CRITERION 2.0

Maintenance and Enhancement of Forest Ecosystem Condition and Productivity

"Maintaining the health and productivity of forest ecosystems is an important prerequisite to sound stewardship and the sustainable development of forested lands. The three elements measured by Criterion 2 – disturbance and stress, ecosystem resilience, and biomass – provide some indication of whether ecosystems are functioning normally."

- CCFM (1997)

PREAMBLE

This section presents a compilation of baseline data gathered for the indicators for Criterion 2.0 – Maintenance and Enhancement of Forest Ecosystem Condition and Productivity. Data for some indicators are complete while other indicators have only monitoring protocols or sampling methodology that can eventually be applied to the whole area to generate the necessary information.

Information for the State of the Forest Report dealing with "Maintenance and Enhancement of Forest Ecosystem Condition and Productivity" was prepared in stages. Some data were accessed from primary sources, and other information came from selected published sources or personal expertise. Several drafts were circulated and refinements were gradually made Much information was available for forest growth and the historic impacts of insects, disease and fire. Models were demonstrated to forecast impacts of a future outbreak of spruce budworm, and these can be used to aid in making forest management and protection decisions pertaining to long-term fibre and non-fibre objectives. Computer-based Geographic Information Systems (GIS) are available to display forest ecosystems classified at the landscape level (e.g. community types and age class structure); and computer models were used to project forest ecosystems into the future based on various forest management practices.

Indicator 2.1a

Area and Severity of Insect Attack

Management Planning Objective -
Monitor annually with the intent to minimize effects of major outbreaks on consumptive and non-consumptive forest values without impacting ecological functioning negatively

Justification for Selection

Disturbance and stress strongly influence the health, vitality, and productivity of our forests, and they are fundamental to the maintenance and enhancement of forest ecosystems. Insects and diseases are dominant causes of natural disturbances in forest environments but they only become pests of concern when their role in natural processes conflicts with human objectives.

Data Sources

- 1993 GIS Forest Inventory – NBDNRE
- NBDNRE - Forest Pest Management Section

Monitoring Protocol

General monitoring was done by the Forest Insect and Disease Survey of the CFS for 50 years until it was curtailed by them in 1995. Since then, NBDNRE has increased its pest monitoring efforts. For non-native pests, the Canadian Food Inspection Agency has the lead under the federal *Plant Protection Act*. Close liaison is maintained between these three levels of government. Various monitoring protocols have been developed for a variety of forest insects. The level of monitoring for each has generally been predicated on the level of impact that each can cause. One major forest insect pest, the spruce budworm (SBW), has been monitored and studied extensively in North America. In recent years, computer-based Decision Support Systems (DSS) have been developed to estimate the effects of this pest, in terms of volume loss from past and future budworm outbreaks in the FMF. Impacts on certain other non-fibre forest management objectives can also be examined. The combined effects of these impacts have been shown for different land ownership, stand types, tree species and time periods.

Pest Volume Losses

Of all insect pests, studies of SBW have resulted in the compilation of the largest database and associated technology development for estimating impact on the forest environment. In FMF, a considerable amount of work was done to quantify past SBW impacts using defoliation data from 1965-1995. A project was conducted by Erdle (1999) (1) to develop a methodology which estimates periodic volume loss from annual defoliation surveys; (2) to apply a methodology to derive periodic volume loss estimates (by ownership for the FMF area) under different outbreak scenarios; and (3) to extend the methodology so that stand yields could be adjusted to reflect unfolding defoliation patterns. Much effort has also been aimed at quantifying possible volume losses from probable future SBW outbreaks. These efforts are part of the ongoing work conducted by the Decision Support Systems Group (DSS) at Natural Resources Canada – Canadian Forest Service (CFS). Results are reported in MacLean *et al.* (1999).

Volume loss and other impacts for other forest pests within the FMF are less well documented.

Baseline Results

Annual surveys of defoliation were conducted by the CFS until 1983; since then, by NBDNRE. These surveys provide an overview of the extent and intensity of feeding damage by insects, or loss of foliage by other causes (Figure 14). Surveys can vary in accuracy from year to year depending on weather conditions, methods, and the observers conducting the surveys.

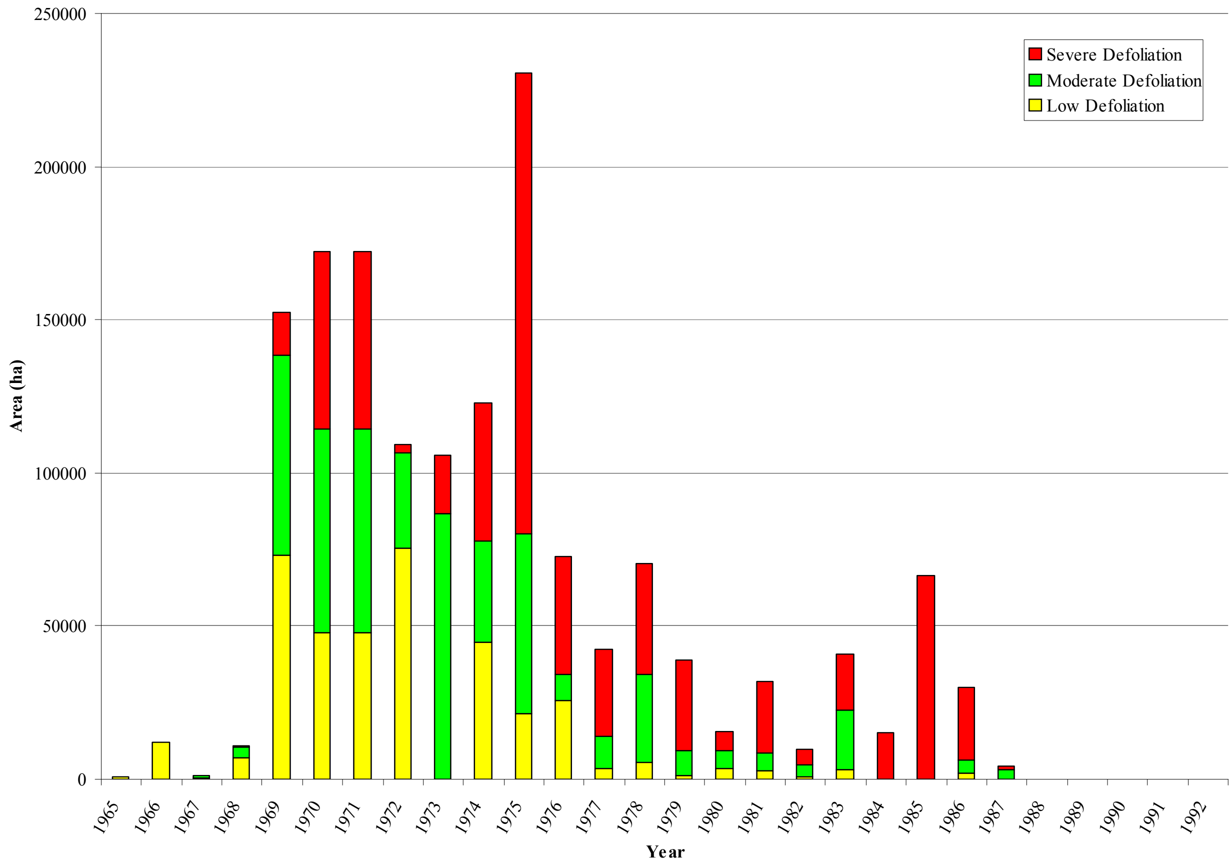


Figure 14. Area and severity of spruce budworm defoliation in the FMF. These data were derived from aerial sketch maps that were transferred digitally to the Geographic Information System (GIS).

During the early-to-mid 1990s, another forest pest, the yellow-headed spruce sawfly, was prevalent in the FMF (Carter 2000). Populations were found in the southeastern part of the FMF near Fundy National Park. At the height of the outbreak in 1995, 37 plantations in the area had varying levels of attack including some tree mortality. To prepare for possible protection actions, a series of Integrated Pest Management (IPM) experimental trials was established in 1996 consisting of: mating disruption by sex pheromone; release of egg parasitoids; spraying with nematodes, neem, and chemical insecticides (i.e. trichlorfon, malathion, permethrin). Since then, populations have subsided. An impact study was conducted in 1998 in one of the most damaged plantations and estimated volumes at the time of harvest were projected to be 3-4 fold lower within damaged areas.

Monitoring annual population trends of balsam twig aphid and balsam gall midge were incidentally possible by noting their presence on branch samples collected to monitor SBW populations. These two insects are not serious forest pests, but are of concern to Christmas tree growers, because damage can affect the quality and marketability of trees. Population changes for these pests in the general FMF area are shown in Figure 15.

