Pre-industrial Forest Condition Report for the Pic River and Big Pic Forests

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1 Introduction

The purpose of this project is to research, acquire, and analyse historical information relevant to the description of the pre-industrial forest condition for the Pic River and Big Pic Forests in Northeastern Ontario. A pre-industrial forest condition report for the Big Pic Forest was previously prepared in 2013; this report has been developed to cover an expanded land base that includes the Pic River Forest. A planned amalgamation of the two Forests is currently (as of November 2016) in process, and preparatory work for a Forest Management Plan for the merged forest is also underway. At this time, it is proposed that the merged Forest will be licenced to the Nawiinginokiima Forest Management Corporation. The two Forests are adjacent, with the Big Pic located in between the two parts of the Pic River Forest. The merged Forest will thus consist of a contiguous forest land base. The land base of the two Forests share many similar ecological characteristics which strengthens the logic for the merger. Also, analysis of historical forest information from one or the other forest land base may logically be extrapolated to the remainder of the merged management unit.

This work is intended to address, in part, the requirements of the FSC National Boreal Standard (NBS) (2004), Criterion 6.1 Indicator 6.1.5 – Pre-industrial forest condition) and related indicators, such as the need to address old growth targets; and the management of uncommon and edge-of-range tree species occurring on the Forest.

Elements of Indicator 6.1.5 include:

- A description of major disturbance factors (fire);
- A description of the distribution, frequency, residual component, stand structure types and landscape patterns resulting from natural disturbances;
- A description of the mean distribution and composition of tree species and forest cover types in the pre-industrial forest;
- Calculation of the mean and range of stand replacing disturbance intervals;
- Calculation of the average fire return interval; and
- Estimated age class distribution in the pre-industrial forest.
- Where possible, these elements are to be described in a spatially hierarchical manner, at successively finer levels of landscape unit/forest zone, landform types, forest units, cover types, and ecosystems.

In the NBS, the pre-industrial forest is defined as "the forest that evolved before large-scale harvesting began". Its character is thought to be dynamic over time, therefore the average historical condition is to be compared with the current forest condition. To address this need for determining an average condition, multiple estimates of the historic forest condition are required in order to calculate an average or to determine trends over time. The quality of the available information will determine the reliability of estimates of the average historical condition; which in turn will determine the weight accorded to it for management goal setting.

To fully address the elements listed above, explicit spatial information will be required to address elements of pattern in addition to purely descriptive statistical information (such as area summaries by forest type for a particular area). This indicates the need for surveys, inventories, historical imagery and maps. Purely anecdotal information will be less useful but may help to confirm apparent trends. The information must also be collected at various scales to address the spatial hierarchy specified in the criterion.

Since Boreal forests are, arguably, representative of the "constant change ecosystem" described by Chadwick Oliver, the pre-industrial condition should be seen as one that undergoes wide variation over time in terms of age class structure, species composition, stand structure and landscape patterns. In fact, that variability may be one of the more enduring features of the Pic River and Big Pic Forests.

2 Sources of Information

With the above in mind, we researched and acquired information in the following categories:

- Ontario Land Survey (OLS) – survey notes on River Surveys
- OLS Township surveys (assembled by OMNR under the direction of Fred Pinto, Southern Science and Information Section, North Bay)
- Historical forest inventories: maps, FRI ledgers, and descriptive summaries
- Information on tree species ranges and historical occurrences from university herbarium records and documents (principally the University of Toronto)
- Descriptions of forest resources from reports prepared by the Ontario government (Summaries of forest inventory prepared at District, Regional, and Provincial levels)
- Historical timber and forest management plans
- Fire history records
- Other historical documents to provide context for the information gathered, e.g., history of forestry, changes in management unit and administrative boundaries.

This report is divided into 6 sections:

- A summarized chronology of historical events, to both provide context to facilitate understanding the information collected, and a local context for the settlement and forest management history of each area;
- Historical information on fire disturbances;
- Historical information on tree species distribution;
- Historical forest inventory information;
- Changes in historical species composition illustrated by the Ontario Land Surveyor Data;
- Simulation models: forecasts of species, forest unit and age class distribution and old growth proportions.

Many of the documents acquired during this project have been scanned to provide a permanent archival copy for AV Terrace Bay (AVTB). This process is ongoing and the data catalogue will continue to be updated. Specifics of the methods employed for data acquisition, the nature of the information collected, and methods for analyses are provided in each section.

3 Description of the Pic River and Big Pic Forests

3.1 Big Pic Forest

The Big Pic Forest is one of the 43 forest management units in the province of Ontario. Most of the Forest is located in the Wawa Administrative District of the Northeast Region of the Ministry of Natural Resources (Figure 1). The exception is the portion of the Forest that falls within Pic Township and parts of McCoy and O'Neill Townships, which are located within the boundaries of the Township of Marathon. This latter area falls within the Nipigon Administrative District of the Northwest Region of the Ministry of Natural Resources (OMNR). All timber management activities on the Forest are coordinated through OMNR's Area Office located in Manitouwadge or the OMNR District Office located in Wawa. The current Forest Management Plan (FMP) was prepared for a ten-year period commencing April 1, 2007, and ending March 31, 2017.

The Forest had been operated by American Can of Canada Inc. up to 1983, almost solely for the purpose of supplying roundwood pulpwood to the Marathon mill. Pulpwood from the Big Pic accounted for approximately one-half of the mill's total fibre requirements. In 1983, following the announced permanent closure of the mill by American Can of Canada Inc., the operation was acquired by a joint venture known as James River– Marathon Ltd. Since then, as a result of parent corporation mergers and acquisitions, the name of the Marathon mill has changed several times. In 1999 the mill was sold and a Tembec/Kruger joint venture operating under the name Marathon Pulp Inc. became the new owner.

A key element of the 1983 sale and continued operation of the mill was a decision by the new owners to convert the mill's entire conifer fibre supply to residual sawmill chips. This move significantly reduced fibre costs, supplied the Regional sawmills with a consumer of residual chips, and supported government initiatives toward value added utilization of the Crown timber resource. The Marathon mill exchanged large tracts of forest licence with the Crown for Crown chip fibre commitments from sawmills in communities such as Hornepayne, Calstock, Hearst, and Chapleau. The exchanged forest licence areas now make up parts of the Hearst and Nagagami Sustainable Forest Licences (SFLs). By improving the opportunity for short- and long-term sawmill timber supply, the decision to utilize sawmill chips rather than roundwood contributed significantly to the stability of the regional sawmill sector.
In 1988, James River-Marathon and Buchanan Forest Products Ltd. (BFPL) entered into a second joint venture with the acquisition of the Dubreuil Forest Products Limited sawmill in Dubreuilville. This helped secure an important fibre supply for the Marathon mill and provided a more cost efficient destination for the Big Pic timber resource when compared to the original Thunder Bay sawmill destinations. The operation has continued as Dubreuil Forest Products Limited. James River – Marathon and Dubreuil Forest Products Limited entered into a volume based business-to-business fibre exchange agreement whereby the annual roundwood conifer harvest is made available to Dubreuil for an equivalent volume of sawmill residual chips. To help augment the sawmill's wood supply, and support the volume exchange, conifer harvested from Buchanan Forest Products Ltd. licences (Black River, Pic River Ojibway, and Magpie) adjacent to the Big Pic has been delivered to Dubreuilville.

The exchange of roundwood sourced from the Big Pic SFL with a sawmill for an equivalent chip volume is consistent with the Provincial best-end-use value initiative. Logging operations also produced the following: poplar tree length and veneer logs for the Longlac Wood Industries mill in Longlac, jack pine poles for the treating plant at Northern Woods, white birch veneer for various veneer mills, white birch sawlogs for Buchanan Northern Hardwoods in Thunder Bay, and birch firewood for local markets. Lower-quality aspen has been chipped and delivered to the Terrace Bay Pulp Inc. (formerly Neenah Paper) pulpmill in Terrace Bay. The Marathon mill contracts with sawmills, independent mobile chipping contractor, and First Nations enterprises, whenever possible, to secure fibre.

During the first phase of the 2007-2017 FMP, the Big Pic Forest (the Forest) was licenced to Marathon Pulp Inc. (MPI) under the terms and conditions of Sustainable Forest Licence No. 542004 dated February 14, 1996, and having a term extending from April 1, 1996 to March 31, 2016. Due to the lack of markets and mill shutdowns in recent years, including the bankruptcy of Marathon Pulp Inc. in March 2009, the SFL license for the Big Pic Forest was withdrawn from Marathon Pulp Inc. and MNR assumed the forest management responsibilities for the Big Pic Forest. Subsequently MNR entered into a service agreement with GreenForest Management Inc. (GFMI) to carry out forest management planning requirements on the Big Pic Forest. As a result of these changes, there was a delay in the preparation of planned operations for the second five-year term of the Big Pic Forest 2007-2017 FMP. In the interim, a Year Six Annual Work Schedule, covering the period from April 1, 2012 to March 31, 2013 was developed to allow for continued operations on the Big Pic Forest until the final planned operations for the second 'four-year' term (e.g. phase II) is approved.

The Big Pic Forest is currently (September 2013) under an interim licence held by the Nawiinginokiima Forest Management Corp. The current FMP in force is the Phase II plan that covers the four-year period from April 1, 2013 to March 31, 2017.

3.2 Pic River Forest

The Pic River Forest consists of the amalgamated former Black River and Pic River Ojibway Forests. Prior to amalgamation, both the Black River and Pic River Ojibway SFLs were held by Great West Timber Ltd. of Thunder Bay, Ontario. Commitment of support to amalgamate the two forests was received from the MNR January 14th, 2008. The amalgamated unit allows for a streamlined planning and approval process for the preparation of the current 2013-2023 Forest Management Plan (Cameron 2013). A detailed legal description of the two former Black River and Pic River Ojibway Forests is contained in the associated SFL documents.

The Pic River Forest is located north of Lake Superior within the 49th degree latitude, and between longitudes 85 degrees and 87 degrees. The community of Manitouwadge is located within the Black River sub-unit and the communities of Marathon and Heron Bay are located adjacent to the southeast corner of the former Pic River Ojibway sub-unit. These communities were serviced by C.N.R. from the north and C.P.R. from the south, but the CPR branch line from the south and the CNR branch line from the north that provided rail service to Manitouwadge were abandoned and removed about 20 years ago. Both rail lines generally ran in a north/south direction. The town has road access in the form of Highway 614 that starts at Highway 17 in the southern part of the forest, and ends at Manitouwadge. The nearest large urban centres are Thunder Bay to the west and Sault Ste. Marie to the east. Aboriginal communities located within or adjacent to the forest include: Pays Plat First Nation, Long Lake 58 First Nation, Ginoogaming First Nation, Constance Lake First Nation, Ojibway's of the Pic River First Nation and Pic Mobert First Nation.

The Pic River Forest is located within both the northwest and northeast regions of the Ontario Ministry of Natural Resources (MNR) and within the administrative districts of both Nipigon and Wawa, however, the management of the forest falls exclusively under the jurisdiction of the Wawa district, northeast region OMNR administration.

