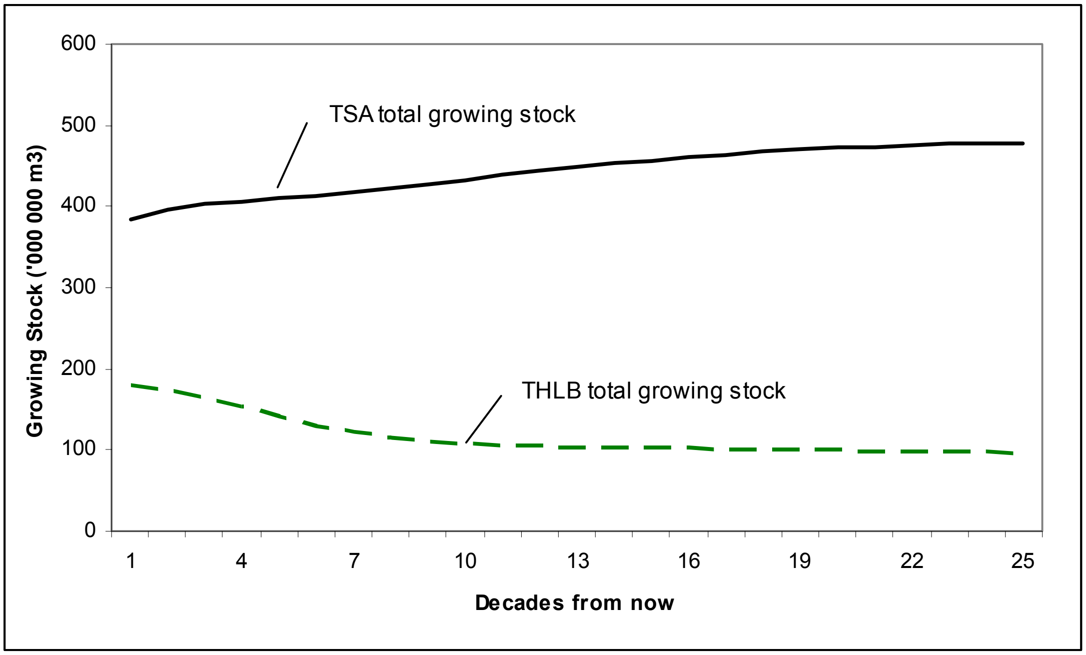

Figure 19 Total growing stock - Fort St. John TSA

3.3 Changing Age Class Distributions

Figure 20 plots the age class distribution of the timber harvesting land base over time. The graph reveals that harvesting transforms the THLB into a mostly normalized forest, with the majority of stands less than 120 years of age. The small amount of area in older age classes are representative of small, highly constrained areas (i.e., visually sensitive areas with a preservation or retention VQO) that hold area in reserve for other resource concerns.

Figure 21 also plots age class distribution over time, but is representative of the entire forested land base. Here, considerably more area is forecast to eventually exist in older age classes. Most of this area is representative of forests that do not contribute to the sustainable harvest levels.

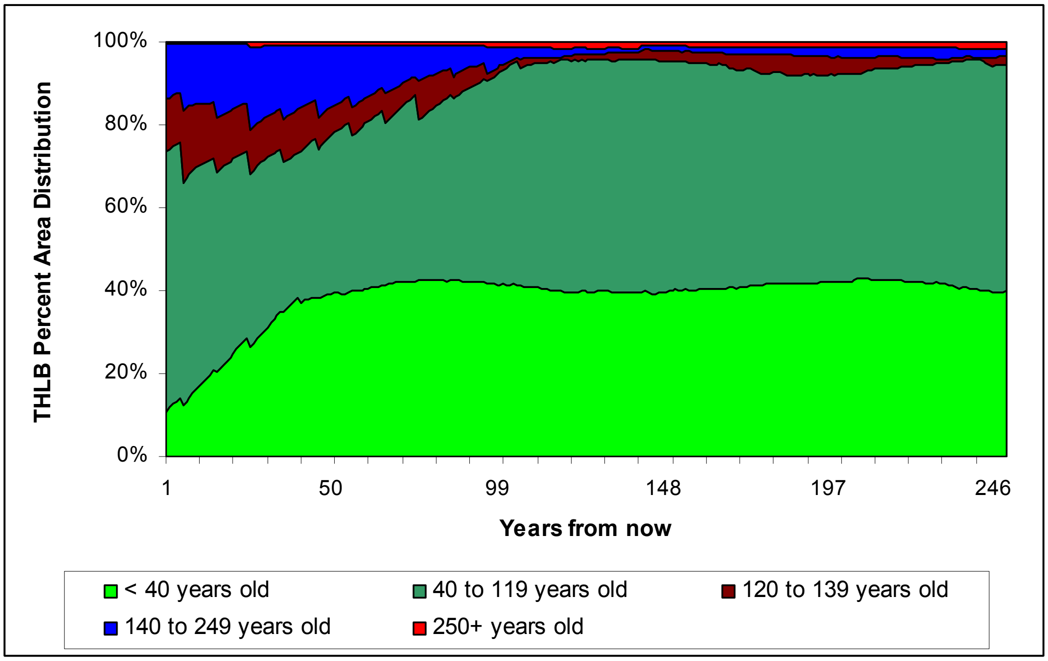

Figure 20 Age class distribution of the THLB over time

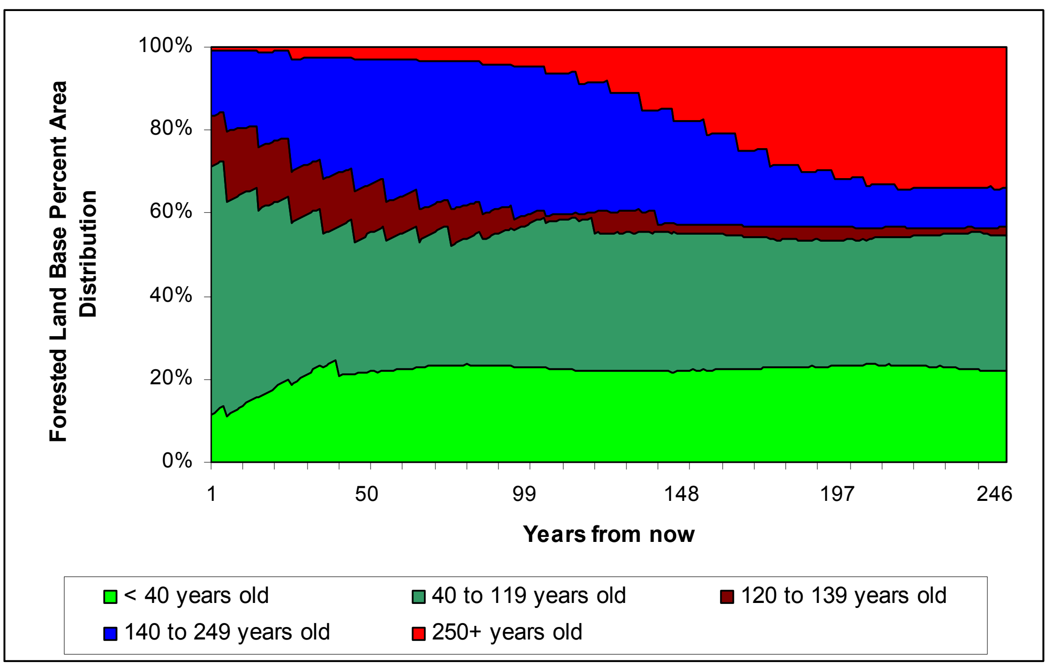

Figure 21 Age class distribution of the entire forested land base over time

3.4 Carbon Cycling

The timber supply model was not originally constructed to model the amount of carbon sequestration over time, for the forest stands within the TSA. Near the completion of this analysis, the desire to show the impact of forest management on carbon cycling became apparent. Carbon tables were created by Dr. Brad Seely (Forest Ecosystem Management Simulation Group, UBC) that described the amount of carbon in forest stands existing and forecast to exist in the Fort St. John TSA. These carbon tables were linked to the existing forest cover analysis units used in this project. The age class distributions of all analysis units, over a 400-year simulation period, were multiplied by the amount of carbon within each stand to describe the trend in carbon sequestration over time. Figures 22 and 23 show the total amount of ecosystem carbon over time and the rate of carbon sequestration.

- Line 1 is representative of the amount of carbon under the Scenario 5 harvest flow.
- Line 2 is representative of carbon under Scenario 5b, using a random harvest selection and the current apportioned allowable annual cut.
- Line 3 is representative of carbon sequestration if no harvesting occurred and the forest land base cycled naturally at a rate of approximately 20,000 hectares per year (based upon NDU disturbance rates).

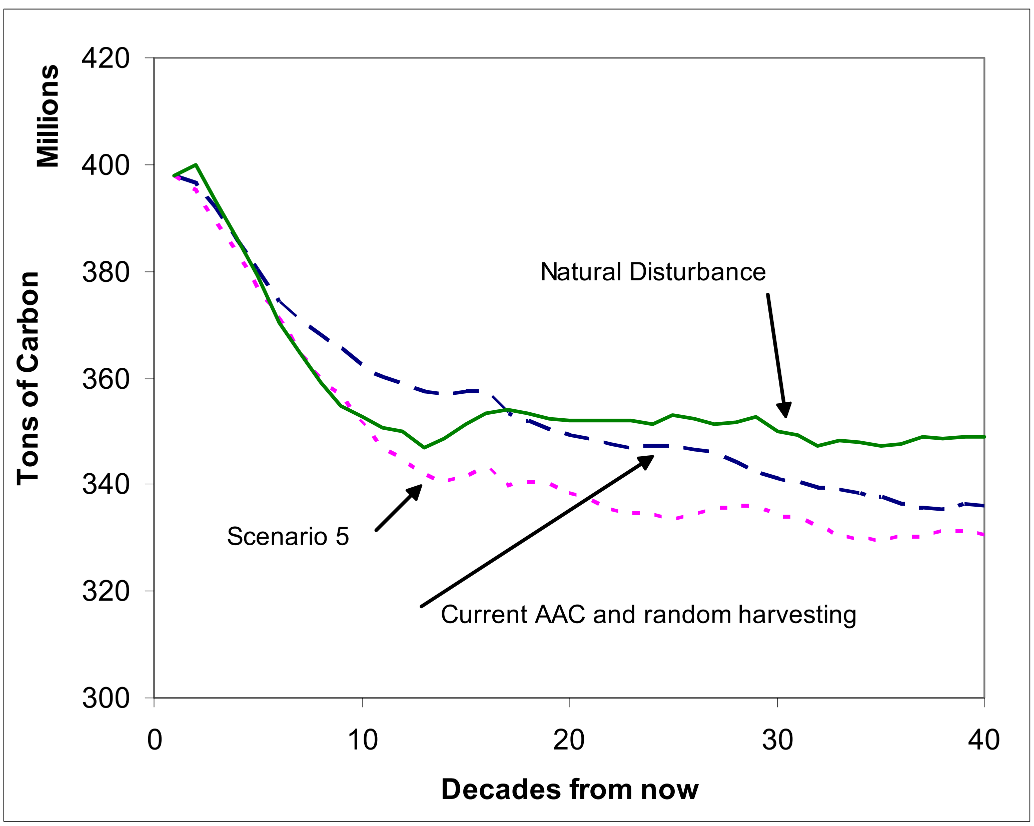

Figure 22 Total ecosystem carbon over time – Fort St. John TSA

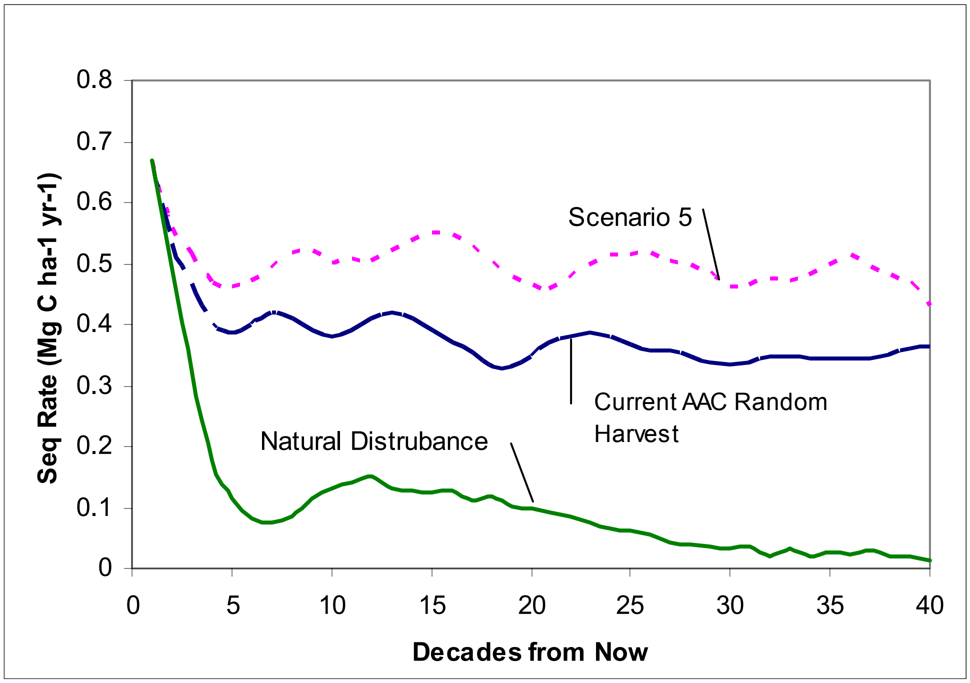

Figure 23 Rate of carbon sequestration – Fort St. John TSA

4.0 Summary and conclusions

A timber supply analysis was assessed for small pine, traditional conifer and deciduous leading stands in the Fort St. John TSA. The analysis began with the resurrection of the MOF's Base Case timber supply analysis scenario, but incorporated new inventories, revised landscape units and some small modifications to management assumptions. The results determined in a new base case (Scenario 1) were sufficiently close to the MOF's results to conclude that the forest estate model used for this report provided a reasonable representation of the TSR2 Base Case.

In support of the results-based code pilot project, for which a sustainable forest management plan has been created, additional analysis was conducted. Several changes to Base Case management assumptions were incrementally applied to quantify the impact of various management initiatives.

Considerable opportunity exists to increase deciduous harvest levels through the inclusion of stands that the Base Case considered deciduous-leading problem forest types. This opportunity is supported by the TSR2 report, which also suggested that deciduous-leading stand volumes may be underestimated by 27 percent. A 41 percent area increase in the deciduous-leading THLB can produce an immediate 14 percent increase in the deciduous harvest level, and keep this level sustainable for an additional 30 years.

The adoption of natural disturbance units in place of FPC natural disturbance types, utilizing minimum old growth targets, does not improve or constrain timber availability appreciably.

Watersheds have been defined for most of the TSA. For each watershed a peak flow index was used to establish equivalent clear-cut area (ECA) targets. The TSA contains sufficient forest area in the non-contributing land base to mitigate timber supply harvest reductions as a result of watershed management.

Biodiversity emphasis options have been proposed for landscape units within the TSA. Once again, the amount of forest area in the NCLB alleviates any significant impacts of harvest constraints in landscape units designated a high or intermediate BEO. A small (i.e., 0.5%) decrease in the TSA harvest was the simulation result.

The Graham River IRMP has spatially defined a THLB and a harvest schedule for a small resource sensitive portion of the TSA. Incorporation of this spatial plan into the analysis results in a small (1.7 %) decrease in the harvest forecast. This reduction is partly in response to the decrease in the THLB and partially in response to a harvest schedule that does not schedule according a harvest plan that better maximizes mean annual increment.

Appendix I

Data Package
in support of the
Fort St. John Result Base Code Pilot
Timber Supply Analysis

Data Package in Support of the Fort St John Code Pilot Project

The following data package was created in support of the Fort St. John Code Pilot timber supply analysis report. The information and logic using in the creation of this Data Package followed, to a great extent, the logic, yield assumptions, management assumptions and land base assumptions created for and used by the B.C. Ministry of Forests (MOF) in the timber supply review (TSR2) for the Fort St. John TSA completed in June 2002. The reader should be aware that several items have changed since the completion of the Ministries TSR Analysis. These changes include an updated land base inventory, watershed coverage, revised landscape units, and proposed natural disturbance unit (NDU) boundaries. The scenarios that investigated alternative management strategies incorporate most if not all these changes. This data package is divided into 3 sections.

1. Land base inventory
2. Management Assumptions
3. Growth and Yield

These three general topics form the basis under which a timber supply forest estate model can be constructed.

Section 1. Land Base Inventory

Table A3 describes the inventory coverage's used in the creation of an Arc-Info GIS semi-spatially explicit resultant data base. The resultant data base was used to formulate the inventor for the forest estate model.