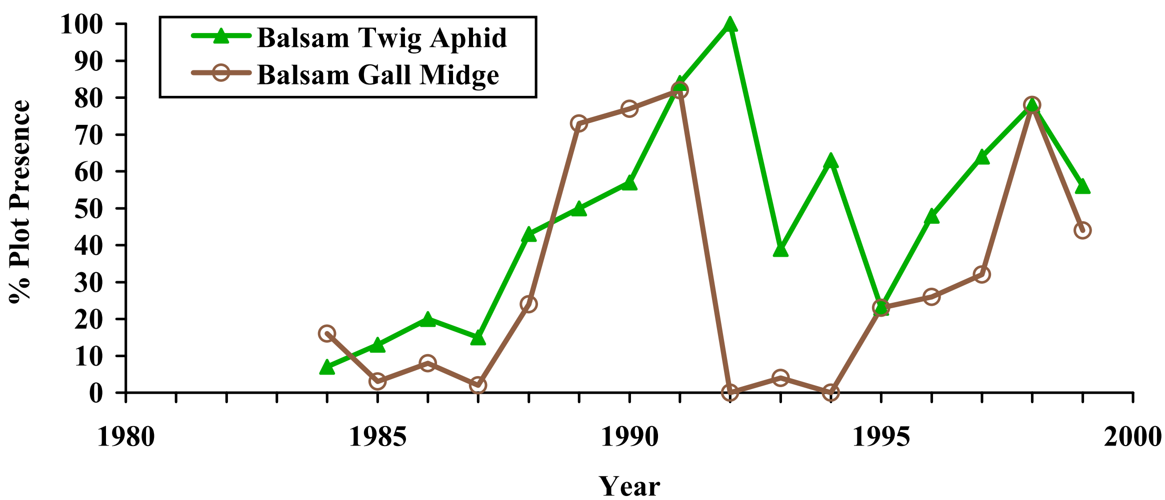
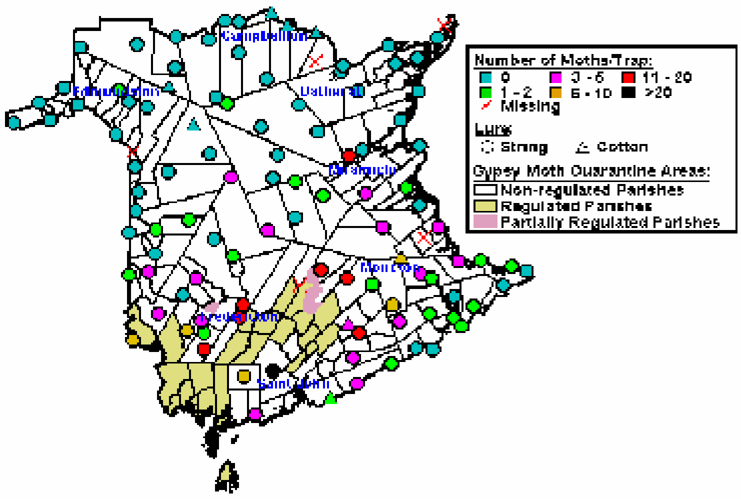
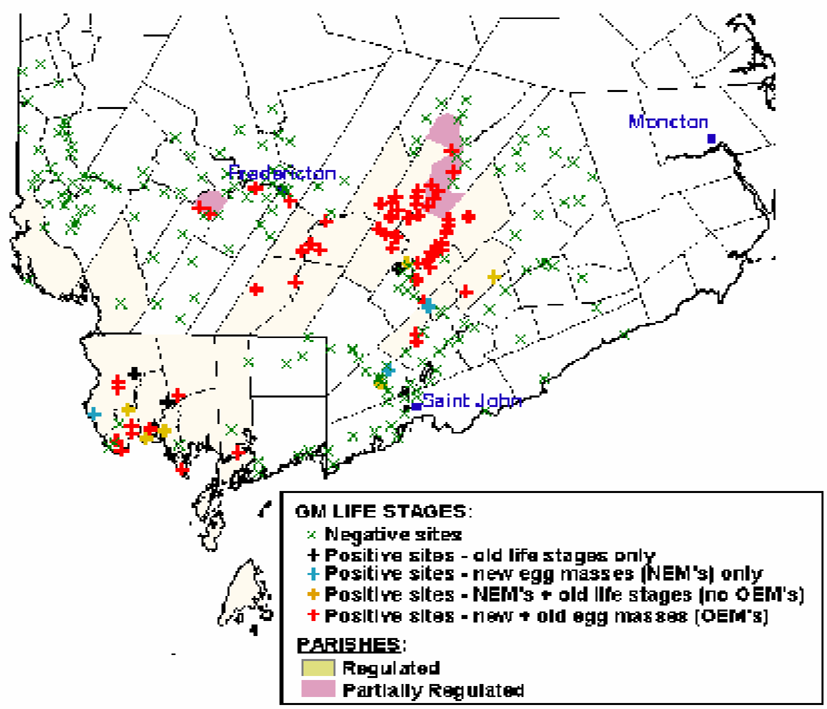


Figure 15. Presence of balsam twig aphid and balsam gall midge in NBDNRE Region 3 (Carter 2000).

Besides native forest pests, many pests of foreign origin can also be found in FMF. One of the most recent is European Gypsy Moth. Since 1981, this insect has become well established in the southwestern and south-central portions of New Brunswick, after an absence of approximately 40 years. Up to 2000, it had not caused any significant defoliation, but its presence has resulted in indirect effects. Quarantine areas have been established by parish by the Canadian Food Inspection Agency under the federal *Plant Protection Act*. Moving plant material and other designated items outside these areas is prohibited unless certain conditions are met. For example, when Christmas trees are sent from areas under quarantine they must be examined and certified as being pest-free. On a provincial basis, it is evident that positive sites with new egg masses and/or old life stage are most abundant around the northwest boundary of FMF (Figure 16). If populations continue to survive and increase, it will only be a matter of time before conditions become right for an outbreak. Weather and host-species do not appear to be limiting factors to its establishment and survival. As gypsy moth populations build within currently regulated areas, there is increased risk of spread by human means to un-infested areas.



110 gypsy moth pheromone trapping locations (2001).



240 gypsy moth egg mass and life-stage survey locations (2001).

Figure 16. Pheromone trapping locations for Gypsy Moth in New Brunswick in 2000 (Carter 2001). Negative and positive occurrences of various life stages are shown for different parishes. Four parishes in the Fundy Model Forest are included in the area.

Spruce Budworm-Caused Volume Losses from Past Conditions

Outbreaks of spruce budworm can have significant impact. In 1952, the provincial government initiated annual aerial control programs with insecticides to protect the forests from large-scale losses due to these outbreaks. In 1977, the Province adopted a policy of no spraying within a one-mile (1.6-km) set-back zone from year-round human habitation. A tree mortality study by Clowater & Andrews (1979) recorded 2 502 000 m^3 (12%) of spruce volume and 7 562 000 m^3 (43%) of balsam fir volume as being dead or moribund within this set-back area. This survey of 241 Provincial forest inventory plots, specific to small freehold land in southern New Brunswick, accounted for 862 363 ha of forest land. In 1980, Clowater & Andrews (1981) estimated 3 054 000 m^3 (15%) of spruce volume and 8 982 000 m^3 (48%) of balsam fir volume as being dead or moribund.

Potential Volume Losses from Future Spruce Budworm Outbreaks

The CFS developed the Spruce Budworm Decision Support System (SBWDSS) to support forest managers in spatial decision-making related to budworm management (MacLean & Porter 1994, 1995). DSS uses: 1) forest inventory to describe the landbase; 2) budworm monitoring data and defoliation predictions to determine outbreak scenarios; 3) a stand growth model and timber supply (forest estate) model to determine stand and forest-level effects of defoliation and protection; 4) the Arc/Info GIS and custom programs for calculations and spatial data manipulation; and 5) ArcView for map generation and a graphical user interface. The Protection Planning System (PROPS) component of SBWDSS models the timber supply benefits of alternative management actions, and thereby facilitates incorporation of effects of budworm damage into forest management planning (Figure 17). It generates volume loss maps that can be used to help design and analyze costs and benefits of insecticide spray programs. The last budworm control program on Crown land in the Province occurred in 1993, so it is anticipated this technology will be very useful when the next outbreak occurs.