3.3 Surficial Geology, Soils, and Climate

The two Management Units fall within the boundaries of the Boreal Forest Region as described by Rowe. The southern portion of the area is located in the Superior Forest Section while the remainder is located in the Central Plateau Forest Section. The physical features of the Unit are typical of these two Sections.

The topography of the Unit is strongly controlled by bedrock. The area within about thirty miles of Lake Superior is broken and irregular with slopes generally ranging from rolling to precipitous. In this area, the valley bottoms between the hills are often occupied by flat lacustrine deposits that may be deeply-eroded by small streams draining the adjacent hills or by the Pic River itself. On the remaining portions of the Unit, the topography ranges from flat to very gently rolling in the north-eastern side of the Unit where the Central Plateau section starts to take on characteristics of the adjacent Clay Belt section) to very gently rolling to moderately rolling on the western and southern sides.

The area of the Units includes the Height of Land between the Arctic watershed (Pagwachuan and Nagagami River drainages) and the Atlantic watershed (Pic River drainage). While numerous lakes and streams can be found on the Unit, water bodies are not as prominent as in many other parts of Northern Ontario. Lakes, in particular, are generally small and scattered throughout the Unit.

The climate is dominated by a continental polar air mass and is characterized by moderately-severe winters and warm summers. The Unit receives an average of 710mm of precipitation of which one third falls in the winter months. The average length of the growing season is 150 days and that of the frost-free period about 80 days. It is worthy of note that frost frequently occurs in early June, after the first flush of growth of most tree species. The bedrock underlying the Unit dates from Precambrian times and is mainly granitic intrusive rocks of the Archean era. However, Archean sedimentary bedrock occurs near Caramat and volcanic bedrock can be found near Marathon, Manitouwadge and at a few other locations. The bedrock has been heavily-eroded, most recently by glaciers of the Pliestocene era. Mineralized zones of economic and potential economic importance can be found in the vicinity of Manitouwadge (base-metal deposits), Marathon (rare metals including gold) and Caramat (iron ore).

The mineral soils of the Unit are largely the product of the glaciation process. The many advances and retreats of the ice sheet heavily scoured the underlying bedrock but deposited areas of molded stony tills in some locations and a thin mantle of stony dump till over many other areas. A concentration of eskers can be found near Caramat, south of Stevens and east of Hillsport. Otherwise, they are found only infrequently. Outwash deposits are not extensive and the largest of these occur west and north of Caramat and near Palmquist lake. Other outwash deposits occur in localized spillways. Several ice re-advances resulted in an indistinct terminal moraine extending from Pagwachuan lake to Stilwell lake to White Otter lake and beyond. Soils in the vicinity of the moraine are somewhat deeper and have frequent occurrences of stratified sands and gravels.

The post-glacial lakes that occupied the Lake Superior basin following the recession of the ice flooded large areas of the Pic, White Otter, Little Pic and Black River valleys. In these areas, both localized and sometimes extensive areas of lacustrine clays, silts and sands were deposited. Another post-glacial lake inundated large areas north of the moraine noted above. Localized deposits of fine sands and silts are found in association with till deposits in these areas and, as one progresses towards the northeast, lacustrine silts, sands and clays begin to predominate. Wave action from these glacial lakes exposed extensive areas of bedrock in the vicinity of Slimjim Lake, Solann Lake and in the areas near Lake Superior. Earlier post-glacial lakes that deposited silts and clays that were subsequently overridden and reworked by readvances of the ice sheets, have contributed to high silt and clay fractions in many of the soils of the Unit, including those derived from ice-contact deposits. Since deglaciation, the soil weathering process has resulted in the development of podsol and Boreal brown podsolic profiles on the better-drained, coarser-textured soils, grey-wooded and brown-wooded profiles on the better-drained, fine-textured gley soils and peats on the poorly-drained sites. Organic soils have developed on the many areas of the Unit where drainage is impeded.

Most of the area was soil-typed using a landform classification developed in 1953 by W.G.E. Brown. The typing was done from photo-interpretation and the maps were produced at a scale of 40 chains per inch. Little use has been made of this work (Anon. 1987). The updated eFRI (2016) maps the predominant Provincial Ecosites for each polygon, providing an inventory of primary soil features at 1:20 00 scale.

The timber resources found on the area are those typical of the Boreal Forest. However, with the relatively high occurrence of deeper-soiled sites with high silt and clay fractions, stands containing a mixture of spruce, fir and aspen are very prominent on the better-drained sites. Black spruce predominates on the lowland and very shallow sites while jack pine or pine-spruce mixtures are found on the drier, sandier sites. On the most productive deep, upland soils, pure aspen stands can be found. White birch is found in varying amounts throughout the Unit but only in the southern sections near Lake Superior does it grow in nearly pure stands. Balsam fir is found extensively throughout the Unit but primarily in overmature or cutover stands on upland sites. The amount of balsam fir on the land base has decreased significantly as a result of the extensive and prolonged spruce budworm infestations of the 1970s and 1980s, but is starting to recover through natural ingress. Cedar, tamarack and balsam poplar are minor species. Red pine, white pine, red maple and black ash are uncommon and are found in very localized occurrences.

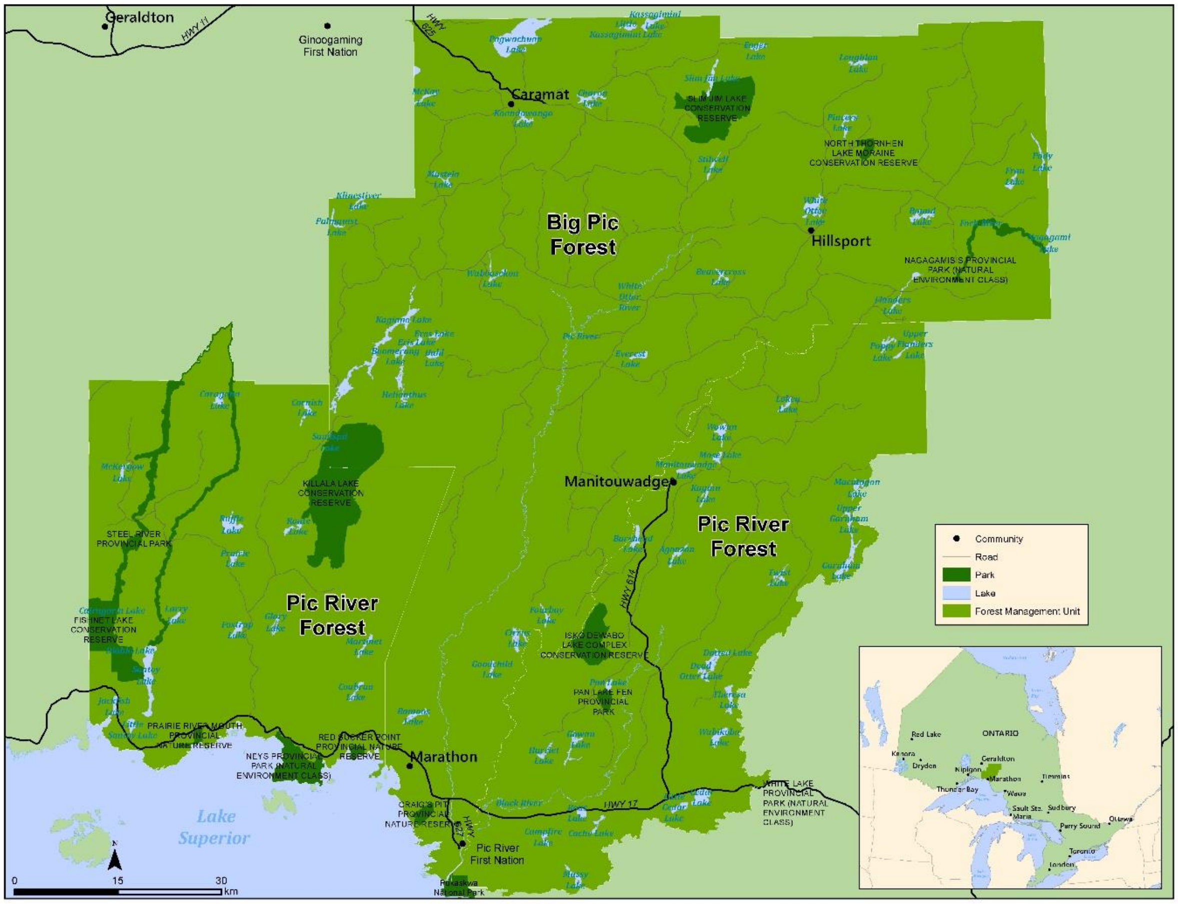


Figure 1. Location of the Pic River and Big Pic Forests in north-central Ontario.

4 History of Forestry in the Big Pic Forest

Knowledge of the history of the forests that were amalgamated into what comprises the Big Pic Forest (BPF) today has significant management implications in that it helps forest managers to better understand how the forest was shaped into what is present on the landscape today. The following provides a brief description of the development and forest management history of the Big Pic Forest and surrounding areas. The currently approved Forest Management Plan for the Big Pic Forest is for the period 2012-2022.

The historic use of the forest resources has management implications with regards to the type of forest that has developed as it has shaped what is present on the landscape today. The initial extractions of timber and non-timber forest products from the Big Pic Forest were done by aboriginal peoples within the area, with no records of these harvesting areas. The harvesting practices were at such a limited scale that there was likely little change to the forest structure and composition. Past activities relating to land settlement, and industrial activities including mining, hydroelectric development and forestry have resulted in a forest that is relatively well accessed throughout, and has experienced large-scale disturbances which have affected the forest composition and structure.

With the improved access into the area, the government and industry began to complete the first forest surveys and inventories. The early map below (1920's vintage) shows the distribution of various natural resources throughout the north, particularly species of trees (Figure 2).