Table A3 Inventory Coverage's

Inventory Coverage	Date	Scale
Forest Cover	1964-1989 Updated to 2003	1:20,000
Vegetation Resource Inventory	2000 updated to 2003	1:20,000
Landscape Units	2003	1:20,000
Biogeoclimatic ecosystem classification		
Range burns	1998	1:250,000
Wildlife burns	1999	1:50,000
Visual quality objectives	1997	1:50,000
Recreation	1998	1:20,000
Natural Disturbance Units	2003	
Graham IRMP cut-blocks and riparian	1998	1:20,000
Pulpwood Areas	1996	1:20,000
Protected Areas	2003	1:20,000
Caribou Management Zones	1989	1:50,000

Fort St. Kohn LRMP Resource	1996	1:20,000
Region / Compartment boundaries	1989	1:50,000
Watersheds		1:20,000

As closely as possible, the net down logic used to identify the timber harvesting land base (THLB) was conducted as per the TSR2 net down. To this end, the MOF's timber supply analyst was greatly supportive in assisting with programming logic. The following sections describe the net down used in the creation of the revised THLB in support of the Fort St. John SFMP analysis.

TSA Area

The Fort St. John TSA area was spatially identified. All area outside the perimeter of the TSA was excluded from the analysis. The total area of the Fort St. John TSA covers 4,676,639 ha.

Reduction for Non-Forest

Non-forest areas were excluded from the productive forest land base using the Type ID indicator codes on the forest inventory files. Type ID 6, 7, and 8 were removed from the productive forest land base.

Reductions for woodlots

Woodlots were removed from the inventory file, using a new inventory coverage that was not available for the TSR2 analysis. As a result considerably more area was removed in this analysis for woodlots. Forest area in woodlots is not used in support of biodiversity or other forest cover requirements.

Reductions for Ownership

Ownership refers to the forested and non-forested parts of the TSA for which the MOF has management jurisdiction. The MOF does not have jurisdiction over private lands, federal lands, Indian reserves and municipal areas that exist within the TSA. These areas are removed from the productive forest land base. The areas are identified on the inventory files by an ownership code. All ownership codes 1N, 40N, 52N, 61C, 61N were removed from this analysis. The remaining ownership codes (i.e., 60N, 62C, 63N, 67N, 69C, 69N, 72B, 76N, 77N) were not removed in this analysis. The total area in each ownership code is provided in Table A4.

Table A4 Land Ownership

Ownership	Schedule	Total Area
0		1.0
1	N	90.7
40	N	505,576.1
52	N	6,705.2
60	N	2,603.9

61	C	41,753.2
61	N	1,055.0
62	C	3,996,735.9
63	N	440.2
67	N	68.8
69	C	113,239.6
69	N	663.4
76	N	76.7
77	N	7,629.2
	Total	**4,676,639.0**

Reductions for Range Lease

Range lease areas were identified in the analysis using a non-standard inventory file. All areas identified as a "LEASE" were removed from the analysis area. These areas were deemed to have an agricultural value that precluded long-term timber supply planning.

Table A5 Range Classifications

Range type	Area (ha)
N/A	4,354,587.9
LEASE	13,388.2
PERMIT	308,662.9
Total	**4,676,639.0**

Reductions for Parks

Parks are identified as provincial parks, new parks, ecological reserves and recreation areas. These areas have been excluded from the timber harvesting land base, but the forests within these parks can contribute towards achieving old growth and biodiversity targets. The areas in parks are identified by ownership codes and by the non-standard inventory coverage associated with the Fort St. John Land and Resource Management Plan (LRMP). The logic used to defined parks is as follows:

1) if the ownership coded was 69N
2) if the resource management zone designation was "park" or "ecological reserve".

Wherever these conditions were met the area was classified as a park.

Reductions for Non-commercial cover

Non-commercial brush species are identified on the standard inventory files as Type ID #5. These areas are excluded from BOTH the timber harvesting land base and from contributing to the productive forest land base. A total of 192,035 ha are classified as Type ID #5 in the Fort St. John TSA.

Reductions for Unclassified roads trails and landings

In the MOF's process of completing the analysis for TSR2, existing unclassified roads and landings were spatially identified using a GIS. This spatial classification resulted in an incredibly large data-set due to the countless sliver polygons created by road buffers (as well as stream, wetland and lakeshore buffers). To simplify the analysis, the original data-set was used to determine the percent area in each polygon that should have area removed for roads (as well as in streams, wetlands and lake buffers). This percentage was then used in place of the GIS spatial reduction. These reduction values were obtained from the MOF and applied to the FIP portion of the inventory files. This information was not available for the newer VRI portion of the inventory files. To address unclassified roads in the VRI database, a TSA average reduction of 0.15156 percent was calculated using the TSR2 net-down summary table.

Reductions for Riparian Areas around Lakes and Wetlands

As with the reduction for unclassified roads and landings, a percent reduction was applied for riparian areas around lakes and wetlands. For the FIP portion of the inventory files, the reduction was polygon specific and matched the percent reduction used by the MOF. The VRI portion of the inventory file used a reduction factor of 0.34387 percent, as determined again from the TSR2 net-down table.

Reductions for Riparian Areas around Streams

Once again, in the reduction for unclassified roads and landings, a percent reduction was applied for riparian areas around single and double line streams. For the FIP portion of the inventory files, the percent reduction was polygon specific and matched the percent reduction used by the MOF. The VRI portion of the inventory file used a reduction factor of 1.66 percent as determined using the TSR2 net-down table.

Reductions for Seismic Lines

Finally, a percent reduction was applied for the corridors created by the construction of seismic lines, gas lines and hydro lines. For the FIP portion of the inventory files, the reduction was matched the percent reduction used by the MOF. The VRI portion of the inventory file used a reduction factor of 0.67004 percent as determined using the TSR2 net-down table.

Reductions for Range and Wildlife Burn Areas

Range and wildlife burn areas are managed for range and/or wildlife use. Prescribed burning is used to keep these areas in an early seral stage, and as such they do not contribute to the THLB, but are part of the productive forest. Range and wildlife burn areas were identified using a non-standard inventory file. There were 3,886 ha removed for wildlife burn areas and 27,563 ha removed for range burn areas for a total reduction of 31,449 ha.

Reductions for Inaccessible Areas

Inaccessible areas were identified in the TSR as region compartment numbers located too far from a timber processing facility to justify the hauling cost at the present time and in the foreseeable future. This analysis expands on this reduction to also include areas that would otherwise fall into the THLB, but existed in an area having a biogeoclimatic ecosystem classification of AT or ESSFmvp. There were 2,063.5 ha of AT and 12,491.0 ha of ESSF mvp for a total reduction of 14,554.5 ha.

The reductions for inaccessible areas are presented in Table A6.

Table A6 Reductions for Inaccessible Areas

Region	Compartment	Productive Forest Area (ha)
78	104	2,764
78	105	1,421
79	178	1,134
79	182	1,425
79	183	3,080
	Sub-Total	**9,824**

Biogeoclimatic Ecosystem Classification	Productive Forest Area (ha)
Alpine Forest (AT)	2,063.5
ESSF mvp (Alpine parkland)	12,491.0
Sub-Total	**14,554.5**

Reductions for Inoperable Areas

Inoperable areas are sites that are deemed to be isolated, or areas with impassable physical barriers (e.g. steep slopes). Classified by air-photo interpretation, these areas are delineated in the FIP file by the operability code “I” for inoperable. There were 20,408.4 ha removed from the THLB for inoperability. The remaining operable areas, have been categorized into one of three other operability codes (“A” for conventional, “C” for cable or “H” for cable/aerial) based upon their slope, soil/parent material and harvest system. Table A7 lists the operability codes and their associated area classifications.

Table A7 Operability

Operability	Productive Forest	Timber Harvesting
(A) Conventional	2,169,650.1	1,026,392.5
(C) Cable	86,005.8	11,954.1
(H) Aerial (heli)	109.8	9.0
(I) Inoperable	20,408.4	0
Total	**2,276,174.1**	**1,038,355.6**

Reductions for Non-merchantable Coniferous Leading Species

Non-merchantable coniferous leading types are physically operable stands that exceed minimum site criteria, are not currently utilized or have marginal merchantability. The areas removed for black spruce, hemlock and cedar leading stands are presented in Table A8.

Table A8 Coniferous Problem Forest Types

Type Group	Description	Percent	Area (ha)
21 to 26	Remove all SB leading stands	100	342,664.4
10, 16	Remove all Hw and Cw	100	35.9
Total			**342,700.3**

Reductions for Non-merchantable Deciduous Leading Species

Non-merchantable deciduous leading types are physically operable stands that exceed minimum site criteria, and are not currently utilized or have marginal merchantability. The area removed for deciduous-leading stands is presented in Table A9.

Table A9 Deciduous Problem Forest Types

Type Group(s)	Description	Percent	Forest
33, 34	Remove all larch (Lx) leading stands	100	3,213.6
35 to 38	Remove all stands with Ac > 49% (not	100	20,896.3
35, 37, 41	Remove all stands with > 30% SB	100	0
40	Remove all stands with E or Ep leading	100	39,226.4
>=35 and <=42	Remove all stands with cmc_pct < 50	100	38,089.4
>=35 and <=42	Remove all stands with operability of C or	100	24,623.1
		Total	126,048.8

Reductions for Low Productivity Species

Stands that are considered to have low productivity do meet the minimum requirements for economic merchantability. Reasons such as poor nutrient availability, exposure, excessive moisture, and so forth may cause this lower yield. There are different criteria for identifying sites with low timber growing potential. The logic used to identify mature and immature low productivity sites is identical to the logic used in the TSR2 Report for the Fort St. John TSA Tables A-10 and A-11.

Reduction for Recreation Areas

Area reductions for recreation were carried out as per the logic identified in Table A-12 in the Fort St. John TSR2 Report.

Table A10 Recreation Reductions

Feature Significance	Management Class					
	Very Sensitive		Sensitive		Not Sensitive	
	% Red	Prod. For	%	Prod. For	% Red	Prod. For
Very High	100	492.1	50	0.0	0	0.0
High	100	1,889.7	50	77,923.5	0	0.0
Moderate	100	0.0	20	66,652.7	0	47,468.5
Low	0	0.0	0	781,844.1	0	282,311.5

Reduction for ESAs

Environmentally sensitive area reduction factors remained largely unchanged from TSR2. However, the VRI portion of the inventory no longer carries an ESA classification. The reduction factors were therefore only applied to the original FIP portion of the inventory. Table A11 describes these reductions and the forested area within each ESA classification.

Table A11 Environmental Sensitive Area Reductions

ESA	Reduction	Productive Forest
Es1	90.0	38,717.1
Es2	50.0	1,094.3
Ep1 Ep2	90.0	2,436.4
Ea	90.0	0.0
Ew1	90.0	814.5
Ew2	30.0	7,165.1

Total	50,227.4

Reduction for Wildlife Tree Patches

The Fort St. John TSR2 applied wildlife tree patch reductions based upon BEC, leading species and landscape unit. The landscape units have been changed (updated) in this analysis; hence the reduction for WTPs has been changed.

Table A12 WTP reductions by Landscape Unit

Landscape Unit	% reduction for WTPs
Lower Beatton	8.0
Milligan	4.0
Kahntah	4.0
Trutch	4.0
Tommy Lakes	3.0
Blueberry	5.0
Kobes	5.0
Crying Girl	6.0
Halfway	3.0
Graham	4.0
Sikanni	4.0

Reductions for non-productive burns areas

Reductions for non-productive burn areas no longer apply to the VRI portion of the inventory, as this information should be captured in the new inventory. However, this information remains a problem in the FIP portion of the inventory. To address the fact that large areas of the TSA have had wildfires that have been classified as NSR, the TSR2 Analysis reduced the amount of NSR that could be included in the THLB by 44.6 percent. This reduction was also applied to the FIP portion of this analysis.

Resultant net land base determination

The foregoing land base reductions resulted in the productive forest land base (i.e., 2,276,290 ha) being reduced to an initial timber harvesting land base of 1,038,355 hectares (THLB1). This THLB1 area was derived as a relative comparison to the THLB reported in the MOF's TSR2. It was used to benchmark the timber supply model to evaluate the relative change in modeling assumptions. The total area of 1,038,355 ha is divided into traditional conifer, small pine, and deciduous area as indicated in Table A13.

Table A13 THLB1 – TSR2 Assessment

Timber Harvesting Land Base 1	MOF's TSR2 Net Area	Net Area (ha)
Traditional conifer	676,523	686,656
Small Pine	56,698	46,977
Deciduous	325,318	304,722
Total		**1,038,355**

Revisions to the Timber Harvesting Land Base

This analysis included an evaluation of the effect of alternative management assumptions. These assumptions lead to the creation of 3 additional THLB's for which analysis was completed. These THLBs are:

THLB1 - As defined by the TSR2 logic

1. THLB2 – Adjust the TSR2 deciduous land base to include stands previously considered problem forest types (i.e., enhanced deciduous THLB)
2. THLB3 – As per THLB1 but remove areas outside the Graham River IRMP clusters and riparian areas from contributing to the timber harvesting land base. This THLB was not utilized in the analysis for the Fort St. John SFMP.
3. THLB4 – As per THLB3 but include the enhanced deciduous THLB

The assumptions leading to the creation of these additional timber harvesting land bases are described in the sections that follow.

Enhanced Deciduous Land Base

The enhanced deciduous land base involved an assessment of deciduous stands which in the TSR2 net-down were considered problem forest types or low productivity sites. This area was added back to the deciduous THLB after reductions for ESAs, riparian reserves, unclassified roads, etc. Table A14 shows the logic used to identify these stands.

Table A14 Deciduous Area Add-Back

AU# / Leading Species	Inventory type group	Stand characteristic where operability is conventional	Productive Forest Area (ha)	Net Area added to the Enhanced Deciduous THLB (ha)
602 - Birch	40	SI >= 14.0 & age <= 70	12,995.3	4550.3
603 - Birch	40	Age >70 & volume >120		6962.5
604 - Cottonwood	35, 36	Age <101 & SI>=9.6 & Ac% >= 49	11,377.2	12,493.1
		Age >=101 Ht>=17.5 vol >=120 Ac%>=49	14,175.9	
605 - Aspen with Conifer [1]	41	Age <101 and SI >=10.5 and <13.0	33,958.7	27,792.8
606 - Aspen with Deciduous	42	Age <101 and SI >=10.5 and <14.7	91917.1	72,491.1

AU# / Leading Species	Inventory type group	Stand characteristic where operability is conventional	Productive Forest Area (ha)	Net Area added to the Enhanced Deciduous THLB (ha)
			Total	**124,289.8**

The adjustment to the deciduous low site and problem forest type definition led to the creation of THLB2. This expanded the Deciduous THLB by 124,290 hectares (a 40% increase). The coniferous land base remained unchanged. The resultant enhanced timber harvesting land base for the TSA increased 12 percent to 1,162,645 ha.

Table A15 THLB2 - Deciduous Enhanced

Timber Harvesting Land Base 2	Net Area (ha)
Traditional conifer	686,656
Small Pine	46,977
Deciduous	429,012
Total	**1,162,645**

Graham River IRMP Adjustment

The SFMP is cognizant of the effort expended by Canfor on the development of the Graham River Integrated Resource Management Plan (IRMP). Through consultation with all stakeholders, a spatial long-term harvest plan was constructed and scheduled in a manner that met the concerns of other resource users. Cut-blocks were developed and "clustered" based upon the natural disturbance guidelines of the time. Riparian areas between the cut blocks were incorporated into the "clusters" and minimum extractions rules were applied. All areas outside the clusters, though merchantable under normal TSR net-down rules, were excluded from future harvest consideration. To incorporate this IRMP into the THLB for this analysis, the area outside defined riparian zones and clusters were identified and removed from the THLB. This was done first as an adjustment to THLB1 and created THLB3. It was then also applied to the enhanced deciduous land base and created a final THLB4. Table A16 describes the adjustment to the net-down logic and the area affected by the adjustment.

Table A16 Graham IRMP Area Adjustment

IRMP Area	Location	Reduction	THLB1	THLB2 Area
Inside Clusters	Graham LU and Omineca NDU or Crying Girl LU	0%	3505.4	3446.5
Defined Riparian Area outside clusters		0%	869.5	889.2
Outside clusters and riparian		100%	8514.5	8627.6
		Total	**12889.4**	**12963.3**

As a result of these adjustments, the THLB1 area was reduced by 8514.5 hectares to create THLB3 (IRMP adjusted), and the THLB2 (enhanced deciduous) land base was reduced by 8627.6 ha to create THLB4 (enhanced deciduous, IRMP adjusted).

The changes to the THLB as a result of the Graham River IRMP led to the definition of two additional THLB determinations. The area for each land base is described in Tables A17 and A18.

Table A17 TSR2 THLB adjusted for Graham IRMP

Timber Harvesting Land Base 3	**Net Area (ha)**
Traditional conifer	674,025.9
Small Pine	46,668.4
Deciduous	304,564.3
Total	**1,025,258.6**

Table A18 TSR2 THLB Adjusted for Enhanced Deciduous and the Graham IRMP

Timber Harvesting Land Base 4	**Net Area (ha)**
Traditional conifer	674,025.9
Small Pine	46,668.4
Deciduous	428,716.8
Total	**1,149,411.1**

These four timber harvesting land bases set the stage upon which several management alternatives were assessed.

Future Roads Trails and landings

A loss to future roads trails and landings of 0.6 percent was applied to all unmanaged stands in Scenario 1. This assumption matched the reduction used in the TSR2 Base Case. In scenarios 2 -5 the percent reduction was changed to 6.39 percent of all unmanaged stands greater than 30 years age.