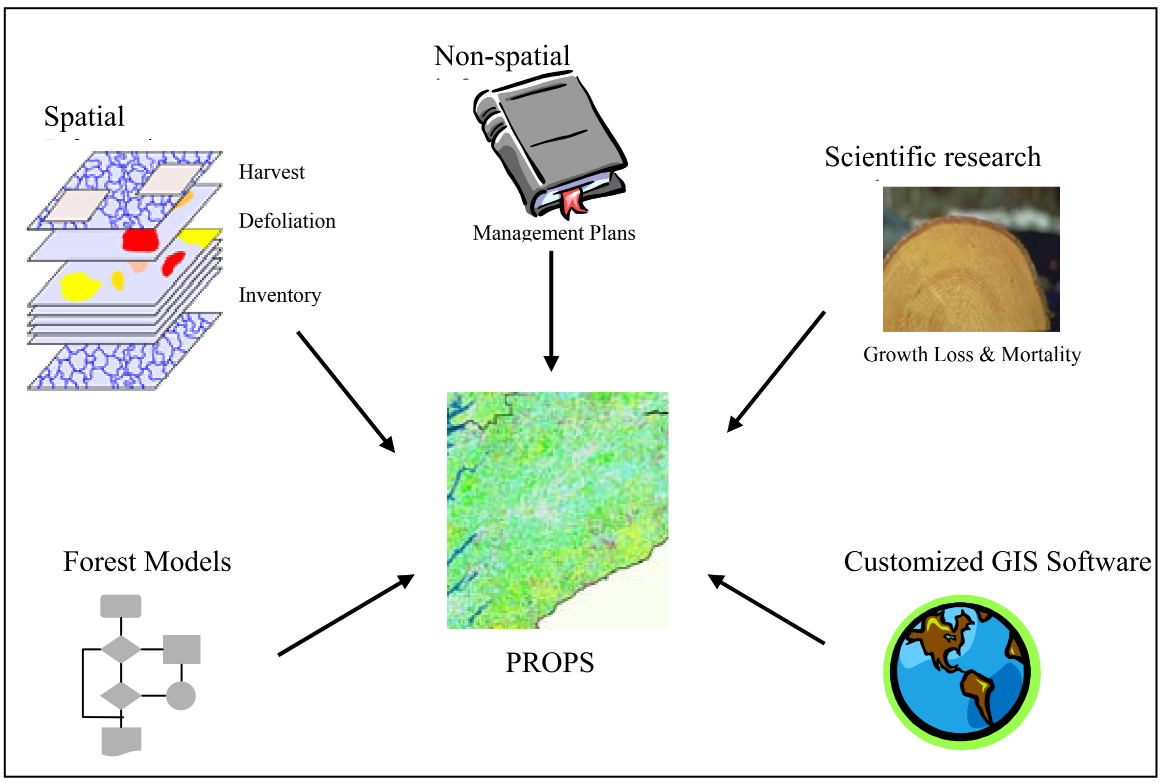


Figure 17. Components of the SBWDSS Protection Planning System (PROPS).

For the FMF, Erdle (1999) estimated volume losses for the following outbreak scenarios: (i) Actual, (ii) Unprotected and (iii) 60% Protection. The graphs presented in Figure 18 show: (A) Five-year periodic volume losses under 3 different outbreak scenarios, (B) Volume loss by species under three defoliation scenarios, (C) Volume loss by ownership under 3 outbreak scenarios, (D) Percent distribution of susceptible forest and total loss between owners under the "Actual" outbreak scenario, and (E) Spruce-fir inventory relative to various defoliation scenarios.

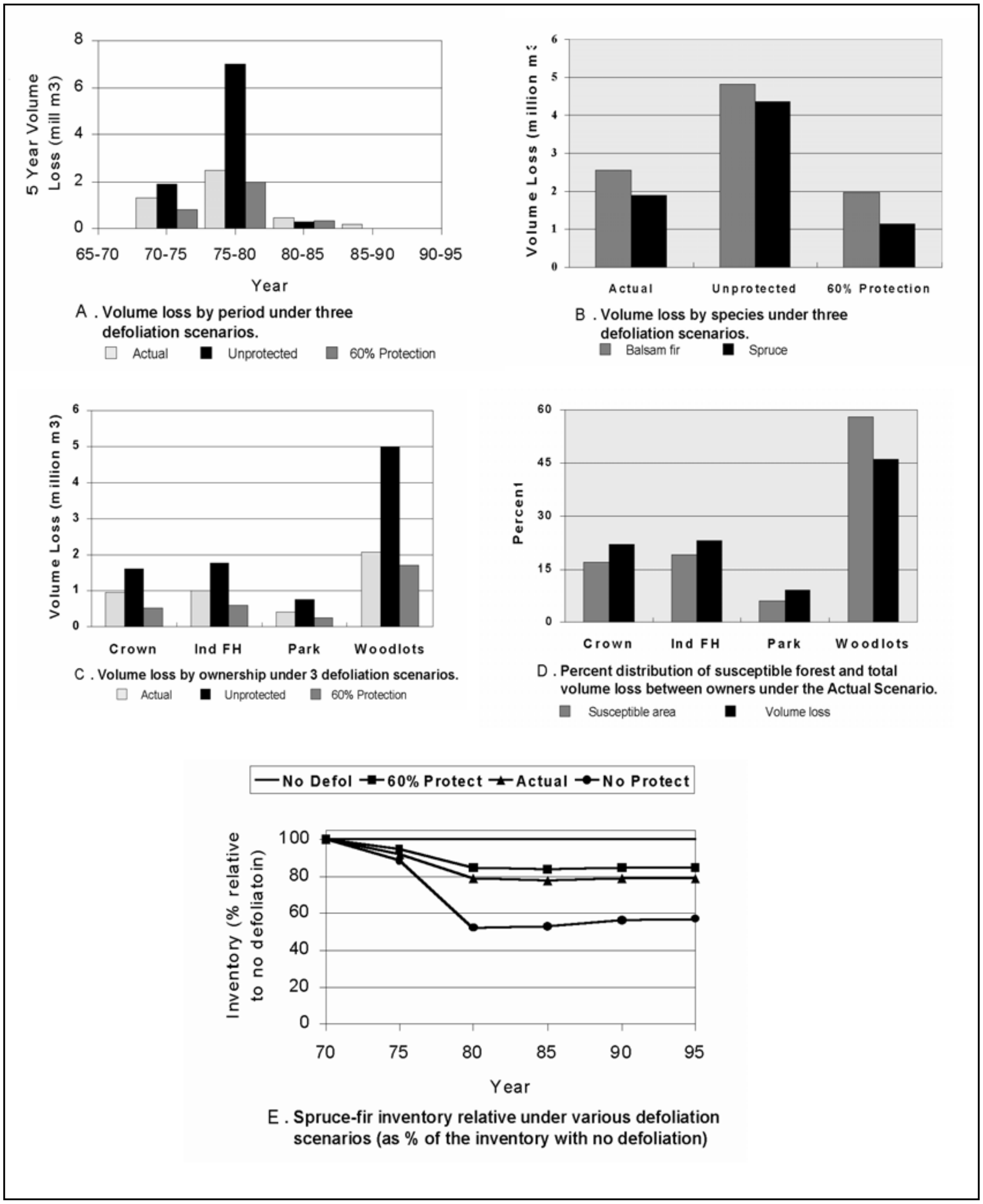


Figure 18. Graphs depicting various volume loss scenarios (Erdle 1999).

Potential Impact on Other Values

From a non-timber perspective, SBW affects stand structure (species composition and age class distribution), wildlife habitat quality, riparian buffer quality, aesthetics, and biodiversity. The SBWDSS was adapted to incorporate measures of forest structure changes to the amount of forest area meeting mature coniferous forest habitat guidelines, changes to deer wintering areas (DWAs), riparian buffers and conservation areas, using the volume loss approach. For example, under a typical SBW outbreak scenario, estimated volume loss in DWAs (in stands expected to achieve a softwood volume >50 m^3/ha) over the next ten years is expected to occur over 307 hectares more area without protection.

Forests and other natural systems change slowly over time making it difficult to determine the effects of natural and human-caused events. Maps and tabular data have traditionally been used to communicate the magnitude and severity of impacts on forests such as those caused by insects. Although they accurately represent the location and extent of impacts, they do little to help create a visual impact of what an insect outbreak means at the ground level. The effects of SBW outbreaks on softwood timber supply are fairly well known. With increasing demand for multiple uses of our forests, aesthetic effects are also becoming a concern.

An image processing approach has been developed to systematically modify photographs of healthy forests to simulate different levels of damage caused by forest pests or alternatively, to simulate recovery of damaged areas. Figures 19 and 20 illustrate an example application of this approach. The first photograph shows a shallow valley with mix of spruce/fir trees (dark green) and hardwood trees. The second image is an altered version of the first in which the spruce and fir trees in the middle of the picture (reddish colour) look like they have been heavily defoliated while the remainder of the image is untouched from the original.

Figure 19. Image of softwood and hardwood trees.

Figure 20. Altered image showing reddish colour indicating defoliation of softwood trees.

These types of altered photographs allow multiple viewers to interpret the same results of the budworm effect on a particular area and therefore may lead to increased 'group' understanding and also more efficient consensus building. Whether the concern is aesthetics or some other quality of the forest, such photos can help to increase understanding.

Best Management Practices

BMPs for dealing with pests can also be called Integrated Pest Management (IPM). IPM approaches include:

- Monitoring insect populations and/or damage to determine potential problems, annual defoliation and forecast surveys (e.g. egg, larval, moth surveys) to monitor population and damage levels.

- Because of interest in providing opportunities for FMF partners to become more aware of insects (and diseases), a project was conducted to produce a CD that depicts sampling methods and diagnostic features for a selected group of pests. This could address heightened awareness and assist in the early detection of potential problems at a local level.

- Assessment of existing or possible impacts - use decision support tools such as PROPS and visual tools to assess impacts to both fibre and non-fibre management objectives.

Evaluation of available control or management options:

- do nothing and incur growth loss, tree mortality, and other socio-economic impacts;
- apply insecticides (biological or chemical depending on circumstances) to prevent defoliation to keep trees alive and/or maintain growth;
- pre-salvage harvest highly-vulnerable stands where practical;
- salvage harvest killed trees before disease renders them uneconomical;
- plant non-susceptible tree species (long term);
- plant less-vulnerable tree species (long term);
- restructure forest using pre-commercial thinning or harvest scheduling to favour non-susceptible or less-vulnerable tree species (long term);
- conduct research to develop new controls (e.g. biological agents, pheromones, etc.), as well as improve current techniques (e.g. improved spray technology).
- Application of control(s) and management options selected from the foregoing, and
- Assessment of treatment/management/results
- Set goals and objectives to determine whether future changes are necessary.