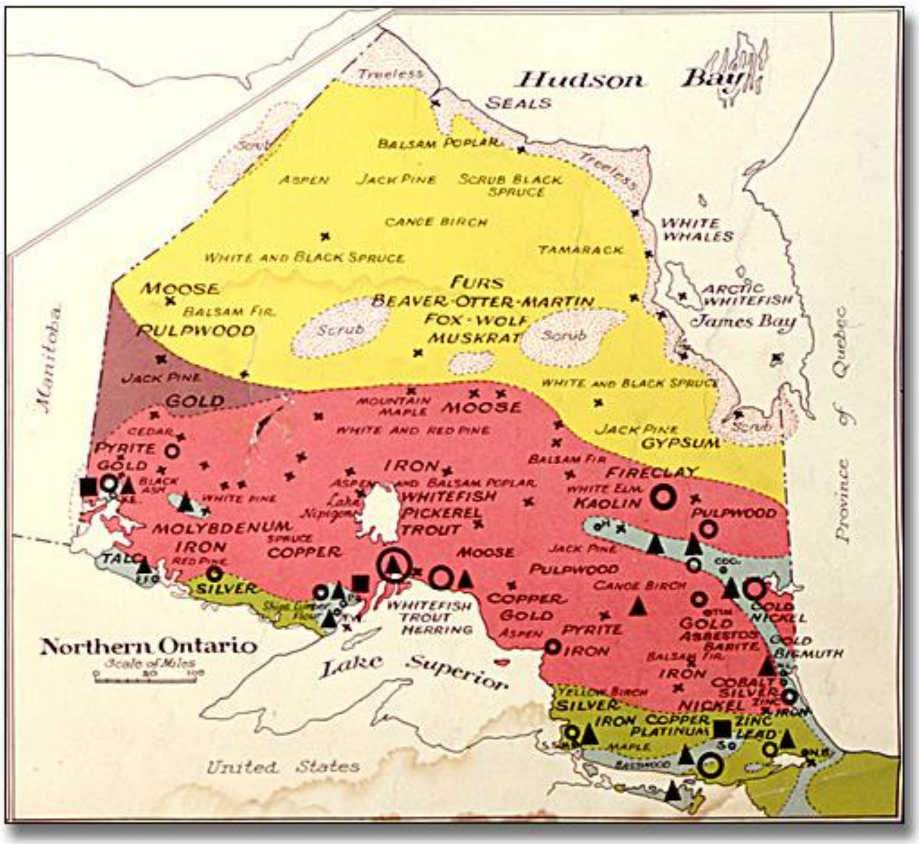


Figure 2. Example of an early map (1920's vintage) showing the distribution of various natural resources throughout northern Ontario.

4.1 History of Logging and the Development of Access on the Big Pic Forest

The earliest historical records for lands contained within the Management Unit date back to the mid-1600s. These records deal largely with early exploration and the fur trade when the Pic River was a reasonably important canoe route connecting fur trade posts near Longlac with a post at the mouth of the Pic. In the 1880s, the main line of the Canadian Pacific Railroad was built across the southern end of the Licence and forest stands within easy reach of the railroad probably supplied, on a local basis, bridge timbers, ties and other timber required at that time. Shortly after the First World War construction commenced on the present main line of the Canadian National Railway crossing the northern section of the Unit and, once again, adjacent timber, mainly jack pine, was used during the construction phase. Early commercial logging operations on the Unit commenced following the creation of the Pic River Pulp and Timber Limited in about 1916. This Unit, part of which was located within the Unit's present boundaries, saw a number of different operators remove small amounts of timber from the lower stretches of the Pic River (Fry 1977).

On the Pic Area, logging first began during World War I with the taking out of large white spruce in the Lower Pic Valley in 1916. Since then, cuttings have occurred from time to time in this area, under a number of different operators. These cuts, up until 1943, were confined exclusively to the Lower Pic Area. With the opening of the White Otter area in 1943, operations commenced in the northern part of the Pic Area. These increased in size each year, until in 1948 all operations were concentrated in that area, and the only cutting in the lower Pic region was for fuelwood for the town of Marathon (Anon. 1949).

Early logging in the Lower Pic Valley was essentially a form of selective logging. Only large white spruce trees were cut. Logging was confined to stands close to the river, on easily operated areas. In many cases, wood so produced was loaded directly onto barges brought upstream to the scene of operations. As the demand for spruce and balsam pulpwood grew, later operators sought out the most accessible and most easily operated softwood stands for harvesting. This practice created large areas of cutover land along the Pic River, with isolated patches of similar cut in easily reached places further back from the river, especially along the larger driveable tributaries of the Pic River. Wherever the stands were mixed hardwoods and softwoods, or were on difficult or rocky terrain, they were left uncut.

lmprovements in this area were few and generally crude, being needed only for a few years at most. Roads built were mainly for toting supplies, not for hauling wood, hence were practically unimproved. As operations moved further back from the Pic, longer roads were necessary, but even these were only of the simplest construction. The main avenue of supply from break-up to freeze-up was the Pic River. During the winter, a winter road roughly paralleling the river provided access to the camps. By 1949, none of these roads were in use, except for those from Marathon to the Pic River at Camps 19 and 14. To help drive some of the tributary streams, a number of dams were built. Three of these were maintained to help regulate the level of the Pic during driving seasons in the early 1950s.

In 1937, as a result of a general reallocation of timber licences, the cutting rights on the Pic River watershed were acquired by General Timber Company, a subsidiary of Marathon Paper Mills which was a corporate predecessor of American Can. Operations undertaken by this company saw spruce pulpwood along the Pic River and its tributaries cut and driven down the Pic to Lake Superior where it was boomed and rafted across the lake to pulp mills in upper Michigan and Wisconsin. Although on a scale larger than previous operations, General Timber's activities remained close to driveable streams and never extended for more than forty miles up the Pic River.

In 1943, previous cutting rights were cancelled and negotiations were undertaken which culminated in 1944, when Marathon Paper Mills received a timber licence which included a Schedule A (the Big Pic), Schedule B (Parcels I to IV) and a Schedule C (the Nagagami). This new licence included most of the present day area as well as a number of townships or parts thereof in the vicinity of Hornepayne (Anon 1987). As a condition of the issuance of this licence, the Company was to build a 250 ton per day bleached kraft pulp mill in Marathon to be supplied by the lands described in Schedule A and B. The land described in Schedule C was to be used as a source of pulpwood for export. Construction of the pulp mill was begun in 1944 and completed in 1947. The last export wood from the Big Pic area was cut in 1943 and the same year saw the establishment of a headquarters at Stevens and the start of the operations on the Upper Pic which have continued to this day. In 1947, logging operations on the Lower Pic were, with a few small exceptions, phased out as were pulpwood export operations on the Nagagami area phased out in 1953.

From 1947 to 1950, no operations were carried on in the Lower Pic District except for some small operations, either to obtain fuelwood for the mill town of Marathon, or to provide employment for the First Nation people of the Heron Bay Reserve. During the driving season, however, there was considerable activity on the area as the year's cut was driven to the mill. Five holding areas were created along the river to handle the flow of wood downstream. These were at Camp 50, Bamoos Portage, Camp 27, Camp 14 Landing, and the mouth of the Pic River. Each was equipped with a power operated winch to open and close the booms. At the mouth of the Pic a rafting camp was maintained, with service facilities for river craft and the smaller rafting tugs, and with accommodation for the rafting crews. A gravel road linked this camp with Heron Bay station on the C.P.R.

In 1943, a depot was constructed at Stevens Spur on the main line of the C.N.R., 59 miles west of Hornepayne. With its construction, pulpwood operations commenced in the Upper Pic Area. Ten miles of gravel road were constructed during 1943 and 1944, giving the depot access to the White Otter Valley. The Klinestiver Highway, as this road became known, was gradually extended and improved until in 1950 "it formed a fine all-weather road linking Stevens and Manitou, 30 miles to the south. This road, as it was extended, opened up first the White Otter-Stevens area, later the Lower White Otter Valley, and more recently the Manitou Falls area" (Anon. 1950).

From 1943 until 1948, cutting in the Upper Pic area was confined to the Stevens-White Otter area. However, with the opening of Caramat depot, 18 miles west of Stevens along the railway, a new area, the Upper Pic River Valley, was made accessible. A road south of Caramat linked this depot with the Pic River, and was extended in 1949 to Camp 5 on the White Otter, where it connected with the Klinestiver Highway.

The growth of operations in the Upper Pic area closely paralleled the construction of these two roads. Shortly after the Klinestiver Highway reached the White Otter in 1944, camps were constructed at its temporary terminus at the river, (Camp 1) and midway between Stevens and the White Otter River (Camp 2). These two camps cut their first wood during the fall of 1944. To permit the driving of this wood the following spring, a dam was built at Ramsay Lake during the winter.

In 1945, the Klinestiver Highway was pushed southward about four miles. This opened up a new area below Camp 1, and to cut there, Camp 3 was constructed in the White Otter Valley. The same summer, a branch road was built into Ramsay Lake, and on the shores of the lake Camp 4 was built. All four camps operated the following winter.

The summer of 1946 saw the Klinestiver Highway extended another six miles south. A branch road led down into the Lower Pic Valley where Camp 5 was located, and near its junction with the main road Camp 9 was established. At the same time, Camps 6 and 7 were built and serviced through the extension of the Ramsay Lake branch. These four camps were a complete departure from those constructed earlier. The buildings in these new camps were placed on skids, so that they could be moved when the need arose, instead of being fixed in one location as in the earlier camps. In contrast to the few big buildings which served as dormitories, these camps made use of a number of small cabins as sleep camps, providing brighter, airier and more pleasant accommodation. Once the camp had cut all the merchantable timber accessible to it, the buildings in it were moved to a new location, and a new camp was generally operating from them within a very short time.

The Klinestiver Highway was further extended in 1947 and reached Hourglass Lake, approximately 25 miles south of Stevens. In this area Camp 8 was established. This camp was a combination of the new and the old in camp construction, having a nucleus of old type buildings augmented by portables. The same summer saw Camp 11 built and in operation. It was similar to Camps 1 to 4 in construction and served the area east of Nifty Lake.

During the summer of 1947, operations from Camp 2 were completely mechanized. This was the first full scale application of mechanical methods of pulpwood logging on the Pic Area. However, during the previous winter, a small trial operation using mechanical equipment was carried on at Camp 1. Camp 3 had a small mechanical operation in the summer of 1947. The balance of Camp 3's operations and those of the other camps were carried on manually.

1948 saw the completion of the Klinestiver Highway to the Pic River at Manitou Falls. Camp 12 was built near the river. The buildings from Camp 9 formed the nucleus of this new camp. The same year, Camp 51 (Caramat Depot) was opened and commenced mechanical operations. The construction of McKay Lake Dam permitted the driving of the Upper Pic River. As a result, Camp 52 was established near the dam to manually operate the area near the outlet of the lake.

In the White Otter Area, mechanical operations were carried on from Camps 1, 2 and 3. However, in the case of Camps 1 and 3, not all the cutting was done mechanically. Some wood was cut manually. The remaining Camps operated manually although Camps 5 and 8 did cut some wood mechanically (Anon. 1949). The last horse operations on the Big Pic were conducted by Camp 2 in the year 1950-51.

The first Management Plans, one for the Big Pic and one for the Nagagami, were submitted in 1949 and 1950 (Anon. 1949, 1950). These Plans established a number of Working Circles and, very early in the management period, a strategy was developed whereby permanent camps were established near the centre of the working Circles on the Upper Pic that would operate at a level related to the Allowable Cut for the Working Circle. An all-weather road network linking the camps was constructed at an early stage and this network formed the nucleus of subsequent road development (Fry 1977).

As the road network was located, a number of logging chances (about one year's cut for one camp) accessed by the road were established and some chances were earmarked for early cutting while others were reserved for future operations. This strategy resulted in the early development of access to much of the mature and over-mature areas of the Unit, and a reasonably good dispersal of the cuts throughout the area. In addition, an inventory of logging chances accessible to the existing road system has been built up that provides for flexibility in operations, minimizes current road building requirements and allows for continued dispersal of the annual cut.

Mechanical logging systems were also developed at an early stage and logging operations from 1948 to the early 1960's were centred around the high-lead cable yard system. Not only did this system have a beneficial effect on regeneration but it also reinforced a commitment to careful operations planning. This attention to planning continued as logging systems developed into more sophisticated mechanical systems (Fry 1977).