Section 2 Management Assumptions

Management assumptions are used to tell the computer when it is allowed to first consider an area eligible for harvesting and then to harvest an area. The assumptions also explicitly define what happens to an area after it is harvested.

Analysis Units

The analysis units used in this report are the same as was used in TSR2. However, because of the inclusion of a new inventory on over 12 percent of the land base, and slight differences in the programming logic used to define the analysis units, the area within each analysis unit differs from the areas reported in TSR2.

Five new analysis units were also developed. These analysis units were devised to represent the area added-back to the deciduous THLB and described the enhanced deciduous land base. The definition for these 5 analysis units was provided in Table A14. The definition for the remaining analysis units is provided in Table A19. The area in each analysis unit (applicable to THLB4) is shown in Table A20.

The conversion of unmanaged stand analysis units to managed stand analysis units is the same in all scenarios. The conversion matches the TSR2 Report.

Table A19 Definition of Analysis Units

AU#	Name	ITG	1st	1st	2nd	site	Age	height	harvest	logging
11	Sw g old	18-21	n/a	n/a	n/a	>14	>140	n/a	A	none
12	Sw m old	18-21	n/a	n/a	n/a	>9.7 &	>140	n/a	A	none
13	Sw p old	18-21	n/a	n/a	n/a	<= 9.7	>140	n/a	A	none
14	Sw g y/t	18-21	n/a	n/a	n/a	>15.5	<=140	n/a	A	none
15	Sw m y/t	18-21	n/a	n/a	n/a	>9.7 &	<=140	n/a	A	none
16	Sw p y/t	18-21	n/a	n/a	n/a	<= 9.7	<=140	n/a	A	none
21	Pl all old	28	n/a	n/a	n/a	n/a	>140	>=19.4	A	none
24	Pl g thrifty	28	n/a	n/a	n/a	>18.5	>30	>=19.4	A	none
25	Pl m thrifty	28	n/a	n/a	n/a	>15.5 &	>30	>=19.4	A	none
26	Pl p thrifty	28	n/a	n/a	n/a	<=15.5	>30	>=19.4	A	none
28	Pl gm young	28	n/a	n/a	n/a	>14	<=30	n/a	A	none
29	Pl p young	28	n/a	n/a	n/a	<=14	<=30	n/a	A	none
31	Small Pl All old	28	n/a	n/a	n/a	n/a	>140	>=17.7	A	none
34	Small Pl good	28	n/a	n/a	n/a	>12.5	> 80 and	>=17.7	A	none
35	Small Pl	28	n/a	n/a	n/a	<=12.5	> 80 and	>=17.7	A	none
51	Aspen g all	42,41	n/a	> 80	n/a	>21	n/a	n/a	A	none
52	Aspen m all	42,41	n/a	> 80	n/a	>15.5 &	n/a	n/a	A	none
53	Aspen p all	42,41	n/a	> 80	n/a	<=15.5	n/a	n/a	A	none
61	Sw/At g old	22-26	n/a	n/a	AT	>14.5	>140	n/a	A	none
62	Sw/At m old	22-26	n/a	n/a	AT	<=14.5	>140	n/a	A	none
64	Sw/At g yt	22-26	n/a	n/a	AT	>18	<=140	n/a	A	none
65	Sw/At m yt	22-26	n/a	n/a	AT	>14.5 &	<=140	n/a	A	none
66	Sw/At p yt	22-26	n/a	n/a	AT	<=14.5	<=140	n/a	A	none
71	Sw/other g old	22-26	n/a	n/a	not= AT	>14	>140	n/a	A	none
72	Sw/other m old	22-26	n/a	n/a	not= AT	>9.9	>140	n/a	A	none
73	Sw/other p old	22-26	n/a	n/a	not= AT	<=9.9	>140	n/a	A	none
74	Sw/other g yt	22-26	n/a	n/a	not= AT	>18	<=140	n/a	A	none
75	Sw/other m yt	22-26	n/a	n/a	not= AT	>14.5 &	<=140	n/a	A	none
76	Sw/other p yt	22-26	n/a	n/a	Not= AT	<=14.5	<=140	n/a	A	none
81	Pl/At all old	29-31	n/a	n/a	AT		>140	n/a	A	none
84	Pl/At g yt	29-31	n/a	n/a	AT	>20	<=140	n/a	A	none
85	Pl/At medium	29-31	n/a	n/a	AT	>16 &	<=140	n/a	A	none
86	Pl/At p yt	29-31	n/a	n/a	AT	<=16	<=140	n/a	A	none
91	Pl/other gm old	29-31	n/a	n/a	not= AT	>13.8	>140	n/a	A	None
93	Pl/other p old	29-31	n/a	n/a	not= AT	<=13.8	>140	n/a	A	none
94	Pl/other good	29-31	n/a	n/a	not= AT	>17	>30	n/a	A	none
				1st	2nd	site			harvest	logging

AU#	Name	ITG	1st	1st	2nd	site	Age	height	harvest	logging
95	Pl/other	29-31	n/a	n/a	not= AT	>13.8 &	>30	n/a	A	none
96	Pl/other poor	29-31	n/a	n/a	not= AT	<=13.8	>30	n/a	A	none
97	Pl/other all y	29-31	n/a	n/a	not= AT		<=30	n/a	A	none
101	At/Sw good all	41	n/a	<= 80	S	>19	n/a	n/a	A	none
102	At/Sw medium	41	n/a	<= 80	S	>15 &	n/a	n/a	A	none
103	At/Sw poor all	41	n/a	<= 80	S	<=15	n/a	n/a	A	none
111	At/Pl good all	41	n/a	<= 80	PL	>19.5	n/a	n/a	A	none
112	At/Pl medium	41	n/a	<= 80	PL	>15 &	n/a	n/a	A	none
113	At/Pl poor all	41	n/a	<= 80	PL	<=15	n/a	n/a	A	none
121	At/Mix good all	35, 36	n/a	n/a	n/a	>19.5	n/a	n/a	A	n/a
		41, 42	n/a	<= 80	not= PL	>19.5	n/a	n/a	A	n/a
122	At/Mix medium all	35, 36	n/a	n/a	n/a	>15 &	n/a	n/a	A	n/a
		41, 42	n/a	<= 80	not= PL	>15 &	n/a	n/a	A	n/a
123	At/Mix poor all	35, 36	n/a	n/a	n/a	<=15	n/a	n/a	A	n/a
		41, 42	n/a	<= 80	not= PL	<=15	n/a	n/a	A	n/a
511	Sw all old	18-21	n/a	n/a	n/a	n/a	>140	n/a	C /H	none
514	Sw all thrifty/y	18-21	n/a	n/a	n/a	n/a	<=140	n/a	C /H	none
521	Pl/Mix all all	28,29,	n/a	n/a	n/a	n/a	n/a	n/a	C /H	none
561	Sw/Mix all all	22-26	n/a	n/a	n/a	n/a	n/a	n/a	C /H	none
1001	Managed Sw	18-21	n/a	n/a	n/a	n/a	n/a	n/a	A	L
1002	Managed Pl	28	n/a	n/a	n/a	n/a	n/a	n/a	A	L
1006	Managed Sw/At	22-26	n/a	n/a	AT	n/a	n/a	n/a	A	L
1007	Mngd Sw/other	22-26	n/a	n/a	not= AT	n/a	n/a	n/a	A	L
1008	Managed Pl/At	29-31	n/a	n/a	AT	n/a	n/a	n/a	A	L
1009	Mngd Pl/other	29-31	n/a	n/a	not= AT	n/a	n/a	n/a	A	L
1551	M unconv Sw	18-21	n/a	n/a	n/a	n/a	n/a	n/a	C / H	L
1552	M unconv	28-31	n/a	n/a		n/a	n/a	n/a	C / H	L
1556	M unconv	22-26	n/a	n/a		n/a	n/a	n/a	C / H	L

Table A20 Analysis Unit Area

AU#	Species	THLB4 Area (ha)	AU#	Species	THLB4 Area (ha)
11	Sw g old	16,287	91	Pl/other gm old	4,801
12	Sw m old	17,902	93	Pl/other p old	8,465
13	Sw p old	34,957	94	Pl/other good thrifty	12,583
14	Sw g y/t	35,656	95	Pl/other medium thrifty	43,346
15	Sw m y/t	36,270	96	Pl/other poor thrifty	56,398
16	Sw p y/t	4,938	97	Pl/other all y	670
21	Pl all old	4,374	101	At/Sw good all	15,314
24	Pl g thrifty	22,420	102	At/Sw medium all	32,981
25	Pl m thrifty	43,032	103	At/Sw poor all	9,639
26	Pl p thrifty	25,713	111	At/Pl good all	12,702
28	Pl gm young	11,533	112	At/Pl medium all	24,942
29	Pl p young	400	113	At/Pl poor all	5,866
31	Small Pl All old	1,805	121	At/Mix good all	7,210
34	Small Pl good thrifty	25,181	122	At/Mix medium all	18,689
35	Small Pl medium poor thrifty	19,682	123	At/Mix poor all	3,676
51	Aspen g all	20,323	511	Sw all old	2,728
52	Aspen m all	131,037	514	Sw all thrifty/y	2,463
53	Aspen p all	22,185	521	Pl/Mix all all	1,380
61	Sw/At g old	8,878	561	Sw/Mix all all	4,226
62	Sw/At m old	6,742	602	Birch medium	4,550
64	Sw/At g yt	12,763	603	Birch good	6,962
65	Sw/At m yt	25,086	604	Cottonwood	12,493
66	Sw/At p yt	13,820	605	Aspen-conifer PFT	27,712
71	Sw/other g old	6,573	606	Aspen - PFT	72,435
72	Sw/other m old	8,585	1001	Managed Sw	18,135
73	Sw/other p old	14,807	1002	Managed Pl	8,940
74	Sw/other g yt	8,580	1006	Managed Sw/At	9,067
75	Sw/other m yt	16,683	1007	Mngd Sw/other	13,531
76	Sw/other p yt	32,230	1008	Managed Pl/At	2,656
81	Pl/At all old	4,633	1009	Mngd Pl/other	2,892
84	Pl/At g yt	8,348	1551	M unconv Sw	75
85	Pl/At medium young/thrifty	32,816	1552	M unconv Pl/mix	22
86	Pl/At p yt	27,500	1556	M unconv Sw/mix	121
				Total Area All Analysis Units in THLB4	**1,149,411**

Notes:
Quality: g = good, m = medium, p = poor
Age: y or yt = young,
PFT = previously defined as a problem forest type

Forest Cover Constraints

Forest cover constraints are used in the timber supply analysis to constrain harvesting within certain spatially defined geographic areas. Constraints are used when consideration is being given to other resource values. Generally there are two types of forest cover constraints.

- Group 1 constraints restrict harvesting when a specified percent of the area is less than a prescribed green up age or height. Harvesting is not allowed to take place when a Group 1 constraint is broken in an area.

- Group 2 constraints are used to ensure that a specified minimum amount of area is greater than a target age. These are typically old growth constraints used for thermal cover or biodiversity. Harvesting can take place in a specified zone if this constraint is not currently met. An appropriate amount of the oldest stands closest to the target age is reserved from harvesting in order to eventually meet this management objective. If sufficient merchantable area exists above the minimum harvest age and is not required for the old growth objective, then this area is available to harvest.

The forest cover constraints for the Base Case and for all scenarios with respect to visually sensitive areas and caribou habitat remain unchanged from TSR2. These constraints are described in Tables A-22, A-23 and A-25 of the TSR2 Fort St. John TSA Analysis Report June 2002.

This analysis utilizes new forest cover requirements with regard to natural disturbance units and watersheds. When modeling according to NDU guidelines, the adjacency constraint for the IRM zone is removed for the analysis. Table A21 shows the forest cover constraints by NDU.

Scenario 1 in this analysis used FPC Biodiversity NDT targets as per the TSR2 Report. Scenarios 2 and 3 used NDU constraints and a low BEO. Scenarios 4 and 5 used NDU constraints and a BEO as per Table A21 and A22.

Table A21 NDU Forest Cover Constraints

NDU Classification	Minimum % Area ≥ 140 years		
	Low BEO	Inter BEO	High BEO
Boreal foothills Mt	33	41	49
Boreal foothills valley	23	32	40
Boreal plains - alluvial - conifer	44	51	57
Boreal plains - Upland - Conifer	17	25	33
Northern boreal mountains	37	49	60
Omineca - mountain	58	64	69
Omineca - Valley	23	32	40
Boreal plains - alluvial - deciduous	10	15	20
Boreal plains - Upland - deciduous	10	15	20

Table A22 Landscape Unit BEOs

Landscape Unit Name	Recommended Biodiversity Emphasis Option	Landscape Unit Name	Recommended Biodiversity Emphasis Option
Graham	High	Milligan	Intermediate
Halfway	Low	Trutch	Intermediate
Sikanni	High	Blueberry	Low
Crying Girl	Intermediate	Lower Beatton	Intermediate
Kahntah	Intermediate	Tommy Lakes	Low
Kobes	Low		

Minimum Harvest Ages

Table A23 provides the minimum harvest ages used for all scenarios in this analysis. The logic used to determine these minimum harvest ages follows the information provided in the TSR2 Report.

Table A23 Minimum Harvest Ages

AU	MHA	AU	MHA	AU	MHA	AU	MHA
11	72	75	79	1005	114	2076	98
12	97	76	102	1006	81	2081	73
13	169	81	83	1007	81	2084	51
14	67	84	53	1008	78	2085	59
15	93	85	67	1009	78	2081	73
16	127	86	83	1051	58	2093	98
21	74	91	67	1052	78	2097	88
24	51	93	109	1053	114	2101	51
25	64	94	55	1056	71	2102	64
26	74	95	71	1551	90	2103	85
28	66	96	103	1552	136	2511	108
29	104	97	69	1556	94	2514	76
31	120	101	55	2011	61	2521	78
34	88	102	68	2012	85	2561	69
35	105	103	83	2013	151	602	71
51	53	111	54	2014	56	603	61
52	69	112	67	2021	69	604	56
53	114	113	93	2024	51	605	100
61	81	121	56	2025	51	606	90
62	108	122	70	2026	62	888	61
64	66	123	90	2029	103	887	61
65	79	511	147	2031	118	886	61
66	102	514	98	2034	75	2602	71
71	79	521	98	2035	96	2603	61
72	100	561	110	2061	69	2604	56
73	153	1001	71	2064	53	2605	100
74	63	1002	68	2073	148	2606	90

Watersheds

ECA constraints on a watershed are typically applied incrementally with varying targets applied to varying tree heights. As a plantation grows the hydrologic recovery of the watershed increases as a consequent. If an ECA target is placed on a watershed, then the maximum area that can be in a denuded state is that target number. However, as portions of the harvested area regenerate into plantations of varying height, the amount of total area with less than 100% hydrologic recovery increases. It is estimated in the Code Interior Watershed Assessment Procedure Guidebook that with each 3-metre increase in plantation height, hydrologic recovery improves by 25 percent. This then can be translated into a 25% increase in the Group 1 constraint in the Forest Estate Model FSSIM.

The following table shows the guidelines used in the application of ECA constraints in the Fort St. John TSA. When reference is made in this document to an ECA constraint, the maximum amount of forest area below three metres is the target number referred to. Additional constraints increasing by 25 percent increments every three metres to a regenerated stand height of nine metres is inferred, and was applied in all of the applicable harvest scenarios examined.

Table A24 Calculating ECA Targets (example)

Average Height (m)	"Trigger Height"	Average Age to Achieve Height (years)	Hydrologic Recovery (IWAP) (%)	Maximum ECA Constraint		
				30%	20%	10%
0 - < 3 m	0	0	0%	n/a	n/a	n/a
3 - < 5m	3	16	25%	30% < 16 yrs	20% < 16 yrs	10% < 16 yrs
5 - < 7 m	5	24	50%	37.5% < 24 yrs	25% < 24 yrs	12.5% < 24 yrs
7 - < 9 m	7	30	75%	45% < 30 yrs	30% < 30 yrs	15% < 30 yrs
9 m +	9	35	90%	52.5% < 35 yrs	35% < 35 yrs	17.5% < 35 yrs

In this analysis watersheds were identified using a three string code. The first character denotes the ECA target. The second character, the watershed region and the third character denoted the watershed number or drainage. Table A25 describes the code logic. Table A26 describes the area in each watershed.