Functionality and Application

Spruce budworm continues to be a major insect pest not only from a historical perspective but also because a large proportion of the softwood growing stock in the FMF is comprised of susceptible balsam fir and spruce. Over 5 185 ha of pre-commercial thinning of spruce-fir, fir-spruce, or fir exist on the landbase, along with over 15 924 ha of less-vulnerable black spruce plantations. Crown Timber License 7 is being managed at the maximum sustainable harvest level possible. Therefore, any major reductions in expected growing stock (i.e. due to an insect outbreak and resulting tree mortality) in the most sensitive harvest periods (periods 4 to 6, 20-30 years in the future) will require reduction in harvest levels to maintain sustainability. Analyses showed that very little defoliation could be tolerated, unless land managers are prepared to reduce harvest levels or increase the overall volume of the forest through other management actions such as silviculture, tree improvement, etc. (MacLean *et al.* 1999). These actions, however, could bring their own risk of future pest problems, and other non-fibre, socio-economic, or management values may also be adversely impacted thus necessitating control action.

Though monitoring for insect pests has been conducted annually, there is a lack of information on long-term impacts of pests other than spruce budworm. Whether they are introduced or native it will be necessary to closely monitor pest impacts to ensure the maintenance and improvement of forest ecosystem productivity into the future.

Monitoring at the provincial level by government agencies provides much information, however, it does not always capture the conditions of insect infestations on private woodlots. The FMF CD-ROM made available to woodlot owners could help them recognize forest insects, and provide information how to manage these conditions.

Indicator 2.1b

Area and Severity of Disease Infestations

Management Planning Objective - Monitor annually with the intent to evaluate effects of major disease outbreaks on consumptive and non-consumptive forest values without impacting the ecology negatively

Justification for Selection

Disturbance and stress strongly influence the health, vitality, and productivity of forests, and hence the maintenance and enhancement of forest ecosystems. Along with insects and fire, diseases are dominant natural causes of forest disturbance. Some of the most significant diseases have been introduced and are not native to NB. In the FMF, disease infestations are important, though there is a lack of specific data for this particular land base. Insidious impacts come from root and stem diseases.

Data Sources

- Forest Pest Management Section – Department of Natural Resources & Energy
- Forest Management Section – Department of Natural Resources & Energy
- Forest Health Network – Natural Resources Canada, Canadian Forest Service

Monitoring Protocol

Approaches to monitoring and surveying forest diseases depend on their particular type (i.e. foliar, stem, root rots, etc.). Many are difficult to detect and assess. Detection and sampling methods integrated into grid-based or existing plot systems are ideal procedures, as is aerial mapping. Disease surveys have often been limited to specific diseases of concern. With few exceptions, results are point-based distributions and are not extrapolated for impact assessment due to lack of research programs and expertise. Unlike insect defoliation, which can be assessed by size of area affected, forest diseases rarely demonstrate impact in a similar way. Losses, in the form of defoliation, growth reduction, and mortality, are often irregular and data compilation is difficult.

The most frequently addressed impact in commercial forestry is the loss caused by stem and root decays. These are routinely accounted for with the use of decay/cull factors when computing volume estimates. According to the 'New Brunswick Forest Inventory (1986) Report' (NBDNRE 1989), prior to 1981, such factors were based on the Provincial Crown Lands Decay Survey Report of 1969. Factors were used to estimate net merchantable volume and useable merchantable volume from gross merchantable volume. The decay/cull results were presented on a Province-wide basis by ecoregion, as defined by Loucks (1962). In 1980, concerns were raised about the accuracy of these factors as they related to the 1980 conditions. Subsequently, a new survey was conducted on Crown land from 1981-86. Results were grouped on a license basis, and local volume tables were developed. Factors are available for spruce, balsam fir, and jack pine.

Baseline Information

To illustrate the magnitude of disease impacts, the following three Provincial estimates for the period 1982-87 are taken from Pendrel (1991):

<u>Hypoxylon canker</u>: a chronic disease estimated to affect 16% of all trembling aspen, killing about 0.6% per year. Average annual mortality losses were estimated at 240 000 m^3 for the period, and were

approximately double the annual losses reported for 1977-81. There are insufficient data to estimate growth loss.

White pine blister rust: a chronic condition, presumed to have the same impact on trees from year to year. Average annual mortality was estimated at 75 000 m^3. No attempt was made to estimate loss due to top kill.

Stem and root decays: Major losses occur largely from unseen decays within the tree. Various tree species are host to different decay fungi and so losses must be host species specific in many cases. Average annual losses due to decays were 548 000 m^3 for the period (Table 11). Cull would account for an additional loss of usable product of about 12%.

Table 11. Average annual losses of wood volume (m^3) due to root and stem decays from 1982 to 1987.

Tree species/Species groups			
Balsam fir	Spruces	Other softwoods	Hardwoods
179 000	87 200	55 400	225 800

European larch canker: European larch canker is another introduced disease, first reported by the CFS in 1980. Its impact has not been quantified. Larch does not make up a large part of the provincial forest inventory, so its overall commercial value is minimal compared to spruce and fir. Nevertheless, a regulated area has been established by the Canadian Food Inspection Agency under the federal *Plant Protection Act*.

Butternut canker: This is another foreign disease, but it has not yet been detected in the FMF. It was first reported in the Province by the CFS in 1997 at five locations close to the Maine border within about 20 km north of Woodstock. It has decimated butternut stands in the United States. Consequently, stands of butternut in New Brunswick could also be at long-term risk, thus weakening our natural biodiversity.

Best Management Practices

Best Management Practices for diseases would be similar to those for insects, though options for control are much more limited. For instance,

- Monitoring disease presence and extent of infection and/or damage to determine potential problems, annual defoliation and detection surveys.

- Awareness of forest diseases will be heightened with the IPM CD developed by the FMF.

- Assessment of existing or possible impacts - refer to text books and other sources for information to support decisions, and conduct research when needed.

Evaluation of available control or management options include those mentioned in insect management as well as:

- apply fungicides (if practical) to prevent defoliation to keep trees alive and/or maintain growth; prune, cut and leave (or burn) infected material depending on circumstances;
- Application of control(s) and management options selected from the foregoing, and
- Assessment of treatment/management/results
- Set goals and objectives to determine whether future changes are necessary.

Functionality and Application

Survey and monitoring results for forest diseases are limited within the FMF, but from this lack of information one should not infer that impacts due to growth loss and mortality are low. Provincial and regional scale information for some diseases would infer similar losses within the FMF over similar time frames. Losses due to forest disease are more likely to appear in the form of reduced increment.

It is difficult to present disease information in a spatial context because point location surveys do not give a true indication of the spatial extent of the problem. One occurrence of a disease in an area does not mean that every tree in the stand is infected. Thus, area determination of the extent of damage does not exist, as it does for insects. Disease information at point source or discrete locations limits the type of spatial representation that can be made. Trends over time are similarly limited.

With FMF support, the NBDNRE and CFS developed a CD for forest disease recognition (the same as for forest insects) directed towards woodlot owners. This tool is readily available and will be useful in monitoring forest diseases.

Indicator 2.1c

Area and Severity of Fire Damage

Management Planning Objective - Minimize occurrence of fire

Justification for Selection

Wildfires consume nearly as much wood in Canada as timber harvesting. They constitute a major ecological and environmental disturbance, and threat to human life and property. Although potentially damaging, fire has less impact in the FMF than some other areas of the Province due to the moist climate and extensive road network that allows efficient suppression.

NBDNRE is responsible for protecting all forest lands in the Province against wildfire. The Province can call upon provincial, national and international support should conditions reach an emergency situation beyond the Province's capabilities to cope.

Data Sources

- GIS Forest Inventory – NBDNRE
- Provincial fire reports – NBDNRE
- Forest Fire Management – NBDNRE

Monitoring Protocol

Methods for monitoring forest fires have traditionally consisted of determining the overall area burned, and classifying causes (e.g. man, lightning, etc.). Forest inventory data can be used to estimate impact in terms of merchantable volume burned. In some cases, salvage harvests can be conducted to minimize fibre losses.

Monitoring the area and severity of fire damage also includes measures of awareness, preparedness, detection and suppression.

Awareness: Each year, citizens of New Brunswick are made aware of the danger of forest fires through advertisements in newspapers, on radio and on television. Many locations post daily hazard ratings based on the Canadian Forest Fire Weather Index (FWI) to alert the public.

New Brunswick uses a network of weather stations across the Province to provide an indication of fire danger and monitor conditions that are conducive to fires. Forecast and actual FWI values are used to plan pre-suppression activities and to alert staff, forest workers, industrial operations, patrols and suppression agencies.

Preparedness: All fire equipment is tested prior to and during the fire season. As the FWI increases, equipment is mounted on vehicles and ready to be deployed, with personnel on stand-by within the district/regional area.