The high proportion of hardwood in the growing stock of the Unit required some utilization in order to improve, to acceptable levels, the economics of logging operations undertaken on a Unit lacking in the extensive stands of conifer that were more common in other areas of Boreal Ontario. Thus the harvesting of aspen, which was started at an early stage, exerted a beneficial effect on the economics of logging operations as well as providing greater silvicultural possibilities through improved fibre utilization from the site.

In 1956, a new licence (D-1673) was issued to the Marathon Corporation which consolidated in Schedule A the former Big Pic area with Parcels 1 and 2. Parcels 3 and 4 were released as well as part of Schedule C, and the Nagagami area became a new Schedule B. In 1961, a trade of timber rights with Kimberly Clark resulted in the acquisition of a new area directly north of Hillsport. In 1960 a new Management Plan for Schedule A was submitted (Sonley 1960) and in 1965 a new Management Plan for Schedule B was submitted. These remained in effect until March 31, 1977.

In 1972, following a change in the Crown Timber Act which ultimately improved American Can's position with respect to fibre purchase possibilities, all but Frances, Flanders and Downer Townships of Schedule B were released to the Crown and those three townships became Schedule B of a new licence 330200. This licence was renewed with no changes in area for a twenty-one year period effective April 1, 1977. Following the establishment of the various camps on the Unit, the communities of Caramat, Hillsport and Stevens sprang up around three of the camps. Stevens, the first such community, was eventually abandoned in the late 1960's. By 1974 all of the original camps had been closed and operations were consolidated at Camp 15.

The road system that was developed starting in 1943 had, for a number of years, remained inaccessible to outside traffic but in 1957 the completion of the Seagram Road (later named Highway 625) resulted in a link to the Provincial Highway system to Manitouwadge, a mining town just east of the Unit that came into existence in the mid-fifties, and Highway 614 was linked with the Unit's road system in 1964. The newly designated Industrial Road became part of the road link connecting Highways 17 and 11. Because of this link, and due to the early establishment of an open road policy by American Can, recreational use of lands within the Unit increased markedly during the 1960's. In addition, as roads were constantly improved and operations were centralized at Camp 15, commuting between the Camp and Manitouwadge became more attractive (Fry 1977). Major roads within the Big Pic Management Unit, as of 1987 (Fry 1987), are shown in Figure 3.

As mill capacity slowly increased through creeping expansion to the 1977 level of 450 tons per day, the conifer cut on the Unit approached the Annual Allowable Cut. Hardwood production varied considerably from year to year but averaged about 50 to 60 thousand cords annually. The production of poplar veneer for the Weldwood plant in Longlac commenced in the mid-sixties and increased hardwood utilization from the Unit, but at the same time, created silvicultural problems in some of those areas that were high-graded for veneer. In 1973, with an increased fibre purchase program at the Marathon mill, conifer production on the Unit was decreased by some 50,000 cords annually thus reducing the proportion of the allowable cut that was harvested. During the 1956 to 1977 Management Period, 75% of the volume of the allowable cut (all species) and 62% of the area of the allowable cut were actually harvested (Fry 1977).

From the small logging enterprise of the 1930's carried out in Marathon and Cirrus Working Circles, the Big Pic Management Unit evolved into an important economic element in northwestern Ontario. Both Caramat and Marathon are company oriented towns that were, directly or indirectly, highly dependent on the woodlands operations on the Unit. Hillsport and Heron Bay are railway oriented towns but a significant number of inhabitants were employed in Company operations. Manitouwadge was primarily a mining town, but gradually became a more important source of manpower for American Can. Hearst, Thunder Bay, Geraldton and Longlac, although somewhat removed from the Unit, have long provided a source of manpower and will probably continue to do so in the future.

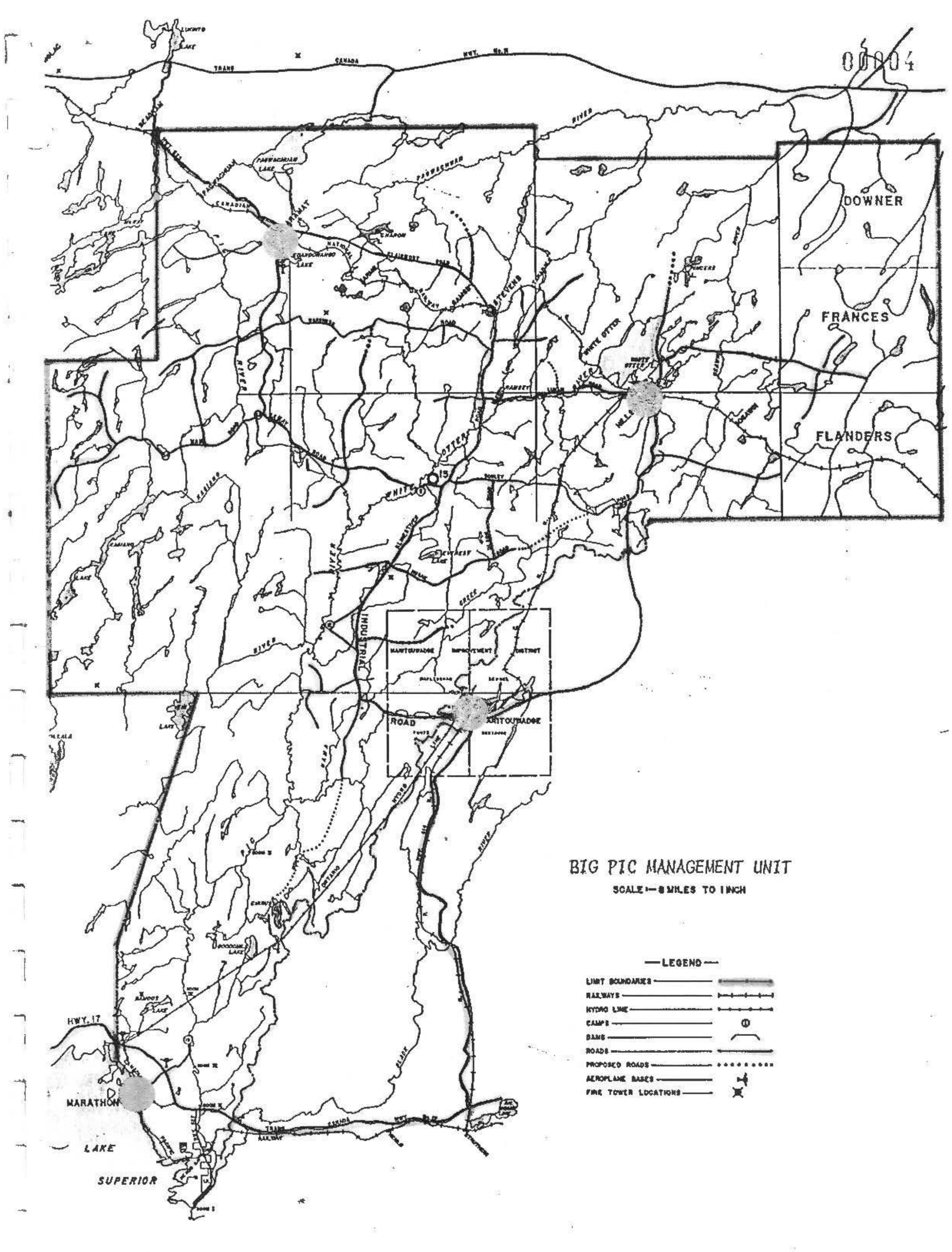


Figure 3. Major roads within the Big Pic Management Unit, as of the year 1987.

In 1965, Weldwood of Canada, who was then constructing a poplar plywood plant at Longlac, entered into an agreement with American Can under which the latter agreed to supply Weldwood with up to 10,000 cords of veneer-grade, eight-foot poplar bolts annually from the area then held under licence by American Can. When American Can's licence area was reduced in 1972, the veneer agreement was also reduced to 5000 cords annually. This agreement expired on March 31, 1981. During the early years of the agreement, veneer logs were produced on American Can's own operations, with any shortfalls being made up by Third Party Agreement operations undertaken by Weldwood in the Pagwachuan Lake and Hornepayne Road areas. For the period 1973 to 1977, most of the veneer was produced by Weldwood from their Third Party operations.

In 1972, Weldwood commenced construction of a wafer-board plant adjoining their veneer plant at Longlac and received notification from the Crown that poplar of pulpwood quality on this Management Unit that was surplus to American Can's requirements, would be considered as a supply for that wafer-board plant. Most of that mill's requirements were supplied from other sources, but prior to 1972 some veneer grade tree length containing pulpwood grade material was shipped to Longlac from the Big Pic Management Unit. At the time, all wood produced for use in the Weldwood mill was delivered by truck over private and public road systems. The American Can mill also received first right-of-refusal to any chips and/or pulpwood generated from their operations on the Big Pic Management Unit.

Small amounts of white birch veneer and some white birch sawlogs were harvested from time-to-time by small jobbers on the southern end of the Unit near Marathon. The veneer logs were sold to mills in the vicinity of Sault Ste. Marie and the sawlogs were used by a small mill that operated for a time near Marathon. Due to the remote location of the Unit from sawmilling centres, up to 1972 there had not been a significant amount of conifer sawlog material produced from the Big Pic Unit.

The 1983 sale of the Marathon pulp mill to the James River Corporation by the previous owner, American Can Canada Inc. had a major impact on forest operations on the Big Pic Forest. Several features of this impact were:

- Inventory Reduction: The previous system of delivering roundwood produced on the Big Pic Unit to the Marathon mill relied heavily on the river drive on the Pic River. Since this was exclusively a spring drive, large volumes of wood had to be built up in inventory at various points - in the bush, at the river landing and in the mill block piles. With the start of direct overland delivery of fibre to the mill, a period of inventory reduction resulted in minimal roundwood deliveries to the mill.
- Chip Purchase Program: For a number of business reasons, the conifer supply to the Marathon mill was changed from a roundwood/chip mix to primarily sawmill chips. For the period of the 1987-1992 Management Plan it was anticipated that only the mill's hardwood fibre requirements would be delivered in roundwood form.
- Sawlog Production: The Big Pic Unit produced only small amounts of sawlogs under previous owners since the Marathon mill used much of the conifer allowable cut as pulpwood. With the mill no longer directly dependent on this pulpwood, other products - sawlogs, tiebolts, etc. - have been produced in increasing amounts. One of the co-owners of the Marathon mill - Buchanan Forest Products Limited - purchased the Great West Timber sawmill in Thunder Bay in 1986. With this purchase, it was anticipated that all of the sawlogs produced on the Big Pic would be used by the Great West mill (Anon. 1987).

James River-Marathon Ltd., the new owner of the mill set a strategic course that resulted in the mill maximizing its use of sawmill chips as one step in a major cost reduction program. With wood-handling facilities that can only process limited amounts of roundwood (and primarily hardwood), the Unit was no longer required to supply the mill with conifer roundwood. Therefore, the Big Pic Unit became dependent on the open market for forest products sales.