Table A25 Watershed code

ECA	Watershed Group	Watershed number
25 = 2	FONT = F	L1 = Z
30 = 3	KAHN = K	L2 = Y
35 = 8	LHAF = L	L3 = X
40 = 4	LSIK = S	S1 = 1
50 = 5	MILL = M	S2 = 2
	UBTN = B	S3=3
	UHAF = H	S4=4
	UPRO = P	S5=5
	USIK = U	S6=6
	UPCE = E	S7=7
	None =N	S8=8
		S9=9
		S10=A
		S11=B
		S12=C
		S13=D
		S0=0

Table A26 Forested Area by Watershed

Watershed	Forest Area (ha)	Watershed	Forest Area (ha)	Watershed	Forest Area (ha)
3H1	14,529	4FY	5,434	5S6	25,644
3H2	17,443	4FZ	13,984	8B1	10,595
3H3	11,635	4K2	12,628	8BA	2,678
3H5	21,072	4K4	12,182	8EO	31,338
3H6	17,131	4KY	16,962	8HX	31,097
3H8	5,916	4L8	23,900	8L1	16,396
3HY	25,518	4M2	16,290	8L2	23,308
3HZ	26,593	4M4	13,940	8L3	19,440
3L7	28,955	4MZ	15,241	8L4	35,255
3LY	48,806	4N0	66,400	8L5	9,979
3P2	3,262	4NZ	80,739	8L9	14,272
3P5	4,726	4S1	16,032	8LA	30,360
3PY	5,726	4S4	2,259	8LB	9,413
4B2	22,526	4S5	18,748	8LC	16,556
4B4	25,233	4S7	3,925	8LZ	26,050
4B5	13,001	4S8	2,582	8N0	172,111
4B6	32,115	4S9	6,370	8P3	7,549
4B7	9,297	4SX	16,104	8PZ	5,428
4B8	27,399	4SY	21,688	8S2	10,389
4B9	5,055	4UA	9,207	8U1	16,533
4BB	16,520	4UD	25,399	8U2	6,712
4F1	1,638	5K5	3,092	8U4	4,173
4F2	4,043	5KI	5,298	8U5	17,242
4F3	5,395	5KZ	24,829	8U6	12,056

Watershed	Forest Area (ha)	Watershed	Forest Area (ha)	Watershed	Forest Area (ha)
4F4	6,461	5M1	926	8U8	11,283
4F5	4,309	5M3	15,125	8U9	15,882
4F7	4,228	5M5	4,044	8UB	14,594
4F8	11,461	5M6	6,555	8UC	51,572
4FX	13,949	5N0	3,391	8UZ	19,046

Forest cover constraints were determined for each watershed area. The area-weighted site index in each watershed group was used to calculate the average years to green-up for all species at green-up heights of 3, 5, 7, and 9 metres. These green-up ages are provided in Table A27. The rate of hydrologic recovery is shown in Table A28.

Table A27 Years to Greenup by Watershed Group

# of Years to Green up				
H2O Group	**3m**	**5m**	**7m**	**9m**
Upper Beatton	16	24	32	41
Upper Peace	13	19	25	31
Fontas	16	22	29	36
Halfway	23	32	41	50
Kahntah	12	18	23	29
Lower Halfway	15	21	28	34
Milligan	12	16	24	30
Lower Peace	13	18	23	29
Upper Prophet	23	33	43	53
Lower Sikanni	12	18	23	29
Upper Sikanni	19	27	36	46

Table A28 Rate of Hydrologic Recovery by ECA

	Average Ht (m)	3	5	7	9
ECA %	Hydrologic recovery %	0%	25%	50%	75%
25		25	31	37	44
30		30	38	45	52
35		35	44	53	61
40		40	50	60	70
50		50	62	75	88

Graham River IRMP

Cut block clusters in the Graham IRMP were scheduled for harvest according to the timing shown in Table A29. Defined riparian areas within the IRMP were given a forest cover adjacency constraint such that during any harvest period there as a maximum of 10 percent of the forest area less than 40 years age.

Table A29 Graham River Clusters

Cluster #	Harvest decade	Forest Area (ha)	THLB (ha)
1	1	1,891.3	1,183.8
2	1	2,137.5	824.7
3	1	2,333.7	590.7
4	1	3,793.6	1,263.4
5	1	2,206.1	1,338.8
17	1	622.9	216.2
6a	1	2,420.9	1,017.4
6b	1	812.5	594.7
6c	1	691.5	367.8
sub-total		16,910.2	7,397.5
7	2	1,840.1	638.2
9	2	914.9	577.7
10	2	821.7	486.9
11	2	1,737.9	810.9
8a	2	1,769.1	974.3
8b	2	2,031.4	1,267.0
sub-total		9,115.1	4,755.1
12	3	3,299.5	2,261.6
13	3	2,340.7	1,375.3
14	3	2,640.4	1,919.2
15	3	3,012.3	1,850.0
sub-total		11,293.0	7,406.1
16	4	1,970.7	1,083.5
18	4	1,241.0	703.1
19	4	2,923.2	1,825.4
sub-total		6,134.8	3,611.9
20	5	1,301.4	852.6
	Total	**44,754.4**	**24,023.2**

Cycling the NCLB

In Scenario 1, the NCLB was cycled according to the TSR2 analysis, which cycled 5,000 ha per year. In all other scenarios the NCLB was cycled according to the rates show in Table A30. These vales were derived using the report: Natural Disturbance Units of the Prince George Forest Region: Guidance for Sustainable Forest Management, 2002. DeLong, Unpublished 2002.

Table A30 NDU Area in NCLB cycled annually

NDU	Area cycled per year (ha)
Omineca - Valley	72
Omineca - mountain	23
Northern boreal moutains	55
Boreal foothills valley	16
Boreal foothills Mt	99
Boreal plains - Upland - deciduous	177
Boreal plains - Upland - Conifer	657
Boreal plains - alluvial - deciduous	3
Boreal plains - alluvial - conifer	3
Total	**1105**

Wildlife and Range Burn Areas

Range and wildlife burn areas have been spatially identified on the inventory file. During the running of all simulations, the stand ages in these areas were re-assigned to age 20 over the first 30-year period. Thereafter, every stand that reached the age of 60 was reassigned an age of 20

There are 31,449 hectares of forest land that does not contribute to the THLB and is cycled on a 60-year rotation for wildlife and range burns.

Section 3 Growth and Yield

Yield tables for most analysis units are identical to the tables used in Tables A-27 and A-28 in the Fort St. John TSR2 Analysis Report. Only the yield tables for previously excluded deciduous stands were created using VDYP. These yield tables are provided in Table A31 following.

Deciduous Yield Tables

Scenarios 2-5 in the analysis changed the longevity of deciduous leading stands. As Table A31 shows, birch stands (AU#s 602 and 603) were assumed to yield merchantable volume until 110 years of age. All other deciduous stands were assumed to yield merchantable volume until 150 years of age. The logic for this is in current age class distributions for deciduous stands, wherein almost no area exists in deciduous stands greater than 140 years of age. Deciduous stands that reached an age of 150 years without being harvested were transferred to immature deciduous stands having a reversion age of 5 years.

Table A31 Enhanced deciduous land base yield tables

Age	602	603	604	605	606
0	0	0	0	0	0
10	0	0	0	0	0
20	0	0	0	0	0
30	0	0	1	0	0
40	27	35.1	25	0	14
50	61	79.3	89	11	39
60	91	118.3	141	37	64
70	118	153.4	186	62	85
80	141	183.3	224	84	103
90	163	211.9	257	104	119
100	182	236.6	285	121	132
110	199	258.7	310	137	142
120	0	0	331	151	149
130	0	0	350	162	156
140	0	0	365	171	162
150	0	0	379	178	164
160	0	0	0	0	0

Carbon Cycling

Volume tables that reflect carbon cycling were created using the FORECAST model by Brad Seely. These tables were used to predict the total amount of carbon in the TSA over time and the rate of carbon sequestration. Carbon volume tables were created for the TSA and matched to existing analysis units. The age class distribution for each analysis unit in each period was then multiplied by the corresponding carbon volume in the appropriate carbon table and age class.

The relationship between analysis units and carbon table identifiers is shown in Table A32. Carbon for the NCLB was apportioned according to the proportions identified in the last column of Table A32.

Table A33 shows the total amount of ecosystem carbon (Mg C ha-1) and the carbon sequestration rate (Mg C ha-1 yr-1) for each carbon identified table.

Table A32 Carbon table ID versus AU# associations

Carbon Table	Analysis unit	Carbon Table	Analysis unit	Carbon Table	NCLB Analysis unit	Proportion
1	13,16,511	25	101	15	886 & 888	0.0402911
2	12,15	26	113, 913	30	886 & 888	0.2411666
3	11,14,514	27	112,914	11	886 & 888	0.0335798
4	21, 26, 29, 31, 34, 35	28	111	10	886 & 888	0.0190432
5	25,28	29	915	18	886 & 888	0.0485414
6	24	30	902, 887	31	886 & 888	0.2278847
7	53, 123, 602, 605, 606, 909, 910	31	906	21	886 & 888	0.0365591
8	52, 122,604	32	2013, 2511, 2073	20	886 & 888	0.0241764
9	51, 121,603	33	2012	7	886 & 888	0.0550105
10	62, 66,904	34	2011, 2014, 2514, 1001, 2551, 1551	8	886 & 888	0.1495651
11	61,65, 903	35	2021, 2026, 2029, 2031, 2034, 2035	23	886 & 888	0.0114413
12	64	36	2025, 1002	24	886 & 888	0.0283407
13	73	37	2024	26	886 & 888	0.013997
14	72, 561	38	2076	27	886 & 888	0.0194131
15	71, 901	39	2061, 1056, 1006, 1007, 1556, 2521	29	886 & 888	0.0509898
16	74	40	2064			
17	76,93,96	41	2561, 2093,2081			
18	75, 91, 95, 97, 905	42	1008, 1009, 2097			
19	94	43	2084, 2085, 1552, 2552			
20	81,86,908	44	1053			
21	521,907	45	1052			
22	84,85	46	1051			
23	103, 911	47	2103			
24	102, 912	48	2102			
		49	2101			

Table A33 Ecosystem Carbon and Sequestration Rate by Carbon ID

Year	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10
1	117.0	0.0	170.1	0.0	199.9	0.0	151.3	0.0	234.2	0.0	225.5	0.0	151.0	0.0	234.2	0.0	225.7	0.0	151.1	0.0
10	98.2	-1.9	145.0	-2.5	174.5	-2.5	125.5	-2.6	200.5	-3.4	203.1	-2.2	124.6	-2.6	201.8	-3.2	206.5	-1.9	123.3	-2.8
20	85.2	-1.3	127.2	-1.8	156.8	-1.8	113.0	-1.2	184.9	-1.6	205.1	0.2	111.9	-1.3	189.2	-1.3	213.9	0.7	104.8	-1.8
30	75.6	-1.0	114.4	-1.3	142.8	-1.4	112.5	-0.1	179.3	-0.6	225.1	2.0	110.9	-0.1	182.8	-0.6	226.8	1.3	98.6	-0.6
40	69.3	-0.6	105.5	-0.9	132.6	-1.0	117.9	0.5	184.6	0.5	244.5	1.9	117.1	0.6	186.7	0.4	240.5	1.4	100.2	0.2
50	67.1	-0.2	101.6	-0.4	127.8	-0.5	129.8	1.2	198.8	1.4	267.2	2.3	130.2	1.3	200.7	1.4	255.0	1.5	109.2	0.9
60	70.0	0.3	104.0	0.2	130.9	0.3	145.8	1.6	219.8	2.1	289.3	2.2	146.5	1.6	216.6	1.6	269.0	1.4	123.3	1.4
70	77.5	0.7	112.6	0.9	141.6	1.1	161.5	1.6	240.3	2.0	308.4	1.9	160.9	1.4	231.7	1.5	280.1	1.1	139.2	1.6
80	87.6	1.0	125.8	1.3	158.0	1.6	174.1	1.3	255.1	1.5	320.1	1.2	171.3	1.0	244.2	1.3	287.0	0.7	153.7	1.5
90	97.9	1.0	139.7	1.4	175.7	1.8	185.0	1.1	266.1	1.1	327.8	0.8	178.4	0.7	253.0	0.9	291.8	0.5	166.5	1.3
100	107.6	1.0	152.8	1.3	192.3	1.7	195.9	1.1	276.2	1.0	335.4	0.8	182.2	0.4	256.1	0.3	292.9	0.1	176.4	1.0
110	116.7	0.9	164.7	1.2	207.2	1.5	205.8	1.0	285.2	0.9	342.6	0.7	184.1	0.2	255.0	-0.1	290.9	-0.2	184.5	0.8
120	125.4	0.9	175.9	1.1	220.8	1.4	212.2	0.6	291.5	0.6	347.0	0.4	186.9	0.3	255.9	0.1	290.5	0.0	192.2	0.8
130	133.5	0.8	185.9	1.0	233.0	1.2	211.8	0.0	290.2	-0.1	343.3	-0.4	189.5	0.3	258.1	0.2	290.6	0.0	199.3	0.7
140	141.1	0.8	195.1	0.9	244.0	1.1	207.6	-0.4	285.4	-0.5	335.7	-0.8	192.4	0.3	261.4	0.3	292.1	0.2	206.0	0.7
150	148.3	0.7	203.6	0.8	253.9	1.0	202.2	-0.5	279.5	-0.6	327.2	-0.9	194.9	0.2	265.6	0.4	294.7	0.3	212.3	0.6
160	154.6	0.6	210.8	0.7	262.0	0.8	196.2	-0.6	272.5	-0.7	317.7	-0.9							217.9	0.6
170	158.9	0.4	215.9	0.5	267.3	0.5	189.2	-0.7	264.6	-0.8	307.4	-1.0							221.8	0.4
180	162.3	0.3	219.7	0.4	271.0	0.4	181.6	-0.8	256.0	-0.9	296.5	-1.1							224.9	0.3
190	165.6	0.3	223.3	0.4	274.7	0.4	173.5	-0.8	247.3	-0.9	285.3	-1.1							228.0	0.3
200	168.8	0.3	226.7	0.3	278.4	0.4	167.6	-0.6	242.6	-0.5	278.2	-0.7							231.0	0.3

Year	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20
1	234.0	0.0	224.9	0.0	116.9	0.0	151.1	0.0	233.9	0.0	225.0	0.0	151.2	0.0	234.0	0.0	225.3	0.0	151.2	0.0
10	196.0	-3.8	196.6	-2.8	98.2	-1.9	122.1	-2.9	194.4	-3.9	194.7	-3.0	123.6	-2.8	197.1	-3.7	199.9	-2.5	125.2	-2.6
20	170.2	-2.6	186.9	-1.0	85.2	-1.3	100.4	-2.2	164.5	-3.0	177.4	-1.7	105.9	-1.8	173.4	-2.4	194.6	-0.5	112.7	-1.3
30	156.9	-1.3	195.7	0.9	76.0	-0.9	88.4	-1.2	146.2	-1.8	171.6	-0.6	100.3	-0.6	162.4	-1.1	206.1	1.2	112.1	-0.1
40	154.4	-0.3	210.6	1.5	70.4	-0.6	83.3	-0.5	138.3	-0.8	175.3	0.4	101.6	0.1	162.3	0.0	224.7	1.9	117.9	0.6
50	163.2	0.9	224.0	1.3	68.9	-0.2	85.0	0.2	142.6	0.4	190.0	1.5	110.1	0.8	172.8	1.0	243.8	1.9	130.6	1.3
60	178.5	1.5	234.1	1.0	72.9	0.4	92.3	0.7	153.6	1.1	199.4	0.9	123.9	1.4	190.6	1.8	261.6	1.8	147.4	1.7
70	199.6	2.1	241.4	0.7	81.0	0.8	102.4	1.0	170.3	1.7	213.1	1.4	138.5	1.5	211.7	2.1	275.0	1.3	163.9	1.7
80	221.0	2.1	243.3	0.2	91.3	1.0	113.2	1.1	190.9	2.1	228.7	1.6	151.2	1.3	230.8	1.9	285.9	1.1	177.3	1.3
90	239.9	1.9	246.7	0.3	101.5	1.0	124.2	1.1	213.9	2.3	243.8	1.5	163.1	1.2	247.9	1.7	298.0	1.2	188.1	1.1
100	255.2	1.5	258.7	1.2	111.5	1.0	135.0	1.1	234.4	2.0	261.1	1.7	174.7	1.2	263.5	1.6	308.7	1.1	196.6	0.8
110	267.7	1.3	271.4	1.3	120.9	0.9	145.1	1.0	251.9	1.8	276.3	1.5	185.6	1.1	277.0	1.3	317.1	0.8	202.2	0.6
120	279.3	1.2	284.9	1.3	129.7	0.9	154.4	0.9	267.7	1.6	289.3	1.3	195.1	0.9	288.7	1.2	324.8	0.8	207.2	0.5
130	289.6	1.0	297.3	1.2	137.3	0.8	162.1	0.8	281.2	1.4	300.9	1.2	200.5	0.5	295.8	0.7	331.5	0.7	209.6	0.2
140	297.9	0.8	309.7	1.2	144.2	0.7	168.7	0.7	292.8	1.2	313.4	1.3	203.7	0.3	300.5	0.5	332.5	0.1	210.4	0.1
150	304.5	0.7	315.1	0.5	150.6	0.6	174.7	0.6	302.5	1.0	316.8	0.3	206.1	0.2	304.9	0.4	329.9	-0.3	210.4	0.0
160	309.7	0.5	317.1	0.2	155.8	0.5	179.5	0.5	309.4	0.7	317.6	0.1	207.4	0.1	308.9	0.4	325.6	-0.4	209.7	-0.1
170	294.7	-1.5	316.3	-0.1	159.2	0.3	182.4	0.3	312.0	0.3	315.9	-0.2	207.7	0.0	309.0	0.0	319.6	-0.6	208.9	-0.1
180	291.2	-0.4	314.6	-0.2	161.5	0.2	184.3	0.2	312.6	0.1	313.6	-0.2	207.4	0.0	304.0	-0.5	313.1	-0.6	207.7	-0.1
190	286.5	-0.5	314.1	-0.1	163.9	0.2	186.2	0.2	313.5	0.1	312.3	-0.1	207.2	0.0	298.0	-0.6	307.3	-0.6	205.0	-0.3
200	283.1	-0.3	314.5	0.0	166.7	0.3	188.2	0.2	309.4	-0.4	311.9	0.0	206.9	0.0	291.3	-0.7	301.9	-0.5	202.4	-0.3