Operational communications are maintained by NBDNRE. Portable radios that can be programmed with department frequencies and cellular phones are used extensively in the field.

Detection: Detection aircraft operate in each region during the fire season. All flights are monitored from Regional Headquarters and at Airtanker Dispatch, with the aircraft calling in the position and time at each turning point. The regional controller keeps a log of each flight. New Brunswick does not currently use any of the technology that is available to count and/or locate lightning strikes.

Suppression: Volunteer firefighters and municipal fire departments are heavily depended upon to supply extra manpower and equipment. The forest industry also provides manpower and equipment but are generally focused on fire suppression on their own freehold or licensed land.

Air suppression is used when necessary. Airtanker Dispatch monitors all fixed-wing aircraft operations and coordinates any search and rescue efforts in an emergency. The Air Attack Officer or Air Attack Boss is responsible for coordinating these efforts at a fire site.

Baseline Results

Figure 21 depicts the number of fires and area burned each year in FMF from 1982 to 2000. Except for 1985 and 1986, the number of fires seldom exceeded 10-15 per year, and they were usually extinguished before any significant area was burned (the notable exception being 1986).

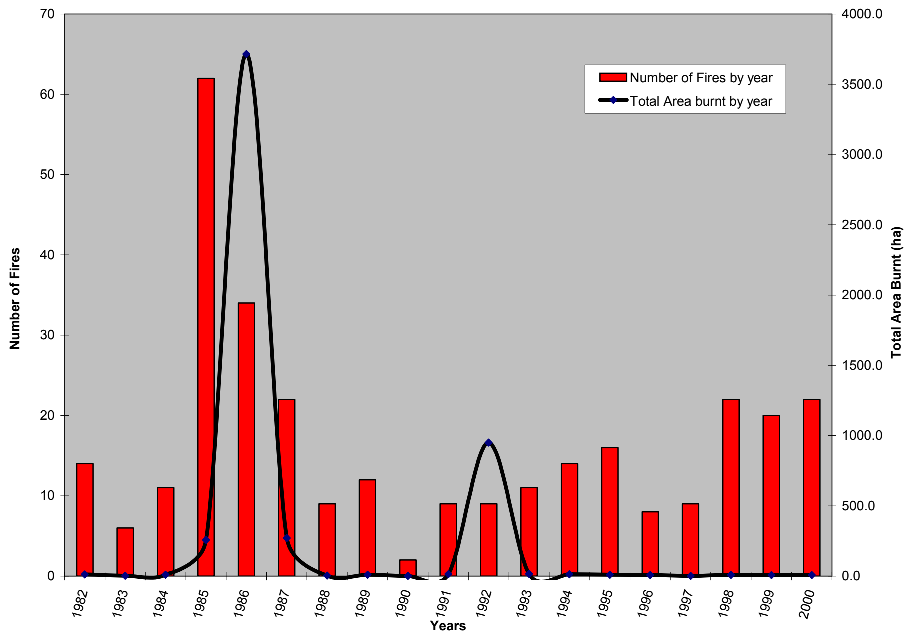


Figure 21. Number of fires and area burned by year in the Fundy Model Forest from 1982 - 2000.

Best Management Practices

Basic components to BMPs for forest fire management include:

Awareness	-	Public information
	-	Fire Weather Index
Preparedness	-	Training of ground and aerial crews
	-	Availability of ground and aerial support materials
Detection	-	Routine and special aerial reconnaissance
	-	Public reporting
Suppression	-	Efficient ground and aerial support with prompt response
Rehabilitation	-	Salvage harvesting (to minimize economic losses when appropriate)

Natural regeneration
Planting to establish a new forest cover

Functionality and Application

Monitoring protocols are mostly limited to reporting the number of fires by cause and computing the area and volume burned. These measures can be reported annually to track the area, severity and impact that forest fires have on forest resources.

Indicator 2.1i

Area and Type of Human Disturbance Specific to Forest Harvesting

Management Planning Objective - To maintain sustainable forest harvesting levels and to harvest at the sustainable AAC (m^3/period) by treatment type and by ecological community type

Justification for Selection

This indicator was chosen as an area of concern because human disturbances and forest management actions are as important as natural disturbance in assessing sustainability. This indicator along with 2.1a and 2.1b forms a "total disturbance" suite of indicators.

Data Sources

- SNB Forest Products Marketing Board - Woodstock Wood Supply model 1994-2019
- J.D.Irving, Limited - Woodstock Wood Supply model 1998-2023
- Crown License 7 - Wood Supply model 1997-2022, 2002-2027
- Fundy National Park - Wood Supply Model 1998-2023

Monitoring Protocol

Disturbance resulting from forest harvesting can be categorized by various types of actions, generally classed as the type of harvest operation: clear-cut, partial cut, selective cut, multiple entry, spacing, and commercial thinning. The one generally regarded to be most invasive is clear-cut.

Baseline Results

There has been a major effort to limit the size of clear-cuts within the Province, and increase the use of other harvesting methods. With information provided by the ELC (NBDNRE 1998) and the GFE Guidelines (Woodley & Forbes 1997) managers in the FMF are developing management plans that more closely follow the natural development of forests. This means they are more discriminating about using gap replacing methods (selection harvesting) versus stand replacing methods (clear cutting). Therefore there is a move away from as much clear cutting to more selection harvesting. Figure 22 shows projected trends in various harvesting methods over the next 75 years.

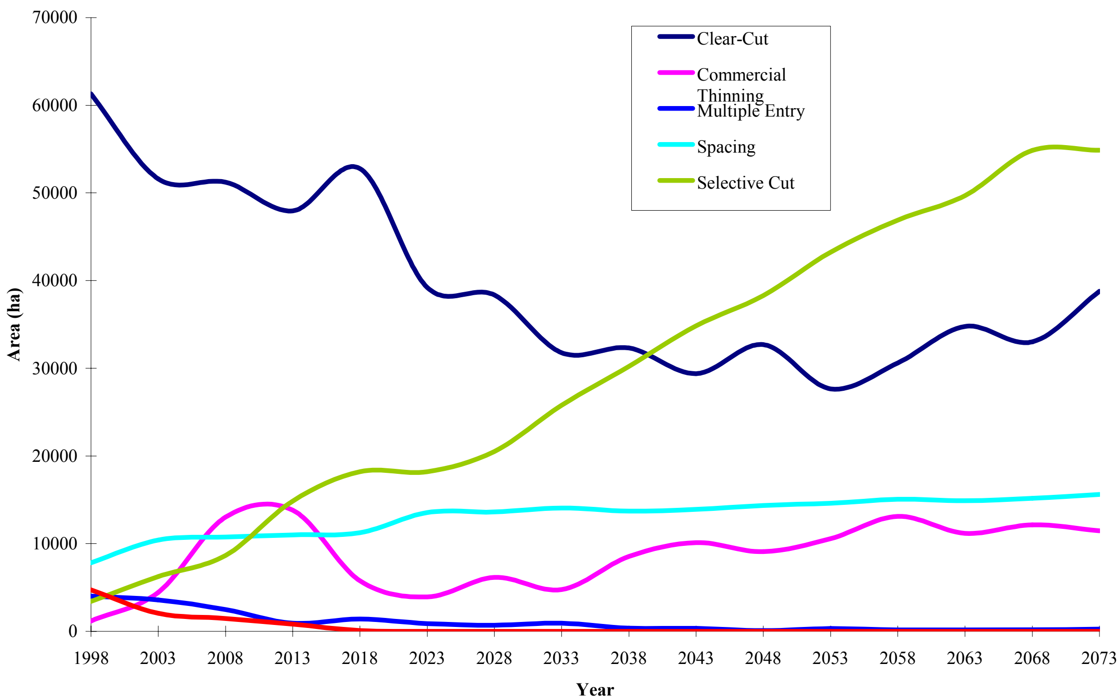


Figure 22. Projected area and type of human disturbance specific to forest harvesting methods. (Data derived from SNB, JDI, and Crown land management plans.)

Best Management Practices

BMPs to address human disturbance by harvesting include the integrated use of all techniques in situations most conducive to their practical and acceptable application. Efforts have been made to reduce the practice of clear-cutting and increase other harvesting techniques that have less impact on the site. These harvesting methods attempt to emulate the natural development of forests.

Functionality and Application

This indicator can be measured annually and is addressed in the management plans of the land managers and owners in the FMF. Technology (GIS, remote sensing) allows the areas of human-caused disturbance specific to forest harvesting to be tracked and mapped practically as it occurs. Forest inventories provide information about ecological communities and these are also mapped. Combining this information in management planning allows managers to meet their objectives of sustainable harvest levels by employing specific harvesting methods on specific forest sites.

Indicator 2.1j

Level and Extent of Active Pest Control Operations

Management Planning Objective - To minimize the effects of major insect outbreaks using Integrated Pest Management strategies

Justification for Selection

This indicator was chosen because it is integral in intensive forest management to assist industrial forest managers and woodlot owners attain sustainable objectives. Actions taken by either can be influenced by the magnitude of the problem as reflected by the size of their respective landbases and management objectives. Control actions can directly and indirectly maintain and/or modify forest ecosystem processes and non-fibre values. Although control operations can encompass many different strategies, from harvest scheduling to silvicultural practices (e.g. planting, thinning) the one frequently brought to mind is the application of insecticides, usually by air. This is a complex subject with many diverse views, especially when environmental issues are considered. Full discussion of these views is beyond the scope of this document, hence, only a summary of area treated and insecticides used is included here.