The original owner had put the Marathon operation up for sale in April of 1981. By 1982, with the possible closure of the operation likely if no buyer materialized by the summer of 1983, woodlands operations began winding down. Following the sale, the necessity of establishing completely new markets for wood produced from the Unit, resulted in harvesting operations starting at a low level. During the 1982-1987 Plan term only about 40 percent of the planned harvest operations were actually carried out. It was only in the latter part of the 1982-1987 Plan period that operations began to return to more normal levels.

Prior to the sale, almost all of the operations were oriented to the production of pulpwood for Marathon. During the period after the sale, production had to become more oriented to the production of sawlog material, the most readily saleable forest product. Operations at the north end of the Unit which had been de-emphasized for some time due to distance from the mill, became more attractive since it was closer to the new markets than many points on the Unit. The higher priority put on ensuring that products could be delivered in the summer also created a shift with respect to the type of summer logging areas that were required. The requirement for sawlog material at the Great West Timber sawmill in Thunder Bay also had a stabilizing influence on operations in the final year of the 1982-1987 Management Plan (Anon. 1987).

The long-term Crown Timber Licence that was held for sixty-five years was reissued in 1956 and again in 1977. It was replaced on April 1, 1996, with a Sustainable Forest Licence that expires on March 31, 2016 (Schwedack 2007). Nawiinginokiima Forest Management Corp. presently has responsibility for management of the forest and is negotiating a new Sustainable Forest Licence. In future the Big Pic Forest is intended to be managed as a community-based SFL.

It is worth noting that until the construction of the mill in Marathon, there was little, if any, commercial timber harvesting activity on the upper reaches of the Pic River watershed. Consequently, until the early 1940's, the forests on the upper Pic were essentially undisturbed by human activity except to the extent that the construction and operation of the CNR line might have given rise to human-caused fires. Thus, the forest as it existed on the upper Pic in the early 1940's could lay claim to being at least one iteration of the pre-industrial industrial forest condition. One final point worth noting, after the 1940's, it was found that adverse terrain conditions on the lower part of the Big Pic were such that road construction and timber harvesting were, to all intents and purposes, too costly if not impossible to conduct particularly as harvesting operations became more and more mechanized.

4.2 Notes on the River Drive on the Big Pic Forest

The river drive of pulpwood on the Pic River and its tributaries was a major part of the forest scene on the Big Pic Unit for over forty years (Fry 1977). The precipitous terrain characteristic of the lower two working circles and the resultant high costs associated with building and maintaining a direct road link from the woodlands operations to the mill, resulted in the continuance of the river drive until the early 1980s. Nonetheless, there were small volumes, mostly hardwood, delivered to the mill from the Unit by truck over public highways. A railway siding was built at Hillsport in the late 1960s and small amounts of wood have also, over the years, been delivered from the Unit by rail.

The existence of the river drive which requires that all timber cut be "driveable" had a direct effect on utilization and harvesting patterns. Species such as balsam poplar, white birch and tamarack are very dense woods and due to high sinkage rates, cannot be water delivered. As long as the river drive remained the main wood delivery system, these species were bypassed (Fry 1977). In addition, trembling aspen cut during the dormant season (i.e., after September 15) must be "dry landed" for one season to allow it to cure enough to be put in the river drive. Thus, most aspen stands were cut during the leaf on season for water delivery the following spring.

In 1977, the limitations imposed by the river drive, plus the limited market for hardwood pulp resulted in another of the objectives of the 1960 Management Plan--namely the fuller use of what is now considered unmerchantable species not being achieved. Another objective of the 1960 Management Plan was maintaining or increasing the productive capacity of the area. In addition to this objective, in 1972 the Crown assigned, as part of its Provincial Forest Management Strategy, a level of sustained production for this Unit. An implementation schedule was developed which outlined by year how much regeneration work of various types was to be undertaken on the cutover areas of the Unit.

4.3 Development of the Silviculture Program on the Big Pic

A development characteristic to the Big Pic Management Unit has been the early utilization of a relatively high proportion of the aspen allowable cut that kept partially cut areas to a minimum. The better utilization provided conditions ideal for regeneration of the aspen component as well as facilitating other silvicultural treatments such as site preparation and tree planting. Another characteristic of the Big Pic Management Unit has been the early implementation of mechanical harvesting systems relative to other management units in the province. The high lead cable yarding system was developed by American Can and used over a period of about fifteen years starting in 1948. The yarding system dragged either bundles of eight-foot wood or bunches of tree-lengths out to the roadside and in the process accomplished a degree of scarification and scattering of cone bearing slash. Distribution of the scarification was better on the tree-length yarded areas than on bundle-yarded areas since, in the latter case, the piles (or bundles) were concentrated in rows perpendicular to the roads and scarification tended to be located only along those rows. On the basis of a few small surveys that have been carried out and general impression, it is felt that regeneration of merchantable tree species was improved on the areas so logged, particularly those logged during the snow-free season (Anon. 1987).

During the period from 1956 to 1966 silvicultural work was undertaken on a relatively small scale and consisted largely of nursery stock planting with a gradual increase in scarification and seeding. In 1967 there was a marked expansion in the silvicultural effort and it was during the period 1967 to 1969 that American Can carried out silvicultural work under a Regeneration Agreement with the Crown. Subsequent to 1969, the occasional scarification project was carried out using Company tractors hired on an equipment rental basis for short periods of time.

During the late 1960's many of the large planting projects involved the planting of tubed seedlings and this accounted for a large proportion of the acres treated. This program did not live up to expectations and was phased out in the early 1970's. In the nursery, the production of bare root nursery stock shifted from the traditional transplant stock to the cheaper, easier and faster to produce 3-0 seedling stock. Of generally poorer quality, the 3-0 stock produced inconsistent and generally poorer survival rates. As this problem became better recognized the nurseries have concentrated on producing better quality stock and this, in combination with improved field handling, has produced higher and more consistent plantation survival rates in recent years. Planting efforts during the past management period have largely been confined to the deeper-soiled, better-drained upland sites. The planting of nursery stock on wetter sites and on stoney and/or shallow soils on this Unit has met with a singular lack of success. In addition, many white spruce plantations have encountered serious frost damage problems in spite of good survival rates.

The development of scarification equipment and techniques during the 1970s and 1980s was very rapid, and probably the more dramatic developments in silviculture on the Big Pic Management Unit were in this area. From the first scarification drags, consisting of several large boulders towed behind a tractor, have developed the more elaborate shark finned and flanged barrels, spiked anchor chains, tractor pads, Bracke Scarifier, "seed bombs", the C and H Scarification Plough and a number of others. Up to the mid-

1980s, scarification for natural regeneration comprised a large portion of the annual regeneration work undertaken on the Big Pic Management Unit. Direct seeding was often used to supplement natural seed sources on these scarified areas. Most scarification for natural regeneration was concentrated on the sandy-soiled Mixed Softwood and Jack Pine cover types and, although good results were often achieved, results were variable, and Fry (1987) concluded that the technique could not be depended on to consistently produce desirable levels of regeneration, although the regeneration levels on scarified areas were often better than on unscarified areas.

Site preparation for planting did not become an integral part of the silviculture effort until the early 1970's and this accounts, in part, for the higher survival rates attained in the tree planting program since then. Prescribed burning as site preparation for planting was carried out sporadically from 1966 to the mid-1990s and these prescribed burns, as well as occasional wildfires in cutover areas, has provided generally excellent site preparation for planting.

Modified cutting was not practised to any great extent on the Big Pic Unit. The clearcutting of adjacent hardwood and mixedwood stands in conjunction with the often small and broken-up nature of black spruce stands on the Unit generally makes alternate strip or block cuts impractical and very susceptible to windthrow. The regeneration cruise data gathered over the past ten years by the Crown is limited in scope but does give some indication as to the success of various silvicultural treatments. Statistically speaking, the summary of the data gathered is subject to question as are some of the stocking standards used to determine the adequacy of regeneration. Nevertheless, the information does tend to support field observations. In general, the mixedwood and hardwood cover types are regenerating to merchantable tree species although a considerable proportion of the conifer regeneration is balsam fir. The percentage of treated areas that are satisfactorily stocked is higher than that of untreated areas. However, even for treated areas major problem areas exist, particularly in the MS, jP and bS cover types--the cover types responsible for producing 60% of the conifer volume in the past. And, of course, there is even more of a problem on the untreated areas of these cover types.

Road access developed less rapidly than expected in the 1980s, largely due to the low level of harvest that, obviously, required less road construction. However, the Camp 8 bridge was completed in 1982 thereby providing access to a large area west of the Pic River. Construction started on the Michal Lake Road to access this wood. The Olie Lake Road was connected to the road system on the Black River Forest thereby opening up much of the Hillsport area to a more direct haul of forest products. The amount of cutover generated from harvesting operations has a direct impact on renewal and maintenance activities. Consequently, these activities were much reduced from planned levels as well. In addition to the area covered, other changes involved a shift from seeding to planting and an increase in aerial tending operations.

Some points of interest with respect to renewal and maintenance operations are as follows:

- Group seed tree cutting was not carried out during the 1982-1987 Plan period since there were only limited operations on suitable lowland areas.
- About one-half the bare-root planting was carried out primarily due to the lack of suitable planting area. A reduction in the availability of stock was a lesser factor.
- Approximately twice the forecast amount of container stock was planted due to the replacement of container stock for bare-root stock losses and because there was a shift to shallower sites more suited to this stock type.
- Direct seeding was reduced significantly due to the poor success of this treatment in the past and to the lack of suitable sites.
- Site preparation levels were reduced due to the reduction in cutting levels.

- Manual cleaning was significantly reduced due to high costs of this treatment. Chemical tending, most of it unplanned, was carried out over a substantial area. The need for this tending was not anticipated at the time of preparation of the 1982-1987 Plan (Anon 1987).

5 History of Forestry in the Pic River Forest

5.1 History of Forestry on the Black River Forest

Timber harvesting has been active on the Black River Forest since the early 1930's and a chronological history follows:

The General Timber Company was formed by Marathon Paper Mills of Rothschild, Wisconsin and operated by Alfred Johnson, a nephew of E.E. Johnson, and Burton Stewart. Cutting rights and camps were acquired from Pigeon Timber and a 110,000 cubic metre cut was commenced during the winter of 1936/37 along the TransCanada Highway and the Canadian Pacific Railroad between Pringle and Hemlo. All of these operators worked close to the Black River near the C.P.R. and were notorious for exploiting only the best Spruce stands. They built camps of a very temporary nature, usually good for one or two winters, and moved up the river when the good wood close to the water ran out.

The Ontario Paper Company had been operating a newsprint mill at Thorold, Ontario since 1912 using purchased wood, with some wood from as far away as Anticosti Island. Newsprint produced at Thorold was shipped to the parent company, The Chicago Tribune. In 1919 when the New York Daily News was founded, timber limits were acquired at Shelter Bay in Quebec to provide more wood to Thorold. Additional limits were acquired at Franquelin in 1921 and at Manicouagan in 1923, but this limit was not operated until a mill at Baie Comeau was built in 1936. With a good deal of the Quebec wood going to the Baie Comeau mill it was decided to look into the acquisition of an Ontario Limit to help supply Thorold.