Year	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30
1	151.2	0.0	225.4	0.0	151.1	0.0	234.0	0.0	225.2	0.0	151.1	0.0	234.1	0.0	225.5	0.0	46.1	0.0	116.9
10	125.2	-2.6	202.5	-2.3	124.5	-2.7	198.4	-3.6	199.6	-2.6	125.6	-2.6	200.8	-3.3	203.0	-2.2	38.8	-0.7	98.2
20	112.7	-1.3	205.4	0.3	110.8	-1.4	180.0	-1.8	198.6	-0.1	114.8	-1.1	186.7	-1.4	208.0	0.5	36.6	-0.2	85.2
30	112.1	-0.1	223.7	1.8	109.2	-0.2	171.2	-0.9	212.6	1.4	114.3	0.0	180.6	-0.6	223.3	1.5	37.2	0.1	76.0
40	117.9	0.6	243.3	2.0	114.5	0.5	173.6	0.2	226.9	1.4	120.5	0.6	185.3	0.5	239.8	1.7	39.3	0.2	70.4
50	130.6	1.3	265.2	2.2	127.0	1.2	187.9	1.4	243.1	1.6	133.3	1.3	201.0	1.6	258.0	1.8	42.6	0.3	68.9
60	147.4	1.7	286.7	2.2	143.1	1.6	208.5	2.1	259.6	1.6	149.6	1.6	222.2	2.1	276.2	1.8	48.7	0.6	72.9
70	163.9	1.7	304.1	1.7	158.6	1.6	229.1	2.1	275.1	1.6	164.9	1.5	241.4	1.9	290.7	1.5	55.9	0.7	81.0
80	177.3	1.3	313.8	1.0	170.3	1.2	244.4	1.5	287.3	1.2	175.9	1.1	255.0	1.4	299.0	0.8	62.8	0.7	91.3
90	188.1	1.1	319.2	0.5	178.5	0.8	255.0	1.1	297.4	1.0	183.5	0.8	263.6	0.9	303.3	0.4	69.1	0.6	101.5
100	196.6	0.8	323.6	0.4	182.5	0.4	261.5	0.6	302.2	0.5	187.0	0.3	266.5	0.3	303.6	0.0	74.9	0.6	111.5
110	202.2	0.6	326.6	0.3	184.3	0.2	266.8	0.5	302.1	0.0	188.2	0.1	265.9	-0.1	301.5	-0.2	79.7	0.5	120.9
120	207.2	0.5	326.9	0.0	188.1	0.4	270.8	0.4	302.1	0.0	191.0	0.3	266.2	0.0	301.0	-0.1	83.9	0.4	129.7
130	209.6	0.2	319.8	-0.7	192.3	0.4	270.2	-0.1	299.2	-0.3	193.6	0.3	265.1	-0.1	298.8	-0.2	87.6	0.4	137.3
140	210.4	0.1	309.9	-1.0	196.3	0.4	264.4	-0.6	292.7	-0.7	195.8	0.2	264.0	-0.1	296.4	-0.2	91.0	0.3	144.2
150	210.4	0.0	300.2	-1.0	200.0	0.4	255.6	-0.9	284.1	-0.9	197.0	0.1	263.8	0.0	294.8	-0.2	94.2	0.3	150.6
160	209.7	-0.1	290.8	-0.9	203.3	0.3	246.3	-0.9	275.9	-0.8	197.3	0.0	264.7	0.1	294.3	0.0	96.9	0.3	155.8
170	208.9	-0.1	281.8	-0.9	206.1	0.3	237.5	-0.9	269.4	-0.7	197.0	0.0	266.7	0.2	295.1	0.1	98.6	0.2	159.2
180	207.7	-0.1	273.3	-0.9	207.8	0.2	230.1	-0.7	264.8	-0.5	195.3	-0.2	269.6	0.3	297.0	0.2	99.6	0.1	161.5
190	205.0	-0.3	265.6	-0.8	209.2	0.1	224.5	-0.6	262.1	-0.3	193.1	-0.2	273.1	0.3	299.6	0.3	101.0	0.1	163.9
200	202.4	-0.3	263.2	-0.2	210.2	0.1	219.9	-0.5	260.4	-0.2	192.5	-0.1	278.2	0.5	304.2	0.5	102.5	0.2	166.7
Year	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40
1	117.0	0.0	75.8	0.0	99.5	0.0	120.2	0.0	105.0	0.0	143.6	0.0	173.8	0.0	97.5	0.0	134.5	0.0	158.8
10	98.7	-1.8	61.5	-1.4	81.8	-1.8	99.9	-2.0	83.6	-2.1	117.4	-2.6	139.7	-3.4	76.1	-2.1	106.9	-2.8	125.6
20	87.1	-1.2	56.7	-0.5	74.8	-0.7	92.7	-0.7	78.5	-0.5	111.0	-0.6	132.8	-0.7	70.6	-0.6	101.9	-0.5	120.1
30	79.5	-0.8	59.2	0.3	75.8	0.1	94.8	0.2	85.6	0.7	120.5	0.9	147.1	1.4	77.0	0.6	116.4	1.4	139.7
40	75.5	-0.4	66.9	0.8	82.2	0.6	103.6	0.9	97.1	1.1	141.2	2.1	176.3	2.9	88.6	1.2	135.3	1.9	164.6
50	75.2	0.0	75.7	0.9	92.5	1.0	115.5	1.2	109.9	1.3	165.0	2.4	207.4	3.1	103.6	1.5	157.8	2.3	191.5
60	81.7	0.7	85.5	1.0	104.4	1.2	129.5	1.4	124.3	1.4	191.3	2.6	239.4	3.2	120.6	1.7	176.4	1.9	215.1
70	92.9	1.1	96.0	1.1	117.7	1.3	145.4	1.6	137.9	1.4	214.8	2.4	267.0	2.8	137.2	1.7	192.1	1.6	233.9
80	104.1	1.1	106.4	1.0	131.0	1.3	161.7	1.6	149.8	1.2	233.7	1.9	288.7	2.2	152.2	1.5	203.4	1.1	241.9
90	115.0	1.1	116.9	1.0	144.1	1.3	178.2	1.6	161.0	1.1	250.1	1.6	306.4	1.8	165.0	1.3	212.7	0.9	241.8
100	126.1	1.1	126.7	1.0	156.1	1.2	193.1	1.5	171.8	1.1	265.3	1.5	321.9	1.6	175.5	1.0	221.3	0.9	239.8
110	136.3	1.0	135.9	0.9	167.1	1.1	206.8	1.4	182.0	1.0	278.9	1.4	335.1	1.3	183.0	0.7	229.9	0.9	246.6
120	144.5	0.8	144.3	0.8	177.4	1.0	219.3	1.2	190.6	0.9	289.5	1.1	344.5	0.9	189.1	0.6	238.7	0.9	257.9
130	149.2	0.5	151.7	0.7	186.6	0.9	230.1	1.1	196.0	0.5	294.4	0.5	346.3	0.2	194.8	0.6	247.1	0.8	269.3
140	152.1	0.3	158.6	0.7	195.2	0.9	240.0	1.0	199.6	0.4	295.1	0.1	344.2	-0.2	200.4	0.6	254.8	0.8	278.6
150	154.3	0.2	165.0	0.6	203.2	0.8	249.1	0.9	202.5	0.3	293.7	-0.1	340.6	-0.4	205.4	0.5	261.3	0.7	283.2
160	155.6	0.1	170.2	0.5	210.0	0.7	256.4	0.7	204.4	0.2	290.5	-0.3	335.3	-0.5	209.7	0.4	265.3	0.4	284.3
170	155.9	0.0	173.8	0.4	214.8	0.5	260.7	0.4	204.5	0.0	286.0	-0.5	328.6	-0.7	213.0	0.3	268.6	0.3	282.8
180	155.7	0.0	176.7	0.3	218.9	0.4	263.6	0.3	203.9	-0.1	280.8	-0.5	321.0	-0.8	216.0	0.3	267.8	-0.1	281.3
190	156.0	0.0	179.7	0.3	222.9	0.4	266.4	0.3	203.3	-0.1	275.5	-0.5	313.3	-0.8	219.0	0.3	267.2	-0.1	280.5
200	158.7	0.3	182.9	0.3	226.8	0.4	269.2	0.3	202.8	-0.1	272.1	-0.3	308.1	-0.5	222.0	0.3	265.8	-0.1	280.3

40	41	41	42	42	43	43	44	44	45	45	46	46	47	47	48	48	49	49
0.0	101.9	0.0	140.4	0.0	167.9	0.0	99.2	0.0	131.8	0.0	156.0	0.0	97.8	0.0	134.0	0.0	156.4	0.0
-3.3	81.5	-2.0	114.5	-2.6	135.6	-3.2	81.6	-1.8	115.8	-1.6	138.1	-1.8	81.9	-1.6	117.8	-1.6	136.6	-2.0
-0.5	78.8	-0.3	110.2	-0.4	129.0	-0.7	81.2	0.0	126.5	1.1	151.1	1.3	84.0	0.2	127.8	1.0	147.1	1.1
2.0	88.6	1.0	125.4	1.5	148.4	1.9	94.3	1.3	149.8	2.3	176.5	2.5	98.1	1.4	150.7	2.3	174.3	2.7
2.5	101.0	1.2	147.9	2.3	181.2	3.3	111.3	1.7	177.1	2.7	204.8	2.8	115.6	1.7	175.9	2.5	202.4	2.8
2.7	116.4	1.5	174.3	2.6	214.7	3.4	133.0	2.2	206.0	2.9	234.1	2.9	136.0	2.0	202.8	2.7	231.5	2.9
2.4	134.3	1.8	201.8	2.8	247.6	3.3	154.0	2.1	232.3	2.6	259.4	2.5	155.8	2.0	226.7	2.4	257.6	2.6
1.9	151.6	1.7	226.2	2.4	275.2	2.8	173.0	1.9	253.2	2.1	279.6	2.0	173.9	1.8	245.1	1.8	278.4	2.1
0.8	166.5	1.5	245.5	1.9	294.6	1.9	187.8	1.5	267.0	1.4	293.2	1.4	188.5	1.5	256.9	1.2	293.3	1.5
0.0	178.9	1.2	260.4	1.5	307.5	1.3	198.2	1.0	275.5	0.8	300.7	0.8	200.2	1.2	262.9	0.6	303.5	1.0
-0.2	189.7	1.1	272.8	1.2	317.2	1.0	202.2	0.4	276.9	0.1	300.7	0.0	207.3	0.7	259.8	-0.3	303.2	0.0
0.7	197.5	0.8	281.2	0.8	323.1	0.6	201.2	-0.1	273.2	-0.4	295.3	-0.5	211.3	0.4	254.6	-0.5	293.0	-1.0
1.1	203.2	0.6	286.4	0.5	325.1	0.2	201.7	0.0	272.6	-0.1	293.2	-0.2	215.9	0.5	251.0	-0.4	280.2	-1.3
1.1	207.5	0.4	287.0	0.1	320.6	-0.5	202.6	0.1	274.0	0.1	293.4	0.0	220.3	0.4	246.6	-0.4	267.6	-1.3
0.9	211.0	0.3	284.2	-0.3	313.6	-0.7	203.3	0.1	276.1	0.2	294.3	0.1	224.5	0.4	240.7	-0.6	257.1	-1.0
0.5	213.9	0.3	278.5	-0.6	306.5	-0.7	202.5	-0.1	278.2	0.2	295.2	0.1	228.3	0.4	233.5	-0.7	248.7	-0.8
0.1	216.0	0.2	270.9	-0.8	299.1	-0.7							231.7	0.3	225.9	-0.8	241.9	-0.7
-0.1	217.6	0.2	263.3	-0.8	291.8	-0.7							234.6	0.3	218.6	-0.7	236.4	-0.6
-0.2	219.2	0.2	257.5	-0.6	284.3	-0.7							237.3	0.3	212.6	-0.6	232.5	-0.4
-0.1	220.5	0.1	253.8	-0.4	277.2	-0.7							239.1	0.2	208.0	-0.5	229.8	-0.3
0.0	221.6	0.1	253.4	0.0	273.1	-0.4							239.9	0.1	204.4	-0.4	228.0	-0.2

Appendix 17: Development of Carbon Curves for Analysis Units Within the Fort St. John TSA

FORRx CONSULTING INC.

ECOSYSTEM MANAGEMENT SIMULATION

Knowledge, Experience, Innovation

Development of carbon curves for analysis units within the Fort St. John TSA

Prepared by:

Brad Seely, Ph.D.

Oct. 17, 2003

For:

Don Rosen

Canadian Forest Products Ltd.

1. **Introduction**

This project was undertaken to address the short-term needs around assessing the potential implications of forest management activities on ecosystem carbon (C) storage and sequestration rates within the context of the Fort St. John SFM plan. To properly evaluate the potential impact of forest management activities on global C cycles it is necessary to go beyond coarse estimates based on growing stock and MAI from standard yield curves and work toward developing appropriate C indicators. An initial step towards resolving this problem was the development ecosystem carbon storage curves for the discrete forest analysis units used for the timber supply analysis within the SFM plan. The incorporation of C curves facilitates an evaluation of the direct impacts of proposed forest management activities on long-term patterns of carbon storage and sequestration rates in the forest ecosystems within the Fort St. John TSA. It also provides a foundation upon which to build more detailed methodologies for evaluating C indicators in the context of other forest values.

The primary tasks involved in this project were the following:

1) *Dividing the NHLB into more specific analysis units*
2) *Clumping existing THLB and new NHLB analysis units into C analysis units*
3) *Use of the FORECAST model calibrated for forest types in northeastern BC to generate carbon curves for the C analysis units*
4) *Preparation of a database of ecosystem C storage and sequestration rate curves for each of the C analysis units*
5) *Preparation of a report describing the use of the curves to develop and assess C indicators within the context of the Ft. St. John TSA.*

2. Methods

2.1. Dividing the NHLB into representative forest types for analysis

For the purposes of the timber supply analysis in the Ft. St. John TSA, the NHLB was divided into only three general AUs. To meet the requirements of a C analysis, it was necessary to subdivide these units into more specific AUs based on forest cover types and site indices. After evaluating the range of site indices and forest types within the NHLM, a series of discrete analysis units were described that were consistent with the AUs used in the THLB. The areas and average SI for each of the new NHLB AUs is shown in (Table 1).

Table 1. Description of the new AUs created for the NHLB based on the forest cover data.

Old AU	New AU	Forest Area (% of Total TSA)	Sp1	Other Sp	Avg SI	Avg Sp1%
887	887	15.9%	Sb leading		9.2	
886 & 888	901	1.3%	S	Pl	16.1	68
886 & 888	902	7.6%	S	Pl	8.3	70.1
886 & 888	903	1.1%	S	At	17	69
886 & 888	904	0.6%	S	At	10	75
886 & 888	905	1.5%	P	S	16	69
886 & 888	906	7.2%	P	S	9.5	71
886 & 888	907	1.2%	P	At	16.8	65
886 & 888	908	0.8%	P	At	10.5	69
886 & 888	909	1.7%	At		10.6	80
886 & 888	910	4.7%	At		17.2	77
886 & 888	911	0.4%	At	S	10.7	59
886 & 888	912	0.9%	At	S	16.9	58
886 & 888	913	0.4%	At	Pl	10.8	57
886 & 888	914	0.6%	At	Pl	16.8	58
886 & 888	915	1.6%	Bl	S	6	74
All	**All**	**31.7%**				

2.2. Clumping the existing THLB and new NHLB AUs into carbon AUs

Since many of the existing AUs were similar in terms of species and average SI, they were clumped together to fit within a series of 49 carbon analysis units developed for simulation in FORECAST. The FORECAST carbon analysis units were designed to represent a range of a site quality classes and a range of species mixtures that was consistent with the existing AUs. The regeneration assumptions for each of the carbon AUs were based on those described for the existing managed-stand AUs. Each of the existing THLB and new NHLB AUs was subsequently assigned to one of the new carbon AUs based on species, site index, and regeneration assumptions. Details of the FORECAST carbon AUs is provided in Table 2.

Table 2. Description FORECAST carbon AUs including: a list of existing AUs to be assigned to each carbon AU, management status, stand type, represented species both naturally regenerated and planted, and the regeneration densities (stems ha^{-1}) for planted and naturally regenerated trees.