Data Sources

- NBDNRE – Forest Pest Management Section
- NB Department of Environment and Local Government (NBDELG)

Monitoring Protocol

Historic records were reviewed and summary data compiled to provide an overview of insecticide use and the amount of area planted and thinned in FMF. Projections of insecticide use into the future depend on so many factors that it is not practical to perform these projections.

Baseline Results

In 1952, New Brunswick began protecting fir-spruce forests from spruce budworm attack using the aerial application of insecticides primarily to maintain fibre supplies for the developing forest industry. In the early years, DDT was commonly used. Environmental concerns led to reduced dosages and development of less persistent insecticides in the late 1960s (e.g. phosphamidon and fenitrothion). Another insecticide, aminocarb, was used for approximately ten years until the manufacturer ceased producing it (c.1987) due to limited sales. Other insecticides had minor use. Development of the bacteria Bt (*Bacillus thuringiensis*) as a biological insecticide greatly expanded in the 1970s, ultimately leading to its more common use in the 1980s and beyond. Much research was done to find other viable alternatives (e.g. parasitoids, fungi, virus, pheromones, etc.), but with limited success. The most recent product registered is an insect growth regulator, tebufenozide. It causes larvae to die by interfering with their normal molting process. FMF has contributed some funds towards ongoing research of pheromone use for control.

During the perennial large-scale aerial control programs in New Brunswick, various parts of FMF were treated between 1966 and 1987. The greatest area treated was in 1971 (approximately 260 000 ha). DDT was only used over minimal areas in 1966 (5 400 ha) and 1969 (7 000 ha).

Silvicultural activities in the Province began on a limited basis in the 1960s, and often consisted of trials to develop various planting techniques (e.g. container type, bare root, etc.), and success rate of different tree species on different site conditions. These studies, and follow-up survival and growth studies, provide much of the needed information that guides present-day operations. Thinning activities followed a similar history.

Planting and thinning can have the dual purpose of increasing yield and creating conditions less favourable to insect outbreak. For instance, planting black spruce and jack pine creates future stands that will be less vulnerable to spruce budworm attack. Likewise, during thinning operations, the retention of species other than balsam fir decreases stand vulnerability to spruce budworm attack. Nonetheless, no species is immune to potential insect or disease attack, so these actions to address one problem, could lead to others that are less understood.

Over 5 185 ha of pre-commercial thinning of spruce-fir, fir-spruce, or fir exist on the FMF landbase, along with over 15 924 ha of less-vulnerable black spruce plantations.

Another technique to reduce stand vulnerability to spruce budworm is to remove mature and over-mature stands of balsam fir that tend to suffer greatest loss during spruce budworm outbreaks. This is implicit in scheduled harvesting of stands when they have reached their maximum annual growth increment, or some other target level.

Best Management Practices

Control or management options identified for particular forest pests may vary from pest to pest, however, they should be based on principles of Integrated Pest Management. This approach would include:

a thorough understanding of the pest’s biology and its potential or expected impacts,
a review of all available control options including their economic feasibility, efficacy, and environmental effects,
selection of one or several control and/or management options,
on-going monitoring of control/management options to ensure that pest populations and expected levels of damage are reduced below target thresholds, and
on-going evaluation of environmental risks with respect to controls/management options.

Functionality and Application

Once fibre or non-fibre objectives have been established, there is a need for controlling or managing pest outbreaks. Control and management options can be pre-emptive, proactive, or reactive in nature. The most difficult and perhaps impossible is to be pre-emptive. By implication, this means managing so that no pest reaches the stage where control is needed. In agriculture, with annual or short-term crop rotation, this might have some success. In forestry, however, the very nature of long-term growth and possible changing objectives works against this being feasible.

An IPM approach can be used to identify all the control and/or management options available for a pest. Options adopted for any pest are then measurable in terms of pest control and reduction of overall damage. The FMF, CFS, and NBDNRE cooperated to develop a pest detection and recognition CD. This will allow land owners and managers to identify pests if they are suspicious of their presence in a given location. It will also provide expertise and information for possible early detection and intervention. The management planning objective of minimizing the effects of insect outbreak through IPM will be advanced by the creation of this tool.

Indicator 2.2a

Percentage and Extent of Area by Ecological Community Type and Age-class

Management Planning Objective - To maintain/restore the natural portion of community types in the mature/over-mature condition. Specific objectives for each ecological community type should be established by Partnership /Landowners (12% may be unrealistic for some community types)

Justification for Selection

Resilience of forest ecosystems at the landscape level is a function of the occurrence of various forest types and age classes at the stand level. Maintenance of all ecological community types and an appropriate distribution of age classes are conducive to ecosystem resilience. Nonetheless, ecosystems are dynamic and react to disturbances that create different transient levels of stability. Humans, through their dependence upon and use of various ecosystems for survival, exert great pressures on their surroundings. The resilience of these surroundings (ecosystems) is compromised when an attempt is made to maintain an imposed level of stability in a dynamic system.

Data Sources

- SNB Forest Products Marketing Board - Woodstock wood supply model 1994-2019
- J.D. Irving, Limited - Woodstock wood supply model 1998-2023
- Crown License 7 - wood supply model 1997-2022, 2002-2027
- Fundy National Park - wood supply model 1998-2023

Monitoring Protocol

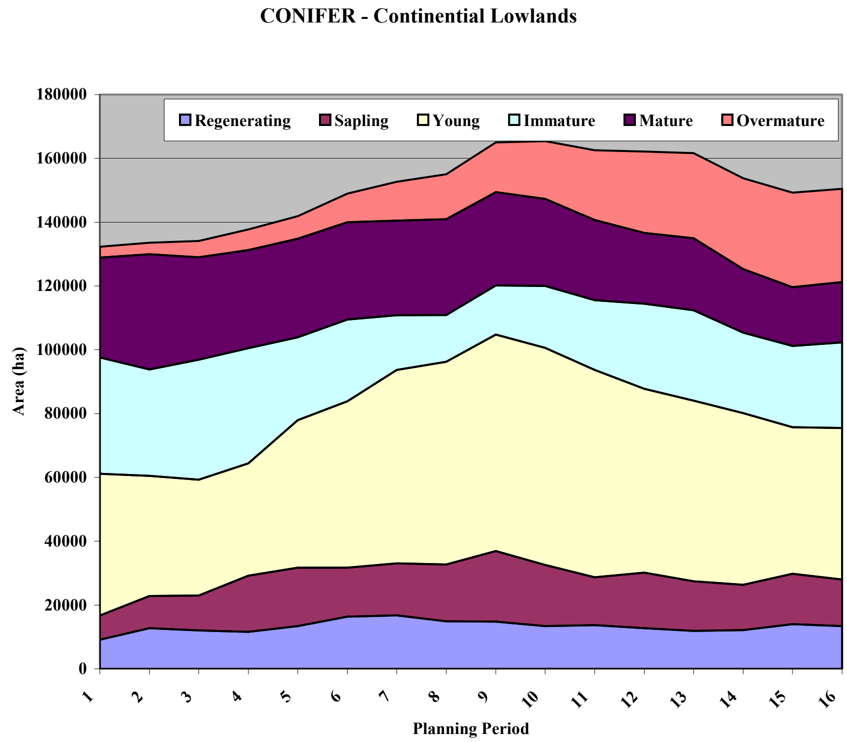
One basic requirement for forest management is knowledge of the landbase and the inventory it contains. Without a baseline inventory, change cannot be measured. Traditional forest inventory monitoring in New Brunswick has undergone many changes, but basically consists of aerial photography, photo interpretation, and ground-truthing. The inventory database consists of maps and area summaries of non-forest and forestlands, and estimates of forest volumes specified by forest type and age class.

The development of computer technology, especially Geographic Information Systems (GIS) to manipulate spatial data, has created the ability to work with very large databases. This provides both opportunities and challenges. The opportunities arise from the amount and detail of information - more choices are available for management options. On the other hand, the challenge is to use the information wisely and consolidate it into a format consistent with the current ecosystem-based approach to forest management.