1936
T.B. Fraser explored the Longlac Watershed but decided its potential as a pulpwood producer was limited. E.B. McGraw conducted his study of the Pic and Black Rivers and recommended the Black River area. McGraw stated that:

- the Pic would only yield 17.5 cubic metres softwood per hectare compared to the Black’s 30-35 cubic metres per hectare
- the first 30 kilometre section of the Pic was too rough to operate whereas the Black wasn't so bad, and
- the Black was a better driving river since the Pic had problems with a great disgorge of ice in the spring, breaking holding booms at its mouth.

April 1937
General Timber relinquished its cutting rights and a licence was granted to Ontario Paper on 2,000 square kilometres of the Black River watershed. General Timber acquired to licence to the Pic River area in 1938 and later became Marathon Paper, then American Can of Canada, and then Pic River Forest Products.

1937-1938
The original licence granted the right to cut 110,000 cubic metres per year of Spruce and Balsam Fir pulpwood. However, no proper allowable cut was calculated. Larry Loken did a cruise of the entire watershed which showed that on 1,200 net merchantable square kilometres there were 6,900,000 cubic metres of softwood (58 cubic metres/hectare).

The early operating procedure was to cut, pile and skid by horse, 1.2 metre wood to the nearest driveable stream or lake. Wood was driven on the Black to the barking plant near the mouth of the river. After barking, the pulpwood was flumed 5.6 kilometres over the Pic to be loaded onto ships at Heron Bay. Since wood was delivered in this manner until the spring of 1964 (last boat load 1965) it follows that most cutting kept close to the driveable streams. Slightly longer distances were managed with the use of small capacity (8 cubic metres) stake trucks in the 1950's. As a result, some hectares with less than adequate drainage such as Swede Creek and Barehead were bypassed during this period.

1947
The Black River licence was amended to include all species of timber. By this time the area of the licence had reached 2,540 square kilometres.

1949
The Little Pic Limit (1,350 square kilometres) was acquired from Great Lakes lumber and Shipping. It had an allowable cut of 85,000 cubic metres softwood, however, it was operated for only one season (1951-52) for 47,000 cubic metres. The little Pic was intended to provide more Ontario wood for Thorold and decrease the Quebec supply, however, an economical wood delivery system to Heron Bay was never devised.

A square extension in the northeast corner of Black River licence was added, bringing the total area to 2,600 square kilometres.

1951
The first Forest Management Plan for the Black River District was written, with a softwood allowable cut being calculated as follows.

1950-1995	186,000 cubic metres
1996-2021	161,000 cubic metres
2022-2037	146,000 cubic metres
2037-	198,000 cubic metres

1957
A Revised Forest Management Plan was written for the Black River Forest (2,600 square km). The allowable cut was recalculated:

1956-1993	242,000 cubic metres
1994-2030	173,000 cubic metres
2031-2055	240,000 cubic metres

The increased cut was deemed allowable if a rather unwieldly double cut (jack pine at age 70 and spruce at age 110) was undertaken in the burn areas. This idea has since been discarded by the Company.

1964
The Department of Lands and Forests approved the softwood allowable cuts as follows:

Black River	206,024 cubic metres
Little Pic	69,901 cubic metres

NOTE: Conversions based on 1 peeled cord = 1 cunit = 2.83 cubic metres.

December 1971

White Lake and Neys Provincial Parks were deleted from licence areas.

November 1976
The Little Pic licence was relinquished to the crown in exchange for areas in the Hornepayne area, and a volume agreement at Shining Tree.

April 1977
The Black River licence was renewed and amalgamated with the Nagagami licence in Hornepayne, with a total area of 7,127 square kilometres (licence #384200).

1980
A Forest Management Plan for the Black River licence was written, with an allowable cut as calculated below:

Sp-x, 1,2	689 hectares
Sp-3	68 hectares
B	596 hectares
Pj	339 hectares
Po-x, 1,2	201 hectares
Po-3	118 hectares
Bw-x, 1,2	209 hectares
Bw-3	152 hectares

March 31st, 1982
A Forest Management Agreement (FMA) was signed for the Black River Forest retroactive to April 1st, 1981. At the time, the Ontario Paper Company office, garage and siding complex were located just west of Manitouwadge directly south of Fox Creek. All of the Company's woods operations were on a commuter basis with the total work force residing in Manitouwadge. Within the operations, two thirds of the fibre harvested was cut by Koehring Feller Forwarder with the remainder by conventional gangs. The majority of wood was brought full tree to roadside with the only exception being conventional winter cut which was limbed and topped in the bush. The majority of the trees were mechanically delimbed at roadside. All of the wood in the licence was hauled tree length to the siding by trucks with self-loaders. The trees were then barked and slashed at the siding and either down piled or sent immediately via rail to Thorold, a distance of some 1,200 kilometres.

5.2 Silviculture Program on the Black River Forest

Table 1 summarizes silvicultural activity on the Black River Forest from 1950 to 1982. Up until the late 1960's, very little can be said about regeneration on the Black River Forest. Sporadic attempts were made to treat areas, but only a token number of cutover hectares were ever artificially brought back to productive forests. In the late 1960'san increase in silvicultural activity commenced and the average number of hectares treated per year has been increasing since. The number of hectares treated silviculturally compared to hectares cut did not attain the level required, and to this end the Company and the Ministry of Natural Resources entered into a Forest Management Agreement which will increase silvicultural treatments to a point where virtually all areas cut will have the benefit of proper forest management.

Table 1. Summary of silvicultural activity on the Black River Forest 1950-1982.

	Hectares Treated				
Years	**Hectares Planted**	**Average/Year**	**Hectares Seeded**	**Average/Year**	**Total per year**
1950-59	115	11.5	156	15.6	27.1
1960-69	1,316	131.6	697	69.7	201.3
1970-75	1,674	279	1,681	280.2	559.2
1976-82	2,228	318.3	950	135.7	454

5.3 History of the Pic River-Ojibway Forest

There are some information gaps in the history of forest management of the Pic River-Ojibway Forest. Unlike the Big Pic and Black River Forests where there was management continuity over the course of seventy years or more, the same cannot be said for the former Pic River-Ojibway Forest and Steel River Crown Management Unit, which helps explain the information gap. For example, most of what eventually became the Steel River Crown Management Unit was first licensed in 1916 (the Pic River Pulp and Timber Licence). By 1921, it had been acquired by the Great Lakes Paper Company. After Great Lakes surrendered the licence, likely in the early 1930's, new licences were issued to Abitibi (for the Steel River area) and the Pigeon Timber Company (for the Little Pic Concession area). Pigeon Timber sold their holdings to the Ontario Paper Company in 1949. Eventually both of the principal licensees surrendered these licences, following which the Steel River Crown Management Unit was created in the late 1970's. After the passage of the Crown Forest Sustainability Act in 1994, the land base of the Steel River Unit was folded into the Pic River-Ojibway Sustainable Forest Licence.

5.3.1 Little Pic Concession

The Little Pic Concession, by agreement with the Minister of Lands and Forests, was comprised of an area of approximately 546 square miles. The limit fronted on Lake Superior and extended from CPR mileage 67 to the mouth of the Little Pic River, which empties into Lake Superior about 25 miles west of Heron Bay, via the CPR. Most of the area as described by the meets and bounds in the agreement with the Provincial Government was located within the watershed of the Little Pic River. The limit was acquired by the Ontario Paper Company from the Great Lakes Lumber and Shipping Company and associated companies in April, 1949. At the same time, besides the uncut timber, all camps, buildings, roads, bridges, river and stream improvements, dams, telephone installations and equipment, booms and holding booms were obtained.

At the time, the Company noted that over half of the limit had been logged over. Given the horse logging methods of the time, this meant that isolated patches of merchantable timber were scattered over the area. In the 1951 Operating Plan (Anon. 1951b) Company officials stated that many of the operations required to harvest these patches would be costly and could be accomplished only in years of favourable economic and labour conditions and these may vary from year to year.

The completion of the Trans-Canada Highway between Neys and Heron Bay was necessary before the Company could initiate cutting of the timber in the area behind Angler and Coldwell. This area covered 27,743 acres and contained 146,324 rough cords of merchantable timber.

It was planned that wood cut on this limit would be driven down the Little Pic River to Lake Superior and from there would be transported to the plant at Heron Bay to be barked and to be loaded on to ships for transport to the company's mill at Thorold, ON. In 1951, no definite decision had been reached as to the actual mode of transportation to be used between the Little Pic and Heron Bay. Consequently, the wood was being loaded into the ships, without being peeled, by means of a floating jackladder at the mouth of the river. The 1951 Company Management Plan (Anon. 1951a) noted that:

> "other than for development purposes on our own Concessions, when we use lumber sawn from resources at hand, the Company operates entirely to support the newsprint mill at Thorold, Ontario, and in so doing cuts only pulpwood. Another point worthy of note is the fact that neither of the two principal hardwood species, poplar and white birch, would be considered merchantable, as they are so far beyond their particular age of maturity that up to 75% cull is encountered in both species".

In 1951, the newsprint mill at Thorold required annually 290,000 rough cords of pulpwood. The Company's objective was to furnish to the mill the full capacity of the Little Pic Concession of spruce, balsam fir and jack pine pulpwood. The ultimate objective in managing the concession was to plan the cutting of the forest in such a way that the result over time would be a forest that resembles, as closely as possible, a normal forest, in order to enable the Company to allow for a fixed annual cut in perpetuity.

The bulk of the forested area of the Little Pic Concession was made up of four definite age classes, each of which is in quite a distinct area, as follows:

- Area 1: this area contains the present mature and overmature timber that is ready for cutting now. It constitutes 70.7% of the total forested area (Age Class 1, > 90 years).
- Area 2: this area contains immature timber between the ages of 60 to 90 years and constitutes 4.6% of the total forested area (Age Class 2a).
- Area 3: this area contains immature timber between the ages of 30 to 60 years and constitutes 4.7% of the total forested area (Age Class 2b).
- Area 4: this area contains young growth under 30 years of age and constitutes 10.8% of the total forested area (Age Class 3).

The remaining 9.1% of the area was occupied by logged-over areas and a block of recent burn.

5.3.2 Steel River Crown Management Unit (SRCMU)

The SRCMU was located within the Boreal Forest Region (Rowe 1972). Most of the SRCMU's forests typify the tree species and distribution of the Boreal Forest Region. The SRCMU was 251,751 hectares in size, including the amalgamation of the old Steel River and Gravel River Crown Management Units' amalgamation which was official as of April 1, 1991 (Figure 4).

The SRCMU was located within the administrative boundaries of Terrace Bay and Geraldton Districts of the Ontario Ministry of Natural Resources. The total area of the SRCMU was 251,751 hectares. Only 3,100 hectares were found within Geraldton District. The SRCMU is an amalgamation of the former Steel River CMU (1978) and the Gravel River area. The Gravel River portion of the SRCMU was located approximately 50 km west of Terrace Bay.