Forecast C AUs	Assigned TSA AUs	Status	Type	Lead Sp	Other Sp	Nat Sp	SI	Plant Density	Nat Density
1	13,16,511	natural	Con	Se 75%	Bl 25%	Se,Bl	9		1200
2	12,15	natural	Con	Se 75%	Bl 25%	Se,Bl	12		1200
3	11,14,514	natural	Con	Se 75%	Bl 25%	Se,Bl	17		1200
4	21,26,29,31,34,35	natural	Con	Pl		Pl	12		3000
5	25,28	natural	Con	Pl		Pl	16		3000
6	24	natural	Con	Pl		Pl	21		3000
7	53, 123,602,605,606,909,910	natural	Dec	At		At	12		3000
8	52, 122,604	natural	Dec	At		At	16		5000
9	51, 121,603	natural	Dec	At		At	21		7000
10	62, 66,904	natural	Con-Dec	Sw 65%	At 35%	Sw,At	12		2000
11	61,65, 903	natural	Con-Dec	Sw 65%	At 35%	Sw,At	16		2500
12	64	natural	Con-Dec	Sw 65%	At 35%	Sw,At	21		3000
13	73	natural	Con	Sx 75%	Pl 25%	Sx,Pl	9		1200
14	72, 561	natural	Con	Sw 75%	Pl 25%	Sw,Pl	12		1200
15	71, 901	natural	Con	Sw 75%	Pl 25%	Sw,Pl	16		1200
16	74	natural	Con	Sw 75%	Pl 25%	Sw,Pl	21		1200
17	76,93,96	natural	Con	Pl 75%	Sw 25%	Pl,Sw	12		2000
18	75,91,95,97,905	natural	Con	Pl 75%	Sw 25%	Pl,Sw	16		2000
19	94	natural	Con	Pl 75%	Sw 25%	Pl,Sw	21		2000
20	81,86,908	natural	Con-Dec	Pl 65%	At 35%	Pl,At	12		2000
21	521,907	natural	Con-Dec	Pl 65%	At 35%	Pl,At	16		2500
22	84,85	natural	Con-Dec	Pl 65%	At 35%	Pl,At	21		3000
23	103, 911	natural	Dec-Con	At 65%	Sw 35%	At,Sw	12		3000
24	102, 912	natural	Dec-Con	At 65%	Sw 35%	At,Sw	16		3500
25	101	natural	Dec-Con	At 65%	Sw 35%	At,Sw	21		4000
26	113, 913	natural	Dec-Con	At 65%	Pl 35%	At,Pl	12		3000
27	112,914	natural	Dec-Con	At 65%	Pl 35%	At,Pl	16		4000

Forecast C AUs	Assigned TSA AUs	Status	Type	Lead Sp	Other Sp	Nat Sp	SI	Plant Density	Nat Density
28	111	natural	Dec-Con	At 65%	Pl 35%	At,Pl	21		5000
29	915	natural	Con	Bl		Bl	6		2000
30	902, 887	natural	Con	Se 75%	Pl 25%	Se,Pl	9		1000
31	906	natural	Con	Pl 75%	Se 25%	Pl,Se	9		2000
32	2013, 2511, 2073	managed	Con	S 90%	Pl 10%	Bl	9	1400	400
33	2012	managed	Con	S 90%	Pl 10%	Bl	12	1400	400
34	2011, 2014, 2514,1001,2551,1551	managed	Con	S 90%	Pl 10%	Bl	17	1400	400
35	2021, 2026,2029,2031,2034,2035	managed	Con	Pl 90%	Sx 10%		12	1600	
36	2025, 1002	managed	Con	Pl 90%	Sx 10%		16	1600	
37	2024	managed	Con	Pl 90%	Sx 10%		21	1600	
38	2076	managed	Con-Dec	S 90%	Pl 10%	At	12	1040	2000
39	2061, 1056, 1006,1007,1556,2521	managed	Con-Dec	S 90%	Pl 10%	At	16	1040	2000
40	2064	managed	Con-Dec	S 90%	Pl 10%	At	21	1040	2000
41	2561, 2093,2081	managed	Con-Dec	Pl 90%	Sx 10%	At	12	1300	2000
42	1008, 1009, 2097	managed	Con-Dec	Pl 90%	Sx 10%	At	16	1300	2000
43	2084, 2085, 1552,2552	managed	Con-Dec	Pl 90%	Sx 10%	At	21	1300	2000
44	1053	managed	Dec			At	12		
45	1052	managed	Dec			At	16		
46	1051	managed	Dec			At	21		
47	2103	managed	Dec-Con	S 90%	Pl 10%	At	12	500	3000
48	2102	managed	Dec-Con	S 90%	Pl 10%	At	16	500	5000
49	2101	managed	Dec-Con	S 90%	Pl 10%	At	21	500	7000

2.3. Preparing a database of carbon curves using the FORECAST model

The FORECAST model, which has been calibrated for use in similar forest types in TFL48, works well for an analysis of ecosystem carbon storage as it is a biomass-based model that simulates patterns of carbon accumulation in both above and below-ground biomass components as well as in dead organic matter components including soil organic matter, litter and coarse woody debris. FORECAST was used to generate ecosystem C storage curves for each of the carbon AUs described in Table 2. Because ecosystem carbon storage is a continuous variable (i.e. it cannot easily be reset like merchantable volume following harvest) it was necessary to carefully consider transition pathways when preparing the carbon curves. The transition pathways described for the existing AUs were used to guide this process. The goal was to create a relatively smooth transition, in terms of ecosystem C storage, from a natural stand to a managed stand following harvest. This was achieved by estimating an average harvest age for each of the natural stand types and using this harvest age to generate the starting condition for each of the managed stand-curves. The starting condition of an ecosystem simulation in FORECAST is represented by a series of state variables described within the ECOSTATE file. The average harvest ages for each natural-stand AU and the particular natural-stand AU used to create the ECOSTATE file for each of the managed-stand AUs are presented in Table 3. Despite using this method, there will still be some errors generated during the transition process but they should be relatively small compared to total ecosystem C storage.

Table 3. Estimated average harvest ages for each of the natural-stand AUs used to create starting conditions for managed stands. The parent natural-stand AU is shown for each managed-stand AU.

Forecast C AUs	Status	Type	Estimated Avg. Harvest Age	SI	Nat-Stand AU for managed stand AU
1	natural	Con	200	9	
2	natural	Con	175	12	
3	natural	Con	140	17	
4	natural	Con	100	12	
5	natural	Con	90	16	
6	natural	Con	80	21	
7	natural	Dec	100	12	
8	natural	Dec	90	16	
9	natural	Dec	80	21	
10	natural	Con-Dec	140	12	
11	natural	Con-Dec	120	16	
12	natural	Con-Dec	100	21	
13	natural	Con	200	9	
14	natural	Con	130	12	
15	natural	Con	110	16	
16	natural	Con	90	21	
17	natural	Con	150	12	
18	natural	Con	130	16	
19	natural	Con	110	21	
20	natural	Con-Dec	110	12	

Forecast C AUs	Status	Type	Estimated Avg. Harvest Age	SI	Nat-Stand AU for managed stand AU
21	natural	Con-Dec	100	16	
22	natural	Con-Dec	90	21	
23	natural	Dec-Con	120	12	
24	natural	Dec-Con	100	16	
25	natural	Dec-Con	80	21	
26	natural	Dec-Con	120	12	
27	natural	Dec-Con	100	16	
28	natural	Dec-Con	80	21	
29	natural	Con		6	
30	natural	Con		9	
31	natural	Con		9	
32	managed	Con		9	AU 1
33	managed	Con		12	AU 2
34	managed	Con		17	AU 3
35	managed	Con		12	AU 4
36	managed	Con		16	AU 5
37	managed	Con		21	AU 6
38	managed	Con-Dec		12	AU 10
39	managed	Con-Dec		16	AU 11
40	managed	Con-Dec		21	AU 12
41	managed	Con-Dec		12	AU 17
42	managed	Con-Dec		16	AU 18
43	managed	Con-Dec		21	AU 22
44	managed	Dec		12	AU 7
45	managed	Dec		16	AU 8
46	managed	Dec		21	AU 9
47	managed	Dec-Con		12	AU 23
48	managed	Dec-Con		16	AU 24
49	managed	Dec-Con		21	AU 25

A carbon curve database was subsequently prepared by summarizing the results for total ecosystem C storage on 10-year time steps for each of the FORECAST carbon AUs. In addition, average rates of C sequestration were calculated for each time step based on the following equation:

$$\text{Avg. Sequestration Rate}_t = \frac{\text{Ecosystem } C_t - \text{Ecosystem } C_{t-10}}{10}$$

3. Results and Discussion

3.1. Ecosystem C storage and Average Sequestration Rates

Total Ecosystem C storage provides an estimate of the total amount of carbon stored in a given AU for a specific stand age. In contrast the calculated average sequestration rate represents an estimate of the rate of change in ecosystem C storage with time. It incorporates C losses via decomposition of dead organic matter and C gains via photosynthesis and biomass growth. As such it may be positive or negative.

The carbon curve database resulting from this work is included in the attached Excel file. An example of the carbon curves produced for a natural mixed conifer stand and its associated managed stand are shown in Figure 1. The relatively larger ecosystem C storage observed early in stand development for the natural stand is the result of the larger quantity of dead organic matter (primarily snags and CWD) following the fire which initiated the natural disturbance stand. In contrast, the managed stand has a smaller initial pool of C in dead organic matter resulting from the removal of harvested material. The differences in dead organic matter pools following disturbance also has an effect on the average sequestration rates of natural and managed stands (Fig. 2). There is a greater release of C to the atmosphere following the decomposition of the larger pool of dead organic matter in the natural stand which results in a lower sequestration rate during the first several decades of stand development. In the example provided, the average sequestration rate takes longer to return to positive values in the natural stand versus the managed stand. This is partly related to the fact that the harvested wood removed from the site during harvesting does not contribute to ecosystem C release to the atmosphere. Rather, it is assumed to be stored in wood products.

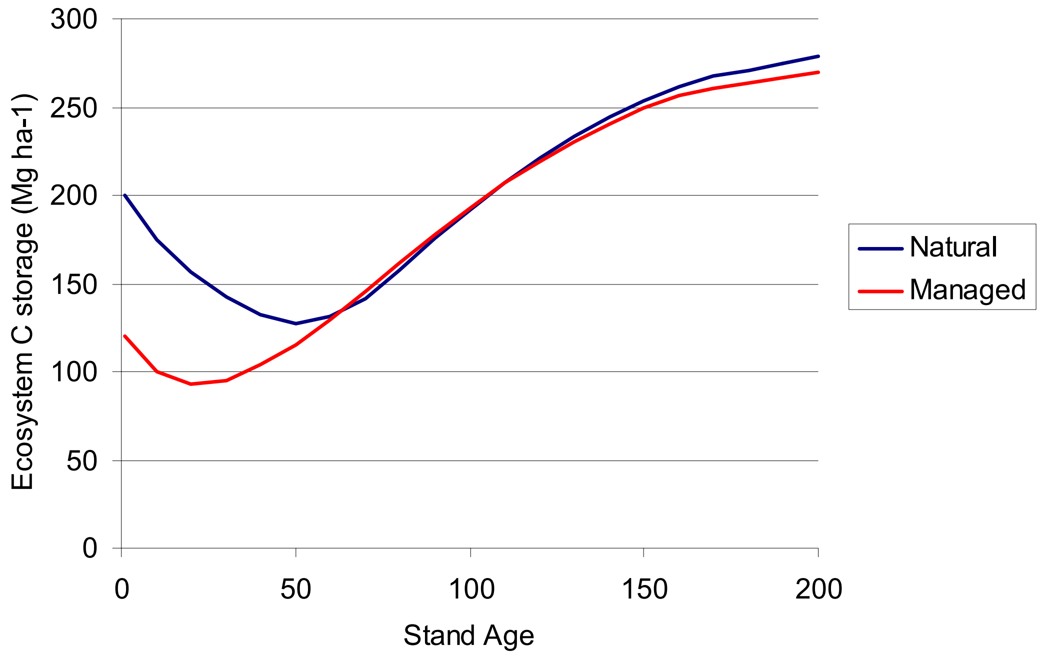

Figure 1. An example of total Ecosystem C storage for a natural stand (FORECAST AU 3) and an associated managed stand (FORECAST AU 34).

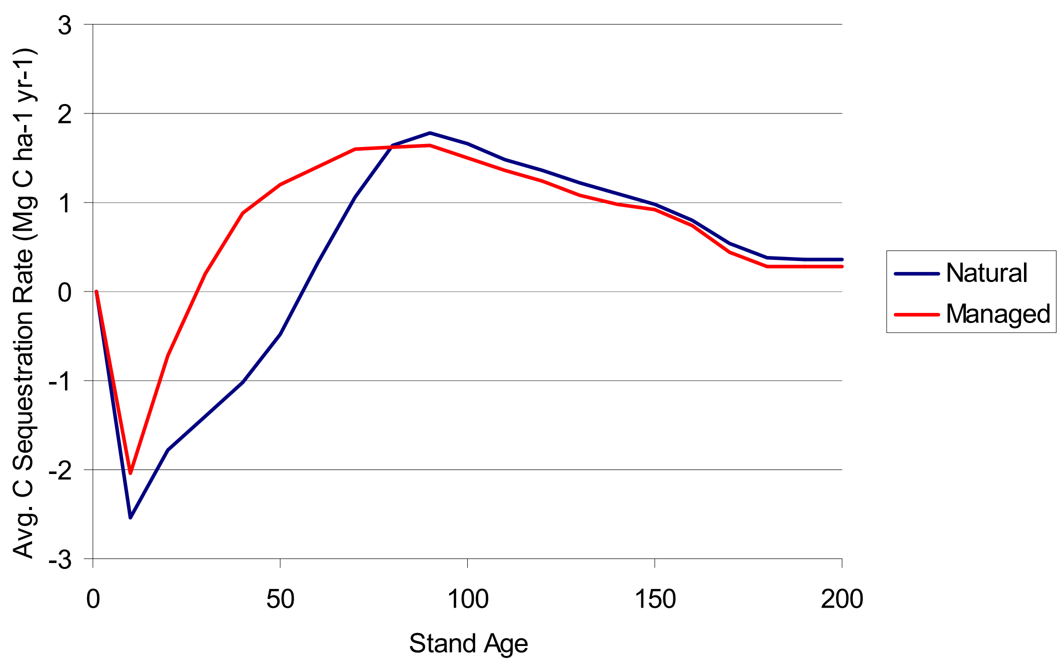

Figure 2. An example of average C sequestration rates for a natural stand (FORECAST AU 3) and an associated managed stand (FORECAST AU 34).

3.2 *The Development of C indicators for landscape-scale analyses*

The carbon curves generated using FORECAST can be used to provide a foundation for the development of landscape-level C indicators for use in support of SFM plans. By incorporating the stand-level C curves into a forest planning model such as FS-SIM, it is possible to estimate the effects of landscape-scale harvesting activities on the global C cycle. Thus, two separate landscape-scale indicators (ecosystem C storage and average C sequestration rates) could be defined and evaluated as described below:

1) Total Ecosystem C storage

Definition: The calculation of total ecosystem C storage within a timber supply area allows for a long-term evaluation of effects of management activities and/or natural disturbance on forest C stocks. Stock change is the current method accepted for C accounting under the Kyoto Protocol. It assumes that C stored in harvested materials is returned to the atmosphere immediately following harvesting.

Spatial Extent: Timber supply area

Units: Mg or Mt (10^6 Mg) C

Establishing Targets: An initial estimate of the target for ecosystem C storage could be based on a long-term (e.g. 300 years) simulation of historical natural disturbance rates in the absence of fire suppression. A target could then be defined as being within the range of variation that occurred during the natural baseline simulation.

2) Average C sequestration rates

Definition: The calculation of average C sequestration rates within a timber supply area allows for a long-term evaluation of effects of management activities and/or natural disturbance on the rate at which the forested landscape is sequestering C. Unlike the stock change method, average sequestration rates are based on changes in ecosystem carbon storage over time without accounting for C removed in harvested biomass. The rationale is that the carbon in harvested materials will be stored in wood products following harvest. An assessment of the sequestration rate provides a measure of the rate and direction of carbon exchange between the forest ecosystem and the atmosphere.

Spatial Extent: Timber supply area

Units: Mg C yr^{-1}

Establishing Targets: Using an approach similar to that used for ecosystem C storage, an initial estimate of the target for average C sequestration rates could be based on a long-term (e.g. 300 years) simulation of historical natural disturbance rates in the absence of fire suppression. A target could then be defined as being within the range of variation that occurred during the natural baseline simulation.

Appendix 18: Glossary

Glossary

AAC (Allowable Annual Cut)

The annual rate of timber harvesting specified for an area of land by the Chief Forester of the BC Ministry of Forests. The Chief Forester sets AAC's for timber supply areas (TSA's) and Tree Farm Licences (TFL's) in accordance with Section 8 of the *Forest Act*.

Abiotic

Not of biological origin (see biotic), e.g., windthrow, forest fires, flooding.

Access Management

The planning, construction, maintenance, use and deactivation of all roads. May also refer to approved methods of restricting access to certain areas to protect other values.

Access Structure

A structure within a cutblock that
(a) is either a permanent access structure or a temporary access structure, and
(b) was constructed for facilitating the harvesting of timber within the cutblock.

Accumulations

Term used in reference to waste calculations on post harvested areas. It measures the amount of waste in areas that have been piled and accumulated along the road or on a landing.