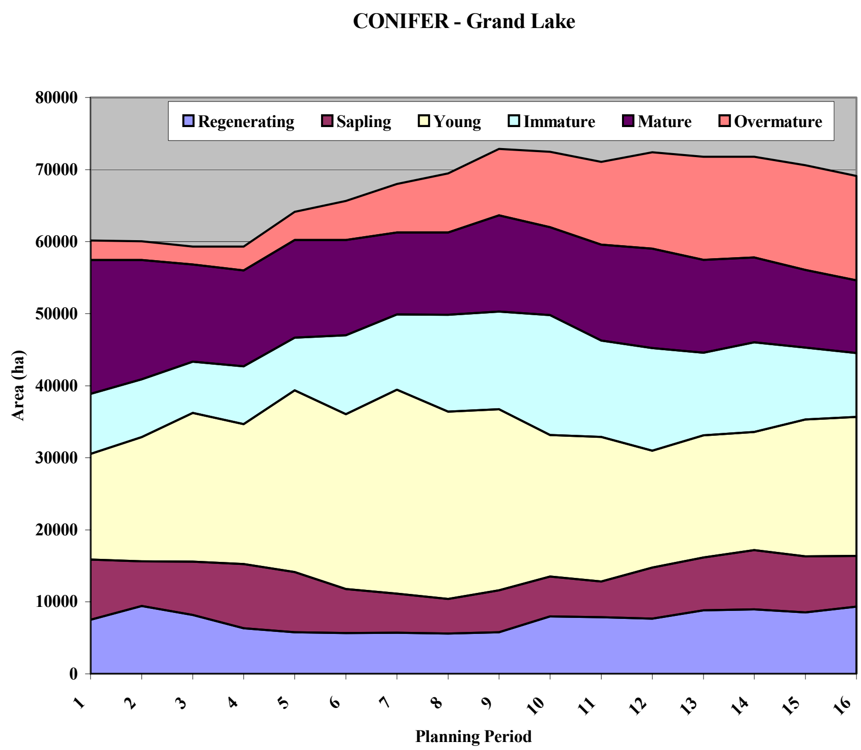
Baseline Results

Figure 23. A-E (next pages) shows some examples of output from the databases of the land managers in the FMF in conifer stands in various ecoregions. Appendix 4 contains graphs for all the forest community types in the various ecoregions.

A.

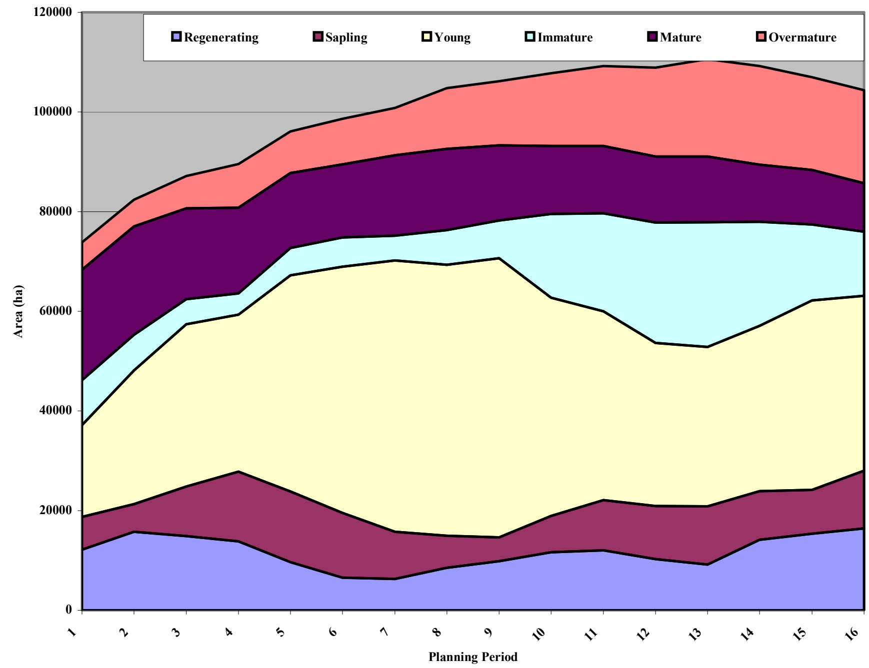

CONIFER - Continential Lowlands
Regenerating
Sapling
Young
Immature
Mature
Overmature
Area (ha)
Planning Period
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

B.


CONIFER - Grand Lake
Regenerating
Sapling
Young
Immature
Mature
Overmature
Area (ha)
Planning Period
80000
70000
60000
50000
40000
30000
20000
10000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

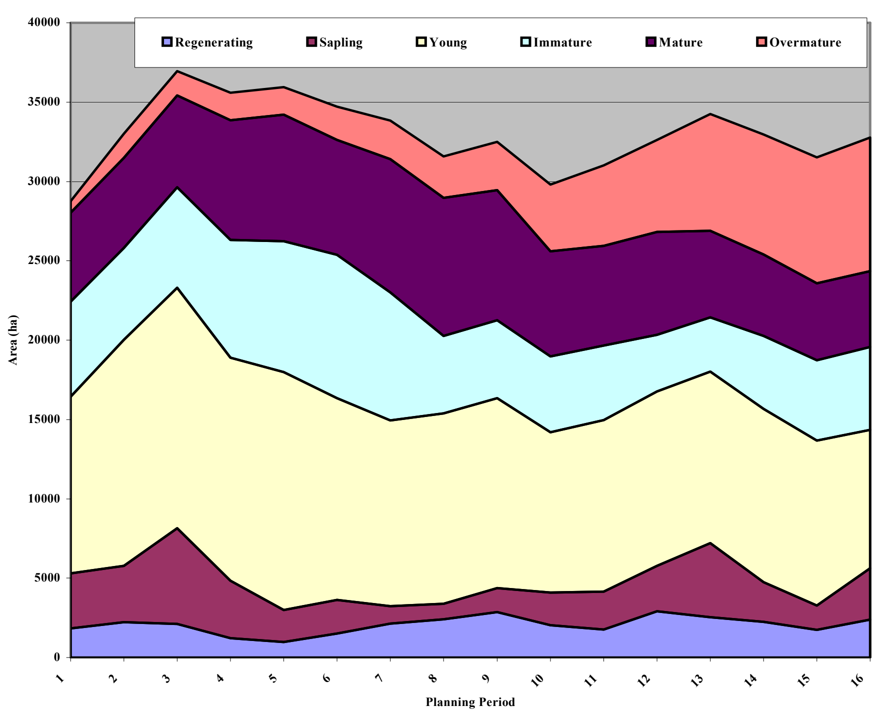
C.

CONIFER - Eastern Lowlands



D.

CONIFER - Southern Uplands



E.

CONIFER - Fundy Coastal

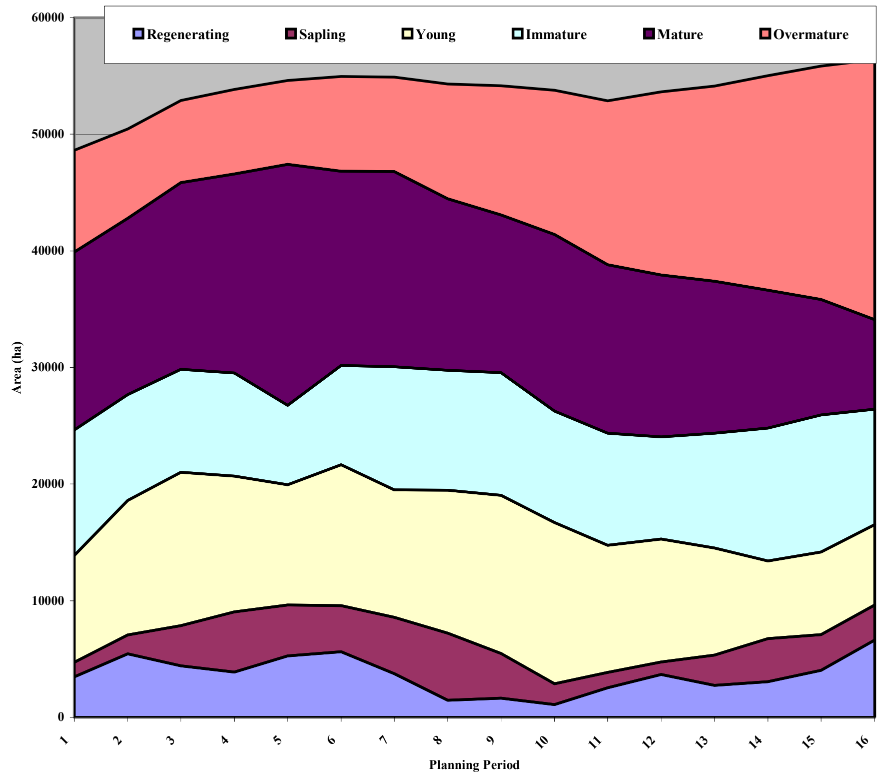


Figure 23 (A-E). Projected changes in area of various conifer stands by ecoregion in the FMF.

Best Management Practices

Each land/owner manager in the FMF is attempting to base management planning on the ecological characteristics of their land bases (ecological land classification is used as a guideline). Where possible, biodiversity guidelines provided by the Greater Fundy Ecosystem Research Group (GFE) (Woodley & Forbes 1997) are followed. The suggested level of protection of mature and over-mature stand types based on GFE recommendations is 12%.

Functionality and Application

When assessments are made for each Forest Community Group (FCG) by ecoregion, problem areas showing low amounts of each FCG can be addressed in a number of ways. The first involves the modeling approach in the Woodstock wood supply model. Secondly, if low representation of a particular FCG is evident in a certain ecoregion then BMPs can be set in place to ensure a proper recovery plan. Before remedies can be set in place, landowners must agree if trade-offs can be made on cross boundary issues across the landscape.

Indicator 2.2b

Percentage of Area Successfully Naturally Regenerated and Artificially Regenerated

Management Planning objective - 100% of harvested areas to be regenerated or maintained as productive forest

Justification for Selection

The ability of forests to regenerate following harvesting or other disturbance is a primary measure of ecosystem resilience.