Highway 17 ran across the southern portion of the SRCMU providing a major transportation link from east to west. The Dead Horse Creek Road provided access through the SRCMU north from Highway 17 toward the northern section of the SRCMU. In addition, a number of other primary roads branched off from the Dead Horse, including the Vein Lake and Jack Pine roads. The Canadian Pacific Railway ran along the entire southern edge of the SRCMU near the shore of Lake Superior. A major Ontario Hydro utility corridor passed through the SRCMU along its southern boundary.

Almost 80% of the SRCMU was drained by the Steel River, Little Pic and Gravel River watersheds. The headwaters of the Steel River are in the vicinity of Cairngorm Lake. The SRCMU was comprised of seven primary watersheds:

1. Owl Creek 5,463 ha
2. Steel River 111,290 ha
3. Prairie-Deadhorse 27,519 ha
4. Little Pic River 76,900 ha
5. Pic River 5,059 ha
6. Mink-Angler 11,230 ha
7. Gravel River 12,670 ha.

The Little Pic watershed was licensed to Great Lakes Lumber and Shipping in 1916. The Pigeon Lumber company operated for a short time in the early 1920s and was succeeded by the Pigeon Timber Company. The Pigeon Timber Company was formed by E.E. Johnson and logged the Little Pic from 1923 to 1935. They had a rafting camp at the mouth of the Little Pic River and offices located at the Neys railway crossing.

In 1936, Marathon Paper formed a subsidiary called the General Timber Company which bought out the rights to the Pigeon Timber Company. The General Timber Company was managed by Alfred Johnson and Burton Steward and operated until 1948. During the Second World War, German prisoners-of-war and Japanese-Canadians cut an estimated 90% of the wood harvested during the war years on the SRCMU. In 1949, the Little Pic watershed was licensed to the Ontario Paper Company. Up to that year, camps had been built and the following five dams constructed: Islington Lake, Martinet Lake, Killala Lake, Glory Lake, Little Pic River (above Islington).

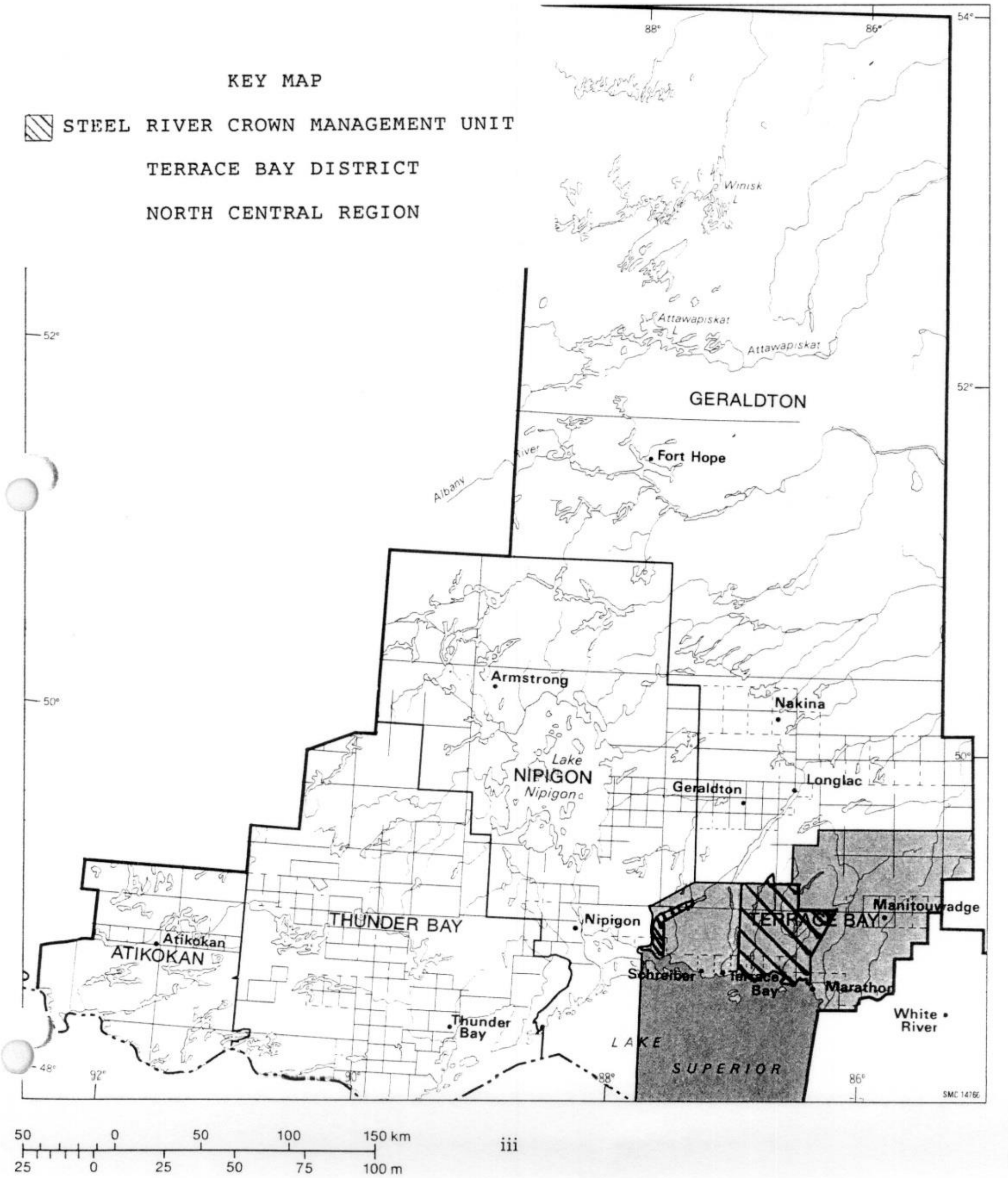


Figure 4. Map showing the location of the former Steel River Crown Management Unit.

During the period 1951 until 1976, operations on the SRCMU were limited to a number of small operators which operated near Highway 17 along the North Shore of Lake Superior. Most of these operations took place on the Steel River Concession which was licensed to Abitibi Paper Company. In 1970 Abitibi returned the Steel River Concession to the Crown. This area became the Steel River Crown Management Unit in 1975. In November, 1976 the Little Pic licence area of the Ontario Paper Company was also returned to the Crown and the amalgamation of these two areas became the Little Pic Crown Management Unit. The Steel River Crown Management Unit was formed in 1978 by adding the old Steel River and Little Pic CMU' s together with some minor changes due to a licence exchange with Kimberly-Clark of Canada.

During the construction periods of the Canadian Pacific Railway and Highway 17 there were a number of communities along the shore. Such communities as Jackfish, Angler, Middleton, and Ripple are now only railway sidings. Port Coldwell, also now a railway siding, was at one time a commercial fishing port.

By 1991, there was only one wood supply agreement for the SRCMU, it is with Great West Timber Ltd. Timber operations within the SRCMU had traditionally been carried out under a third-party agreement with a number of small timber contractors. In 1991, James River Marathon Co. had a directive for all softwood and hardwood pulpwood as well as the right for first refusal for all sawlog chips.

Great West Timber Ltd. did not harvest in 1988/89 due to contractor unavailability. Two new licensees were introduced to the SRCMU in 1988-89: Pic-Heron Bay Development Corporation on a long term basis and Nakoming Development Corporation on a short term basis.

Regarding the forest inventory at the time, authors of the 1991 Management Plan noted that:

> "The current F.R.I. is a difficult database to deal with as the SRCMU has been amalgamated two separate times since the inventory was created (1975); in 1978 the old management units of the Steel River Crown Management Unit and the Little Pic Management Unit were incorporated into one unit and further with the implementation of this plan the SRCMU will add the landbase of the Gravel River area. The two units that were amalgamated at that time split a series of basemaps running north-south. This split created two working circles in the FRI database. The present forest of the SRCMU is composed mainly of overmature forest. This is due to few major natural disturbances. The balsam fir working group is the only working group that is being potentially threatened by a pest, this being the spruce budworm".

6 A Brief Chronology of Important Historical Events

1889 – British Parliament confirms Ontario's claim to Northern Ontario

1896-98 – Alexander Niven runs the North/South survey lines to milepost 120 (Nighthawk Lake), then on to Moose Factory

1899-1900 – Niven undertakes the East/West survey lines

1900 – Ontario Legislature provides funds ($40,000) to begin the survey of the unmapped northern regions.

1898-1923 – During these years a few of the townships in the Pic River and Big Pic Forests were mapped by Ontario Crown Land Surveyors. Surveys of the major rivers in the area were also completed.

1900-1930 – the practice of burning during railway construction resulted in a number of forest fires of various sizes. Many fires were also caused by sparks from the tracks and wheels. More active fire suppression activities beginning in about 1918 began to reduce the number and severity of fires during this period.

1917 – As a result of the disaster of the previous year, the Forest Fire Prevention Act was passed, which regulated fires for land clearing under a permit system, and required timber licencees and pulp concessionaires to pay for maintaining fire rangers on their limits.

1920 – Department of Lands and Forests was established, and the Forest Inventory Section of Lands tasked with beginning the process of forest inventory.

1920-23 – a severe drought during this period resulted in a large number of fires and a large area burned throughout the Clay Belt and Central Divide Ecosections in the years 1921 and 1923.

1921 – Fire rangers were for the first time required to map forest fires and were provided with grid templates to do so. Comprehensive fire records and maps exist from this time forward.

1920-27 – Lands and Forest administrative Inspectorates and Districts undergo a number of boundary changes culminating in 1927; after this they were stable until 1946.

1929-45 – timber operations in northeastern Ontario are limited due to the Great Depression and World War II.

1930s and 1940s – Forest Companies were required to undertake forest inventory on their operating limits. About this time the first forest management planning system, based on some aspects of a sustained yield harvest system, was instituted. Allowable cuts were determined from the forest inventory and yield data collected by the Companies and by Lands and Forests. The first management plans were written for timber licences and pulpwood concessions.

1943 - With the opening of the White Otter area, operations commenced in the northern part of the Pic Area. The first set of high-resolution (scale 1:7,920) aerial photography is acquired for the Pic Concession.

1947-50 – The 'Modern' FRI system (using working groups and detailing species composition, stocking, height and age for forest stands) began to evolve. Inventories conducted on Crown Forests in the late 40's and early fifties continued to use broad forest type and age classes. In 1947, aerial photography for the Pic Concession is updated.

1949 – The first management plan for the Pic Area Concession was prepared.
1950-1985 – Data collection in the form of permanent sample plots and operational cruising are conducted for the purpose of continuous updating of the American Can forest inventory for the Big Pic Management Unit. In 1960, a new management plan is prepared using updated inventory information.

1952 – Lands and Forests Districts were divided into Management Units, and updated forest inventories for these began to be conducted.

1972 – The Department of Lands and Forests was amalgamated with the Department of Mines and Northern Affairs to form the Ministry of Natural Resources.

1973 – The first provincial Forest Resource Inventory (FRI) was prepared for the Big Pic Management Unit.