Act

The *Forest Practices Code of British Columbia Act*.

Adaptive Management

A learning approach to management that incorporates the experience gained from the results of previous actions into decisions. It is a continuous process requiring constant monitoring and analysis of the results of past actions that are used to update current plans and strategies.

Aerial Logging

Harvest method where the logs are carried (fully suspended) from the felling area to roadside or other decking area using some type of aircraft (usually helicopter).

Anthropogenic

Influenced by the impact of man on nature.

Archaeological Sites

Locations that contain physical evidence of post human activity for which the application of scientific methods of inquiry (i.e. survey, excavation, data analysis) are the primary source of information.

Audit

A planned independent and documented assessment to determine whether agreed upon requirements are being met.

BDU (Bone Dry Unit)

A unit of measurement that lumber mills use to measure the amount of byproduct wood chips they can produce. The byproduct chips are used in pulp mills to make paper, etc.

BEC (Biogeoclimatic Ecosystem Classification)

A hierarchical classification scheme having three levels of integration; regional, local and chronological; and combining climatic, vegetation and site factors. The hierarchical classification includes Biogeoclimatic Zone⇒ sub-zone ⇒ variant⇒ site series.

Biogeoclimatic Zone

A geographic area having similar patterns of energy flow, vegetation, and soils as a result of a broadly homogenous macroclimate. British Columbia has 14 biogeoclimatic zones.

Biogeoclimatic Variant

A subdivision of a biogeoclimatic subzone. Variants reflect further differences in regional climate and are generally recognized for areas slightly drier, wetter, snowier, warmer or colder than other areas in the subzone.

Biodiversity (or Biological Diversity)

Diversity of plants, animals and other living organisms in all their forms and levels of organization, including genes, species and ecosystems, and the evolutionary and functional processes that link them.

Biotic

Relating to living beings, or of biological origin (see abiotic), e.g., insect outbreak, disease.

Blue-listed Species

In British Columbia, the designation of an indigenous species, sub-species, or population as being vulnerable or at risk because of low or declining numbers or presence in vulnerable habitats. Included in this classification are populations generally suspected of being vulnerable, but for which information is too limited to allow designation in another category.

Boreal Forest

One of the nine major forest regions of Canada. Typical tree species found in the boreal forest are spruce, pine, aspen and birch.

Botanical Forest Products

Non-timber based products gathered from forest and range land. There are seven recognized categories: wild edible mushrooms, floral greenery, medicinal products, fruits and berries, herbs and vegetables, landscaping products, and craft products.

Cable Logging

Harvest method where the logs are pulled with the use of cables (fully suspended or dragging) from the harvest site to the decking area.

Category A Block

Blocks reviewed and approved in previous forest development plans.

Category I Block

Blocks included in the plan for public information purposes only, and not for official approval. Generally comments received on these blocks will be considered prior to submitting the blocks as proposed Category A blocks (i.e. requested for approval as Category A blocks).

CDC (Conservation Data Centre)

The British Columbia Conservation Data Centre (CDC) (see Blue-listed and Red-listed Species). The staff specialists at the CDC, in co-operation with scientists and specialists throughout the province, have identified those vertebrate animals, vascular plants and plant associations in the province, which have become most vulnerable. Each of these rare and endangered species and plant associations has been assigned a global and provincial rarity rank according to an objective set of criteria established by The Nature Conservancy of the United States, and a status on the provincial Red or Blue lists.

Certification

A system of rules or procedures acknowledging conformance to a standard.

CMT (Culturally Modified Tree)

A culturally modified tree (CMT) is a tree that has been altered by native people as part of their traditional use of the forest. Non-native people also have altered trees, and it is sometimes difficult to determine if an alteration (modification) is of native or non-native origin. There are no reasons why the term "CMT" could not be applied to a tree altered by non-native people. However, the term is commonly used to refer to trees modified by native people in the course of traditional tree utilization.

Coarse Woody Debris

Sound and rotting logs and stumps that provide habitat for plants, animals and insects and, are a source of nutrients for soil development.

Community

A group of people living in the same locality and under the same government, a group of people having similar or common interests.

Coniferous

Cone bearing evergreen trees or shrubs, usually with needle-shaped or scale-like leaves. The wood of coniferous trees is known as softwood (e.g. pine, fir and spruce).

Coniferous Stands

Those forest stands in which the most predominant trees by volume are coniferous trees. Deciduous trees such as aspen and birch may be present, but are less abundant than the coniferous trees.

An area where, at rotation age, the coniferous trees, collectively, represent a minimum of 80% of the volume of timber on the area.

Conventional Logging

Harvest method where the logs are pulled using rubber tired skidders or other ground based machines to a roadside decking area, where the logs are loaded onto trucks and transported to the mill.

Conservation

The controlled use and systematic maintenance, enhancement, restoration and/or protection of natural resources, such as forests, soil, and water systems for present and future generations.

Conserve

To protect from permanent loss or irreparable harm, to use carefully or sparingly.

Consistent

Not in material conflict.

Co-operative

A willingness and ability to work with others.

Coordinated Resource Management Plan

A group of management plans dealing with coordinating range resource developments on range tenure areas with other resource users.

COSEWIC

The Committee on the Status of Endangered Wildlife In Canada (COSEWIC) determines the national status of wild Canadian species, sub-species and separate populations suspected of being in danger. It bases its decisions on the best up-to-date scientific information available.

Crop Tree

A healthy tree that is of a species that is:

(a) ecologically suitable for the site, and

(b) commercially valuable.

Cubic Metre (m^3)

A measure of standing timber volume, based on solid wood 1 metre x 1 metre x 1 metre. A typical merchantable coniferous tree would have approximately 0.45 to 0.5 cubic metres per tree, although some large trees can exceed 2.0 metres per tree.

Cultural Heritage Resources

An object, a site or the location of a traditional societal practice that is of historical, cultural or archaeological significance to British Columbia, a community or an aboriginal people.

Cutblock

A specific area of land

(a) identified in a forest development plan, forest operations schedule or a site plan for areas where timber harvesting is to be carried out,

(b) identified in a site plan for any of the following areas that are to be reforested:

(i) an area where a contravention of section 96 of the Act has occurred;

(ii) an area that has been naturally disturbed;

(iii) a backlog area;

(c) identified in a site plan for areas where silviculture treatments on well-growing stands are to be carried out, and

(d) referred to in paragraph (a), (b) or (c) that the district manager has exempted the participant from the requirement to prepare the forest development plan or site plan as the case may be.

Cut to Length Harvesting

A harvesting method that uses special low ground pressure equipment. The same piece of machinery (harvester) cuts the tree and then bucks it into predefined lengths. A forwarder then brings these pieces to roadside or the landing.

Data

Factual information, especially information organized for analysis or used to reason or make decisions; values derived from scientific experiments.

Deactivation

A term used to describe the process of restoring drainage on roads that are not currently being used. Through the use of ditches across the road surface (perpendicular to the road), water is channeled off the road.

Deciduous

Trees or shrubs, commonly broad leafed, that shed their leaves annually. The wood of deciduous trees is known as hardwood (e.g. aspen).

Deciduous Stand

An area where, at rotation age, the deciduous trees, collectively, represent a minimum of 80% of the volume of timber on the area.

DFA (Defined Forest Area)

A specific area of land, forest and water delineated for the purposes of registration of a Sustainable Forest Management system.

Dispersed

Term used in reference to waste calculations on post harvested areas. It refers to the amount of waste not associated with the road or landing systems (i.e. in the cutblock).

Disturbance

A discrete force that causes significant change in structure and/or composition through natural events such as fire, flood, wind, or earthquake; mortality caused by insect or disease outbreaks or by human-caused events such as the harvest of the forest. Disturbances can occur at very small scales or large scales.

ECA (Equivalent Clearcut Area)

Equivalent clearcut area (ECA) is the area that has been harvested, cleared or burned, with consideration given to the silvicultural system, regeneration growth, and location within the watershed. ECA and road density are the two primary factors considered in an evaluation of the potential effect of past and proposed forest harvesting on peak flows.

Ecosystem

A community of animals, plants and bacteria and its interrelated physical and chemical environment.

Ecosystem Management

A management system which recognizes and incorporates the natural variability of an ecosystem and attempts to emulate these responses with man-made disturbance while managing forests for a range of values.

EMS (Environmental Management System)

An Environmental Management System is a set of standards established by the International Organisation for Standardization (ISO 14001). This process includes commitment, public participation, preparation, planning, implementation, measuring and assessing performance, and review and improvement of a management system. The incorporation of feedback loops into the process allows for ongoing enhancement of the integrity and performance of the management system, and is designed to lead to continual improvement.

Endemic

A disease or organism that is consistently present, but populations are generally not increasing.

Ensure

To make sure or certain of an outcome.

Evenaged

Term given to areas of timber where the tree species are all approximately the same age (+/- 20 years).

Facilitate

To make easier, applied typically to discussion between parties with varying views.

FDP (Forest Development Plan)

An operational plan guided by the principles of integrated resource management (the consideration of timber and non-timber values), which details the logistics of timber development over a period of usually five years. Methods, schedules, and responsibilities for accessing, harvesting, renewing, and protecting the resource are set out to enable site-specific operations to proceed.

Fisheries-Sensitive Zone

A flooded depression, pond or swamp, that

(a) either perennially or seasonally contains water, and

(b) is seasonally occupied by a species of fish listed in the definition of "fish stream" in the Operational Planning Regulation,

but does not include a wetland or lake that has a riparian management area established under Part 8 of the Operational Planning Regulation, Schedule C of the Pilot Regulation, or a stream.

Forage

Vegetation that is suitable as food for wildlife or domestic animals - may refer to an area where this vegetation occurs in abundance.

Forest Cover Type

A stand of trees that have very similar characteristics. Most often grouped together according to tree species, age, and size.

Forest Fragmentation

A process whereby large contiguous forest patches are transformed into one or more smaller patches surrounded by disturbed areas. Fragmentation occurs naturally by fire, disease, wind and insect attack.

Forest Licence

A volume based tenure awarded by the BC Provincial Government which sets out an annual allowable cut a company is allowed to harvest from a specific timber supply area, as well as commitments the company must make, such as operating a manufacturing facility continuously, reforesting cutblocks to government approved standards, payments to the government, etc. Failure to harvest the minimum amount of timber can result in loss of all or a portion of the allowable cut.

Forest Practice

Timber harvesting, road construction, road maintenance, road use, road deactivation, silviculture treatment, botanical forest product collecting, grazing, hay cutting, fire use and fire control and suppression.

FPC (Forest Practices Code)

The Code is a term commonly used to refer to the Forest Practices Code of BC Act, the regulations made by Cabinet under the act and the standards established by the Chief Forester. The term may sometimes be used to refer to field guides as well. It should be remembered that unlike the act, the regulations and standards, field guides are not legally enforceable.

Forest Resources

Resources and values associated with forests and range including timber, water, wildlife, fisheries, recreation, botanical forest products, forage and biological diversity.

Forest Stand

An area of forest that is distinct from the surrounding forest by reason of some combination of topography, species composition, age or other feature.

Fort St. John LRMP

The Fort St. John Land and Resource Management Plan approved by government on October 8, 1997 and as amended from time to time.

Free Growing

Young trees that are as high or higher than competing brush vegetation with one metre of free-growing space surrounding their leaders. As defined by legislation, a free growing crop means a crop of trees, the growth of which is not impeded by competition from plants, shrubs or other trees. Silviculture regulations further define the exact parameters that a crop of trees must meet, such as species, density and size, to be considered free growing.

GIS (Geographic Information System)

Computer systems designed to allow users to collect, manage, and analyze large volumes of spatially referenced information and associated attribute data.

Goal (as applied to CCFM Criteria and Critical Elements)

A broad, general statement that describes a desired state or condition related to one or more forest values.

Grade "Z"

A firmwood reject log where (i) heart rot or hole runs the entire length of the log and the residual collar of the firmwood constitutes less than 50% of the gross scale of the log, (ii) rot is in the log and the scaler estimates the net length of the log to be less than 1.2 m, or (iii) sap rot or charred wood exists and the residual firmwood is less than 10 cm in diameter at the butt end of the log (b). That portion of a log that is less than 10 cm in diameter or that portion of a slab that is less than 10 cm in thickness.

Green Attack

Term given to trees that have been attacked by insects but have not yet shown signs of mortality. Usually occurs at the early stage of attack.

Greened-up

A cutblock that supports a stand of trees that has attained the green-up height specified in a higher level plan for the area, or in the absence of a higher level plan for the area, has attained a height that is 3 m or greater. Also, if under a silviculture prescription, meets the stocking requirements of that prescription, or if not under a silviculture prescription, meets the stocking specifications for that biogeoclimatic ecosystem classification specified by the Regional Manager.

Habitat

An area in which a plant or animal naturally lives, part of a broader unit such as the ecosystem.

Harvested Area

The area within a cutblock, other than that which is occupied by permanent access structures, where timber harvesting has occurred.

Herbaceous

A plant that remains soft and does not develop woody tissue.

Herbicide

A controlled product used solely to control or manage weeds.

Higher Level Plan

Government approved plans that provide strategic context for operational plans that determine the mix of forest resources to be managed in a given area.

Hydrology

The science of the waters of the earth, water properties, circulation, principles and distribution.

Hygric

Term used to describe soils that receive an abundant input of water in the form of soil seepage.

Indicator (as applied to CCFM Criteria and Critical Elements)

A measurable variable used to report progress toward the achievement of a goal.

Indicator Species

Species chosen for their ecological, social and economic attributes to monitor habitat supply over time. Based on the LRMP, provincial and federal endangered species lists, the Identified Wildlife Guide and input from the PAC Canfor has selected the following indicator species: grizzly bear, marten, fisher, wolverine, moose, elk, caribou, mountain goat, Blackthroated Green Warbler, Northern Goshawk, Trumpeter Swan and Three-toed Woodpecker.

Or, in a silviculture prescription, species of plants used to predict site quality and characteristics.

Interior Forest Habitat

Areas generally greater than 600 metres wide which now, or will in the future have continuous forest stand conditions which are relatively consistent. Important because some wildlife species require these larger forested areas to thrive.

IWMS (Identified Wildlife Management Strategy)

Those species at risk that the Deputy Minister of Environment, Lands and Parks or a person authorized by that Deputy Minister, and the Chief Forester, agree will be managed through a higher level plan, wildlife habitat area or general wildlife measure.

Known

When used to describe a feature, objective or other thing referred to in this regulation as known, means a feature, objective or other thing that is:

(a) contained in a higher level plan, or

(b) otherwise identified or made available to a participant by the district manager or designated environment official at least 4 months before the forest development plan, forest operations schedule or site plan for the area was prepared.

Land and Resource Use Planning

The sub-regional integrated resource planning process for British Columbia. LRMP considers all resource values and requires public participation, interagency co-ordination and consensus building in land and resource management decisions.

Landscape

A large area encompassing a wide diversity of adjacent landforms, land cover, habitats and ecosystems.

Landscape Level Strategy

Those activities that are required to be undertaken in order to achieve forest management objectives identified in a sustainable forest management plan.

Landscape Unit (LU)

A planning area delineated according to topographic or geographic features such as a watershed or series of watersheds and, as designated by a district forest manager *(from: Biodiversity Guidebook, September 1995).*

Linear Developments

Manmade features which extend in a linear manner, e.g. roads, seismic lines or pipelines.

Long Run Sustained Yield (LRSY)

The maximum biological capacity of the land base with no recognition of items such as Non Recoverable Losses.

Long-term

At a minimum, twice the period in years of the average life expectancy of the predominant tree species up to a maximum of 300 years.

Long Term Harvest Level (LTHL)

The level at which harvest can occur given management assumptions and rate of harvest. In contrast to LRSY, LTHL takes into account Non Recoverable Losses.

Machine Free Zone

Areas within a cut block that forestry equipment may not enter. These are usually associated with streams and wetlands, and are established to prevent soil disturbance and erosion.

Manage

To handle or direct with a degree of skill; to treat with care; to exercise executive, administrative, and supervisory direction.

Managing Participant

The participant that manages tenures within the pilot project on behalf of another participant(s).

Mean Annual Increment (MAI)

The average annual increase in volume of individual trees or stands up to the specified point in time. The MAI changes with different growth phases in a tree's life, being highest in the middle years and then slowly decreasing with age. The point at which the MAI peaks is commonly used to identify the biological maturity of the stand and its readiness for harvesting.

Merchantable

At or above minimum specific timber values (i.e. diameter, age and height).

Mesic

Term used to describe soil moisture. This refers to sites on which the moisture conditions experienced by plants are primarily under the control of the local climate, with no excessive influx of moisture due to slope position or soil conditions.

Mfbm

A measure of lumber produced - a thousand foot board measure. A board foot is 12 inches x 12 inches x 1 inch in thickness. Approximately 240 board feet of lumber can be extracted from 1 cubic metre of timber, with wood chips being made from the edges.

Mixedwood Forest

Forests that include deciduous and/or coniferous species at landscape and/or site levels over time. These forests occur in compositions ranging from intimate mixtures of coniferous and deciduous species to irregular groupings of discrete species in a patchwork distribution.

Mixedwood Management

A forest management system that incorporates strategies to maintain a deciduous and coniferous component in the forest over time.