Data Sources

Report files from individual landowner's wood supply models showing the amount of planted stock by species for each planning period (5-year increments over a planning period of 25 years). The total area harvested minus the total area planted for the same period will result in the area being left to naturally regenerate.
SNB Forest Products Marketing Board - Woodstock wood supply model 1994-2019
J.D. Irving, Limited - Woodstock wood supply model 1998-2023
Crown License 7 - wood supply model 1997-2022, 2002-2027
Fundy National Park - wood supply model 1998-2023

Monitoring Protocol

Every five years a wood supply analysis is performed for defined forest areas. In the FMF case it is Crown License 7, JDI freehold - Sussex District, and SNB.

Baseline Results

Figure 24 depicts the total area regenerated for each 5-year period over an 80-year planning horizon. The total area fluctuates depending on previous harvest levels and most of the regeneration is natural. In the future, the trend is towards less total area naturally regenerated, and more planted area.

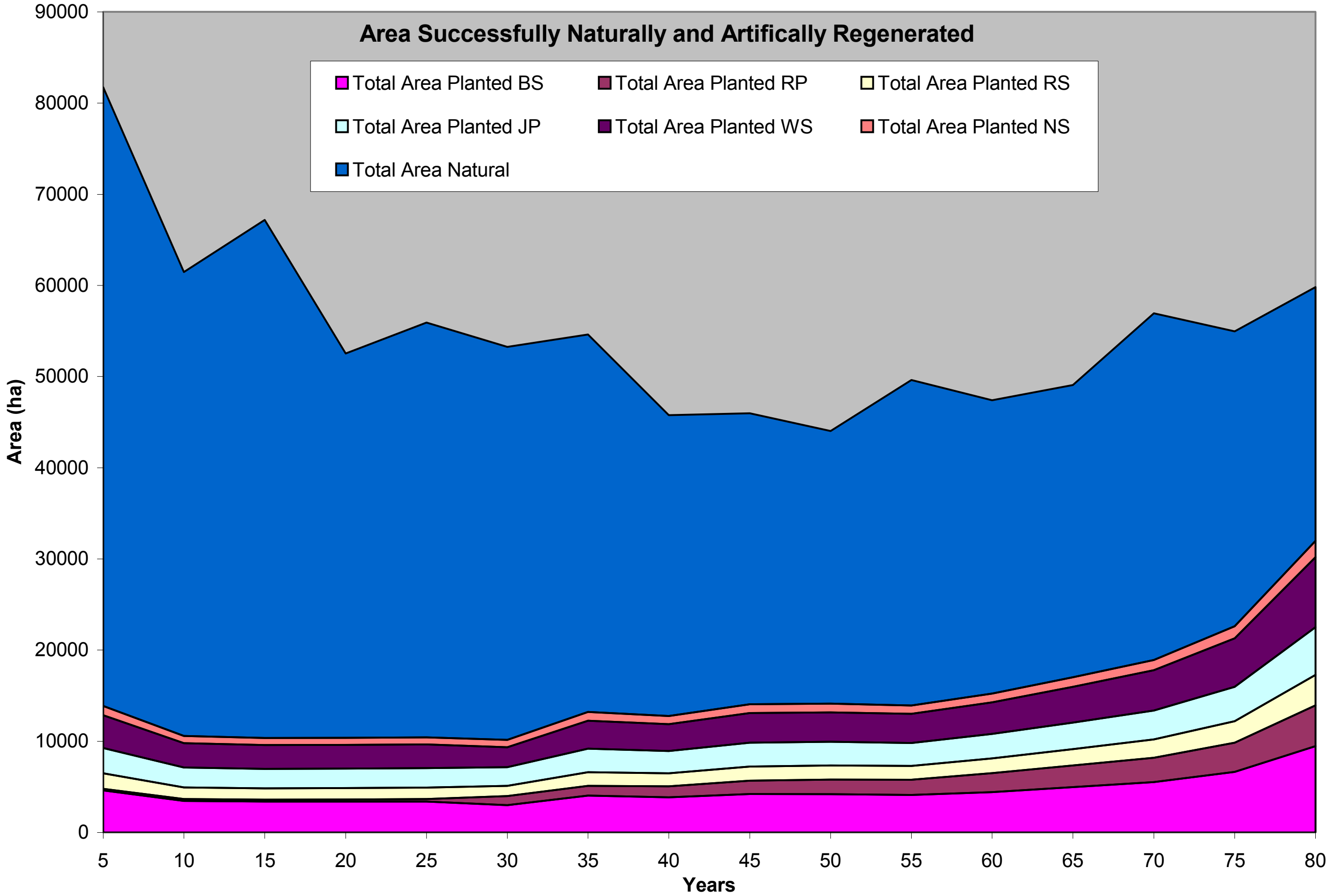


Figure 24. Model projection of the total area regenerated showing the proportion planted and naturally regenerated for all land ownerships within the FMF landbase.

Best Management Practices

The land/owner mangers in the FMF each plan for reforestation in their planning strategies. J. D. Irving, Limited's BMPs state that "all harvested sites will be adequately regenerated". Natural regeneration will be protected where applicable and when this is insufficient, planting will take place while also protecting soil, water and wildlife values. On Crown land, planting is tracked through annual operating plans. Approximately 1000 hectares were planted from 1997-2001 for License 7. SNB follows an objective to maintain 67.5% of the area successfully regenerated at stocking levels of 50% or better either by natural or artificial means. Fundy National Park does not have a planting program; however, there are approximately 4.8 ha of plantation within the Park while natural processes occur on the remainder of the landbase.

Functionality and Application

Through continual measurement and GIS updates, land managers in the FMF monitor the area of successful regeneration. This assures that the management planning objective of maintaining 100% of harvested area in productive forest is met, or identifying when there are shortfalls.

Indicator 2.3a

Mean Annual Increment by Forest Type and Age-class

Management Planning Objective - Improve accuracy of the FMF Forest Development Curves (growth, AAC)

Justification for Selection

Mean Annual Increment (MAI) is the average increase in yield (m^3/ha) of a living tree to a given point in time or age. MAI is, therefore, a measurement of biomass production of forest trees and can be used as a measure of productivity. Comparisons of permanent sample plot (PSP) calculations and forest development survey (FDS) calculations of MAI by ecological community type, with values derived from forest management planning yield curves, provide a check of productivity estimates, and determine if sustainable harvest levels are realistic. Yield curves form one of the cornerstones of the management planning process, therefore, checks on their validity are very important (Spears 2000).

Data Sources

- Fundy Model Forest PSP plots on JDI Freehold, Crown and SNB Wood Co-op.
- Provincial Permanent Sample Plot (PSP) Database – Canadian Forest Service - Atlantic
- Forest Development Survey (FDS) Data – NBDNRE
- GIS Forest Inventory Stand Attributes – Fundy Model Forest
- Yield Curves from Grand Lake, Eastern Lowlands, Southern Uplands, Continental Lowlands and the Fundy Coastal Ecoregions. - J.D. Irving, Limited and FMF
- Calculation of MAI - Spears, 2000

Monitoring Protocol

Yield curves were built for a FMF case study and then for the Grand Lake Ecoregion based on stratification of the landbase from forest development surveys.

PSP data representing natural stands were combined with other forest inventory data. PSPs were stratified consistent with the FMF yield curves.

Mean annual increment and periodic annual increment (PAI – the difference in growth between the end of a period of years and the beginning of that period, divided by the number of years in the period) calculations were made on yield curves and their corresponding PSPs. PAI is used to show variation of growth within stands of the same strata. PAI will permit growth patterns within each curve to be seen in comparison to the PSP data.

Evaluation of the yield curves was done in a three-step process: (1) differences between FDS data and PSP data for each age class were calculated and given a rating. (2) the number of age classes represented in each yield curve was determined, and (3) the amount of land represented by this curve in the FMF defined forest area was determined.

Baseline Results

It was determined that only 54% of the yield curves could be assessed due to the lack of PSP and FDS data to correlate with the remainder. A rating system was devised to indicate how well the MAI measurements fit with the developed curves. Of those yield curves which could be assessed, most were rated excellent to good (Spears 2000).

It was also concluded that PAI was a more revealing measure of stand development than. PAI determines the development and growth pattern of a stand (i.e. the trees in the stand) in any given period of time, where MAI is a measure of the average growth (increase in yield) up to a certain point in time. It does not present as clear a picture of the development of a tree or stand as PAI. PAI ratings did not rate as highly as MAI.

Best Management Practices

BMPs for this indicator are not applicable since this is a specific attempt to verify yield curve data for the FMF and not a practice or method in itself. Accurate yield curves, however, will provide more precise information to determine harvesting schedules and then BMPs can be implemented through harvesting methods on the FMF landbase.

Functionality and Application

This indicator can be reassessed at each management planning cycle for land managers. The land owner/managers in the FMF area rely on an established series of permanent sample plots and forest development surveys to provide accurate information about the growth and changes in the forest.

A project is underway by SNB to update yield curves using more recently available PSP and FDS information. This will provide more accurate information to be used in management plans.

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