Mixedwood Stand

An area where, at rotation age,

(a) the coniferous trees, collectively, and

(b) the deciduous trees, collectively,

each represents a minimum of 20% of the volume of timber on the area.

Modified Shelterwood

A shelterwood system designed to protect an existing established understorey stand while removing most or all of the overstorey stand.

MoF (Ministry of Forests)

Provincial government ministry responsible for the management and protection of the province's forest and range resources for the best balance of economic, social, and environmental benefits to British Columbia.

Monitoring

The process of checking, observing and measuring outcomes for key variables or **specific** ecological phenomena against a predefined qualitative objective or standard.

NAR (Net Area to be Reforested)

The area under a Silviculture Prescription that will be reforested. This excludes areas occupied by permanent roads, areas incapable of growing a stand of trees (rock, wetland etc.), and reserves. This may include areas that did not contain a commercial stand of trees, but because it is capable of growing a stand of trees, will be reforested. See also harvested area.

Natural Disturbance Types (NDT)

Characterize areas with different natural disturbance regimes. Natural stand initiating disturbances are those processes that largely terminate the existing forest stand and initiate secondary succession in order to produce a new stand. Native species have adapted to the historical extent and distribution of these events, so timber harvesting patterns which approximate the patch sizes and distribution of natural disturbances are desirable. The boreal forest is in the NDT 3, which is characterized primarily by very large fires, often hundreds or thousands of hectares in size.

Naturally Disturbed Area

An area where timber has been damaged or destroyed by causes other than harvesting.

Net Forest Landbase

That portion of the land that can potentially produce commercial forests. It includes both mature forests, immature and new forests, and potentially productive land which presently does not have forests established.

Non-harvestable Land Base

Area not considered part of the timber harvesting land base. This would include areas excluded from contributing to timber supply during the TSR process, such as parks, riparian areas, inaccessible areas, inoperable areas, non-merchantable forest types, low productivity sites, recreation features, and environmentally sensitive areas.

Non Recoverable Losses (NRL's)

Losses of timber due to fire, insects or windfall that are either too small or too inaccessible to be retrieved for lumber production.

Objective (as applied to CCFM Criteria and Critical Elements)

A clear, specific statement of expected quantifiable results to be achieved within a defined period of time related to one or more goals. An objective is often stated as a desired level of an indicator.

Note: In the context of the Forest Practices Code, objective is a statement of management direction applied to forest resources.

OGMA (Old Growth Management Area)

Defined in the Forest Practices Code of British Columbia Act Operational Planning Regulation as an area established under a higher level plan which contains or is managed to replace structural old growth attributes.

Old growth forests on BC's coast are characterized by the following:

1. Two or more tree species of variable sizes and spacing;
2. Large live trees;
3. Patchy understorey;
4. A deep, multi-layered crown canopy with gaps;
5. Standing dead trees (snags) and coarse woody debris of variable sizes.

Old Growth

A climax forest that contains live and dead trees of various sizes, species, composition and age class structure. The age and structure of old growth forests varies significantly by forest type and from one biogeoclimatic zone to another *(from: Biodiversity Guidebook, September 1995)*.

Operational Plan

A plan describing the logistics for forestry development. Methods, schedules and responsibilities for accessing, harvesting, renewing and protecting the resource are set out to enable site specific operations to proceed. Includes Forest Development Plans, Access Management Plans, Range Use Plans Silviculture Prescriptions and Stand Management Prescriptions.

OPR (Operational Planning Regulations)

Participant

The BCTS program or a major forest tenure holder who has consented in writing to take part in the pilot project. Currently this includes those listed in Section 2.1 of this SFMP.

Performance Indicator

A measurable variable used to report progress toward the achievement of a goal.

Permanent Access Structure

A road, landing, logging trail, pit, quarry or other similar structure in a cutblock that

(a) is constructed by a participant or holder of a minor timber sale licence and is
  (i) required to be used for timber harvesting or other forest management activities and whose use will continue long enough to prevent the production of a commercial crop of trees on the area occupied by the structure that will be harvestable concurrently with the crop of adjacent trees, or
  (ii) either constructed through material that is not suitable, or contains materials that are not suitable, for use in carrying out the soil rehabilitation treatments necessary to grow a commercial crop of trees, or

(b) was constructed by a person other than a participant or holder of a minor timber sale licence.

Pilot Project

For the purposes of this proposal, means the Fort St. John Forest Practices Pilot Project authorized under Section 221.1, *Forest Practices Code Act* and approved by the Government of British Columbia.

Preferred and Acceptable Species

Preferred and acceptable tree species are those commercial tree species that are suited to the growing conditions of the site, and are identified in the Silviculture Prescription.

Prescribed Broadcast Burning

Term given to the act of burning a large area (i.e. harvested cutblock) to minimize the amount of slash or reduce the fire hazard thus allowing a better area for planting.

Proposed Roads

Planned roads that have not been previously approved in a forest development plan.

Protected Area

An area protected by legislation, regulation, or land-use policy to control the level of human occupancy or activities.

Note: "Categories of protected areas include protected landscapes, national parks, multiple us management areas, and nature (wildlife) reserves" *(The State of Canada's Forests 2001/2002)*, also includes "sites of biological significance" (i.e. critical areas for wildlife habitat, sensitive sites, and unusual or rare forest conditions, as established according to scientific and traditional criteria).

Public Advisory Group

For the purposes of this proposal, means the group established under the Fort St. John Pilot Project Regulation to provide advice to the participants regarding the Sustainable Forest Management Plan and to review Pilot Project Annual Reports, and the results of Pilot Project audits.

Qualified Auditor

A person who is competent to assess compliance with this regulation.

Qualified Registered Professional

With respect to an activity for which this regulation requires a qualified registered professional, a person who

(a) has the education and experience that is appropriate to carry out the activity, and

(b) is a member of, or licensed by, a regulatory body in British Columbia that has the legislated authority to regulate its members or licensees carrying out the activity.

Quantify

To make explicit the logical quantity of; to determine, express or measure the quantity of.

Red-listed Species

In British Columbia, the designation of an indigenous species, sub-species, or population as endangered or threatened because of its low abundance and consequent danger of extirpation or extinction. Endangered species are any indigenous species threatened with imminent extinction or extirpation throughout all or a significant portion of their range in BC. Threatened species are any indigenous species that are likely to become endangered in BC if factors affecting that vulnerability are not reversed.

Reforest

To establish on a harvested area, a naturally disturbed area or a backlog area, as the case may be, within the reforestation period, a stand of crop trees that meets or exceeds the stocking requirements for the area; a well-growing stand in accordance with section 35 of the Pilot Regulations.

Reforestation Period

The period specified in a site plan within which an area must be reforested.

Regeneration Delay

The maximum time allowed in a prescription, between the start of harvesting in the area to which the prescription applies, and the earliest date by which the prescription requires a minimum number of acceptable well-spaced trees per hectare to be growing in that area.

Regional Director

A regional director employed in the Ministry of Water, Land and Air Protection.

Registered Seed

Seeds which are tested to standards for germination and quality, from a healthy source and ensures the uses of local seed sources.

Rehabilitate

To restore to a stable condition and to a condition that does not prevent the reforestation requirement from being met.

Resource Agencies

Any government agency, ministry or department having jurisdiction over a resource that may be affected by any activity or operation proposed under a higher level plan or plan required under this regulation.

Resource Management Zone

A land use designation category under the Forest Practices Code that establishes strategic objectives and special requirements to guide subsequent sub-regional, local and operational planning.

Resource Management Zone Objectives

Statements that apply to specific resource management zones and are derived by the LRMP working group to sustain or enhance identified resource values.

Riparian

In proximity to the edge of rivers, streams, lakes and wetlands.

Riparian Assessments

The evaluation of watercourses or wet areas to determine if they meet the forest practices code requirements as a stream, and if so, whether they are fish bearing or not. Management requirements for reserve zones and management zones depend on the assessed fisheries values and size of the stream.

Riparian Classes

Determined from riparian assessments, streams are classified as follows: S1- fish bearing >20 metres wide; S2 fish bearing 5-20 m wide; S3 fish bearing 1.5 to 5 metres wide; S4 fish bearing < 1.5 metres wide; S5 not fish bearing; >3 metres wide; S6 not fish bearing < 3 metres wide.

Riparian Management Area

An area of a width determined in accordance with Schedule C of the Pilot Regulations that

(a) is adjacent to a stream or wetland or a lake with a riparian class of L3, and

(b) consists of a riparian management zone and, depending on the riparian class of the stream, wetland or lake, a riparian reserve zone.

Riparian Management Zone

An area adjacent to a stream, wetland or lake where constraints to forest practices apply for the purpose of maintaining the integrity of the stream, wetland or lake and associated wildlife habitat.

That portion of the riparian management area that is outside of any riparian reserve zone, or if there is no riparian reserve zone, that area located adjacent to a stream, wetland or lake of a width determined in accordance with Schedule C of the Pilot Regulations.

Riparian Reserve Zone

An area adjacent to a stream, wetland or lake, within the Resource Management Zone, where no logging may occur.

That portion, if any, of the riparian management area or lakeshore management area located adjacent to a stream, wetland or lake of a width determined in accordance with Schedule C of the Pilot Regulations.

Road Deactivation

The process of modifying an existing road which will not be used for a period of time to minimize access and environmental effects through such measures as water bars, removing bridges and culverts, reseeding with grass or trees, or rollback of slash onto the running surface. The extent of road deactivation is determined by the amount of time the road is not required for use, and the potential risks to the environment posed by the road.

ROS (Recreation Opportunity Spectrum)

A recreation opportunity is the availability of choice for someone to participate in a preferred recreation activity within a preferred setting and enjoy the desired experience.

Rotation

Broadly, the time needed from regeneration of a crop of trees through to harvestable timber. Can be classified under financial, technical, biological or ecological parameters.

Scale

Defined on the basis of elements such as size, shape and distribution of ecosystem components.

Selection Silviculture System

A silviculture system that removes mature timber either as single scattered individuals or in small groups at relatively short intervals repeated indefinitely, where the continual establishment of regeneration is encouraged and an uneven-aged stand is maintained. As defined in the Code's Operation Planning Regulation, group selection removes trees to create openings in a stand less than twice the height of mature trees in the stand.

Sequential Clustered Development

The scheduling of operable timber into groups of neighbouring blocks with a single access route, usually within a subdrainage, with each group being developed in sequence over the full harvest cycle. A one pass, one entry harvesting system which concentrates harvesting, thereby minimizing the amount of new access being created, and reducing the amount of forest fragmentation.

Seral Stages

The stages of ecological succession of a plant community over time.

Shelterwood Silviculture System

A silviculture system in which trees are removed in a series of cuts designed to achieve a new even-aged stand under the shelter of remaining trees.

Siltation

The act of introducing foreign substances into a stream or wetland. Usually comes as a result of eroding stream banks.

Silviculture

The art, science and practice of controlling the establishment, composition, health, quality and growth of vegetation of forest stands.

Silviculture Prescription

A site-specific operational plan or site plan that prescribes the nature and extent of timber harvesting and silviculture activities that are designed to achieve desired forest management objectives including reforestation of a free growing stand to specified standards.

Site Degradation

Productive forest land significantly degraded or permanently lost to forest production.

Site Index

An expression of the forest site quality of a stand, at a specified age, based either on the site height, or on the top height (height of the largest diameter tree on a 0.01 ha plot, providing the tree is suitable), which is a more objective measure (FP Code). The measure of the relative productive capacity of a site for a particular tree species, based on height at a given reference or base age (50).

Site Plan

A plan describing the logistics for forestry development prepared under the Fort St. John Pilot Project regulation, but excluding Forest Development Plans. Includes silviculture prescriptions, stand management prescriptions, road deactivation prescriptions, road layout and design and road deactivation prescriptions.

Site Series

Variation in site conditions encountered within a biogeoclimatic unit is accommodated within the site classification of BEC. The site series describes all land areas capable of supporting specific climax vegetation. This can usually be related to a specified range of soil moisture and nutrient regimes within a subzone or variant, but sometimes other factors, such as aspect or disturbance history, are important determinants as well. A classification of site series for most of the biogeoclimatic units of the province has been developed by the BC Ministry of Forests and is presented in regional field guides.

SFM (Sustainable Forest Management)

Small Business Forest Enterprise Program

The government program administered by the Ministry of Forests that facilitates the entering into agreements under the *Forest Act* that generate small business forest enterprise revenue.

SMZ (Special Management Zone)

The Fort St John LRMP has Special Management Zones based on major resource values to be given a high priority in land and resource planning and development. Resource development is permitted but must consider and address all significant values identified. SMZ include wildlife habitat and wilderness recreation, major river corridors, and culture and heritage.

Snag

Standing dead tree or part of a dead tree.

Soil Disturbance

The portion of the harvested area where

(a) the area has been altered by timber harvesting or related forest practices, and

(b) that alteration inhibits reforestation of the area.

Spatial

Pertaining to the physical size, location, pattern and distribution.

Spatial Distribution

The distribution of openings over a landscape, usually in reference to natural disturbance patterns, or to logging. Logging that mimics the natural spatial distribution of natural disturbance patterns is considered to minimize long term effects on wildlife and ecosystems.

Stakeholder

Individual, organization or other entity concerned with or by management activities on a given forest area.

Stand Level

The level of forest management at which a relatively homogeneous land unit can be managed under a single prescription, or set of treatments, to meet well-defined objectives.

Stocking Requirements

For an area under a site plan, the stocking requirements specified in the site plan for that area.

Strategic

Broad scope using generalities, not specifics.

Stub Trees

Snags or live trees that are cut off during harvesting at heights of 3 to 5 metres by feller bunchers, to provide vertical structure and coarse woody debris for wildlife use in the new forest.

Stumpage

Price charged for the right to harvest timber from publicly owned forest land.

Sustainability

The ability of an ecosystem to maintain ecological processes and functions, biological diversity, and productivity over time. Applied more broadly, the ability of society to maintain a balance of economic, social and ecological values over time.

Sustainable Forest Management

Management to maintain and enhance the long-term health of forest ecosystems, while providing ecological, economic, social and cultural opportunities for the benefit of present and future generations.

Temporary Access Structure

An access structure, the area under which will be reforested.

Terrain Stability Map

Terrain mapping is a method to categorize, describe and delineate characteristics and attributes of surficial materials, landforms, and geological processes within the natural landscape. Terrain stability mapping is a method to delineate areas of slope stability with respect to stable, potentially unstable, and unstable terrain within a particular landscape. Terrain stability map polygons indicate areas or zones of initiation of slope failure.

Timber

Timber means trees, whether standing, fallen, living, dead, limbed, bucked or peeled (Forest Act)

Timber Harvesting Land Base

The portion of the total area of a management unit considered contributing to, and being available for, long-term timber supply. The harvesting land base is defined by reducing the total land base according to specified management assumptions.

Timber Supply Analysis

An assessment of future timber supplies over long planning horizons (more than 200 years) by using timber supply models for different scenarios identified in the planning process.

Timber Supply Area

An administrative boundary determined by the Ministry of Forests in which annual allowable cuts are determined, and from which timber harvesting rights may be awarded. Forest Licence A18154 provides harvesting rights only to timber within the Fort St. John timber supply area.

Timber Supply Review (TSR)

The timber supply review program regularly updates timber supply in each of the 37 TSA's and 34 TFL's areas throughout the province. By law, the Chief Forester must re-determine the AAC at least once every five years to ensure AAC's are current and reflect new information, new practices and new government policies.

TIPSY (Table Interpolation Projection Program For Stand Yields)

A program that interpolates data from TASS (tree and stand simulator) – a computer model that simulates the growth of individual trees and stands. This program is based on growth trends observed in fully stocked research plots growing in a relatively pest free environment. The yields will be very close to the potential of a specific site, species and management regime.

Topographic

The general configuration of the land surface, including relief and position of natural and man-made features.

Ungulate

A hoofed mammal (eg. deer, elk, moose, caribou).

Value (as applied to CCFM Criteria and Critical Elements)

A principle, standard, or quality considered worthwhile or desirable.

Vegetation Resources Inventory (VRI)

Vertical Structure

Those components of a forest which are vertically oriented, eg. live and dead trees of various heights and species.

"Vision"

A registered herbicide that targets annual and perennial weeds and hardwoods (grass, aspen birch, etc.) while leaving coniferous trees undamaged. The herbicide is the forestry version of "Roundup", which is used extensively on agricultural and urban areas for the control of grass and other vegetation.

Visual Quality Objective (VQO)

An approved resource management objective that reflects a desired level of visual quality based on the physical and sociological characteristics of the area; refers to the degree of acceptable human alteration to the characteristic landscape.

Watershed

An area drained by a particular stream or river. A large watershed may contain several smaller watersheds.

Waste

The volume of timber left on the harvested area that should have been removed in accordance with the minimum utilization standards in the cutting authority. It forms part of the allowable annual cut for cut-control purposes.

Waterbody

Any land covered by water.

Windfirm

Areas of forest that are able to withstand the effects of heavy gusts of wind.

Windthrow

A tree or trees uprooted by the wind.

Woodlot Licence

A licence issued by the Ministry of Forests to an individual or group to manage a specific area of Crown timber, plus any private forest land the individual or group owns.