1986 – Maintenance of the American Can inventory system on the Big Pic Forest was discontinued and the inventory system on the Big Pic was converted to the OMNR's Forest Resource Inventory (FRI) system.

1990's to present – Consolidation of Forest Management Agreement and some Crown Forest Management Units into Sustainable Forest Licences was completed by OMNR.

7 Fire Information

7.1 Fire Records 1914-1929

Beginning in 1921, the Fire Protection Branch of Lands and Forests began to actively map forest fires on an annual basis. Large fires (greater than 260 ha) that occurred in Ontario from 1921 to 1995 are documented in "Ontario's Forest Fire History: An Interactive Digital Atlas" (Perara 1998). The year 1921 corresponds to the time when Lands and Forest Fire Rangers began to keep mapped records of forest fires within their respective Districts. However, it is likely that fires in more remote areas were not recorded in the early years, since the widespread use of aircraft for monitoring fires did not begin until the late 1920's. Also, there is good evidence to suggest that there were a number of very large fires prior to settlement as well as prior to the advent of record-keeping. Accordingly, we have assembled additional information, from archived Lands and Forests records, for the period 1914-1929, to provide additional context for the information contained in the digital fire atlas.

From 1914 to 1917, forest fires were reported on a Provincial basis, as shown below.

Provincial reporting, 1914-1917.

Year	Caused by Rail	Natural & unknown causes	Total Area (acres)	Total Area (ha)
1914	4,075	6,286	10,361	4,193
1915	2,885	1,219	4,104	1,661
1916	6,252	7,572	13,824	5,594
1917	?	?	30,172	12,211
Total				23,659
Area/year				5,915

Starting in the year 1918, fires were reported by Districts as shown below.

Forest Fire Records from Provincial Archive, 1918-1923.

District	Year	No. of fires	Area (acres)	Area (ha)
Abitibi	1918	7	21	8
Abitibi	1919	11	5,472	2,215
Abitibi	1920	36	2,989	1,210
Abitibi	1921	17	54,755	22,159
Abitibi	1922	6	702	284
Abitibi	1923	10	3,553	1,438
Cochrane	1918	35	219	89
Cochrane	1919	212	11,725	4,745
Cochrane	1920	113	3,798	1,537
Cochrane	1921	75	17,126	6,931
Cochrane	1922	32	366	148
Cochrane	1923	47	38,959	15,767
Hearst	1918	13	3	1
Hearst	1919	14	755	306
Hearst	1920	17	2,645	1,070
Hearst	1921	12	869	352

District	**Year**	**No. of fires**	**Area (acres)**	**Area (ha)**
Hearst	1922	19	163	66
Hearst	1923	13	7,746	3,135
Kapuskasing	1921	13	1,307	529
Kapuskasing	1922	9	308	125
Kapuskasing	1923	19	5,138	2,079

Summary

Districts	**No. of years**	**No. of fires**	**Area (acres)**	**Area (ha)**
Abitibi	6	87	67,492	27,314
Cochrane	6	514	78,946	31,950
Hearst	6	88	12,181	4,930
Timmins	6	199	98,213	39,747
Regions				
Clay Belt	6	888	256,832	103,940
Central Divide	6	99	65,517	26,515

Beginning in 1924 the reporting changed yet again to inspectorates rather than Districts (these were larger areas, some comprising several Districts). In all these tables, Regional results from the Central Divide are most relevant to the Pic River and Big Pic Forests.

Reporting by Inspectorates, 1924-29.

Inspectorate	Year	No. of fires	Area (acres)	Area (ha)
Cochrane	1924	46	7,265	2,940
Cochrane	1925	12	153	62
Cochrane	1927	108	710	287
Cochrane	1928	34	423	171
Cochrane	1929	56	12,591	5,096
Oba	1925	10	1	0
Oba	1927	44	135	55
Oba	1928	104	4,368	1,768
Oba	1929	27	2,893	1,171
Sudbury	1924	328	3,742	1,514
Sudbury	1925	431	38,348	15,519
Sudbury	1927	32	2,065	836
Sudbury	1928	201	10,994	4,449
Sudbury	1929	246	4,105	1,661

Summary

Inspectorates	No. of years	No. of fires	Area (acres)	Area (ha)
Cochrane	5	256	21,142	8,556
Sudbury	5	1238	59,254	23,980
Oba	4	185	7,397	2,994
Clay Belt Total	5	1,679	87,793	35,530

Although this information may prove to be of little use in calculating fire cycles, it does show when the most severe fire years occurred during this period and is offered for its historical value.

7.2 Fire Records - 1930 to Present

Ontario published a digital forest fire history atlas (OMNR 1998), which included information on known wildfires that occurred between 1920 and 1995. Figure 5 is a map showing the locations of recorded fires in the Pic River and Big Pic Forests; these are also listed in Table 2. Table 3 lists the area burned on the Big Pic Forest from 1944 to 1976, sourced from the 1977 Timber Management Plan for the Big Pic Forest (Fry 1977). This table includes all fires, including those less than 260 ha in size, which were not included in OMNR's Fire Atlas.

Table 2. Summary of fires recorded in OMNR's Forest Fire Atlas for Ontario (1998).

Year	Area	Proportion in MU	Estimated Area in Big Pic & Pic River Forests
1922	238	1	238
1923	2,740	0.95	2,603
1923	86,787	0.7	60,751
1923	327	1	327
1931	7,851	1	7,851
1931	731	1	731
1932	16,774	1	16,774
1932	642	1	642
1933	728	0.2	156
1935	746	1	746
1936	273	1	273
1936	33,131	1	33,131
1936	1,562	1	1,562
1936	683	1	683
1937	1,090	1	1,090
1937	534	1	534
1937	2,413	1	2,413
1937	6,255	0.95	5,942
1941	489	1	489
1941	1,666	1	1,666
1945	745	1	745
1948	4,564	1	1,369
1966	1,777	1	1,777
1970	1,428	1	1,428
1971	374.2	1	374
1972	1,673	1	1,673
1975	583	1	583
1975	2,666	1	2,666
1983	299	0.9	269
1983	55	0.6	33
1988	521	1	521
1991	741	1	741
1995	875	1	875
1995	174	1	174

Year	Area	Proportion in MU	Estimated Area in Big Pic & Pic River Forests
Total	182,135		151,830

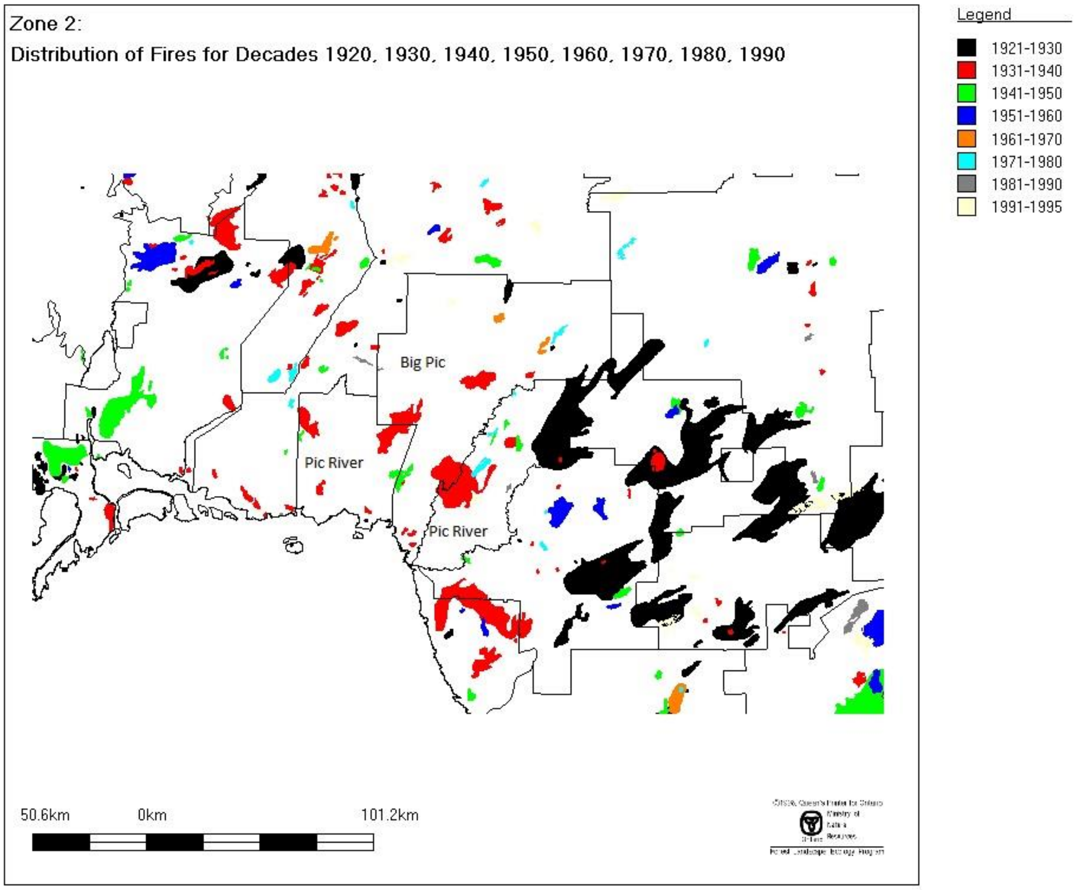


Figure 5. Map showing recorded forest fires from 1921 to 1995 in the Pic River and Big Pic Forests.

Table 3. Forest Fire Record, 1944-1976, Big Pic Management Unit.

Calendar Year	Years	Area (ha)	Cumulative Area (ha)	Mean area burned per yr for each 5-year period
1944	1	0.0	0.0	
1945	2	23.0	23.0	
1946	3	1,291.0	1,314.0	
1947	4	87.5	1,401.5	
1948	5	6,824.0	8,225.5	
1949	6	14.0	8,239.5	
1950	7	3.5	8,243.0	1,177.60
1951	8	3.5	8,246.5	
1952	9	6.0	8,252.5	
1953	10	9.0	8,261.5	
1954	11	6.0	8,267.5	

Calendar Year	Years	Area (ha)	Cumulative Area (ha)	Mean area burned per yr for each 5-year period
1955	12	538.5	8,806.0	733.8
1956	13	27.5	8,833.5	
1957	14	3.3	8,836.8	
1958	15	0.0	8,836.8	
1959	16	12.5	8,849.3	
1960	17	5.6	8,854.9	520.9
1961	18	29.3	8,884.2	
1962	19	0.8	8,885.0	
1963	20	95.3	8,980.3	
1964	21	12.5	8,992.8	
1965	22	2.1	8,994.9	408.9
1966	23	1,007.5	10,002.4	
1967	24	6.7	10,009.1	
1968	25	7.0	10,016.1	
1969	26	11.8	10,027.9	
1970	27	1,096.8	11,124.7	412.0
1971	28	4.9	11,129.6	
1972	29	6,994.0	18,123.6	
1973	30	0.1	18,123.7	
1974	31	0.6	18,124.3	
1975	32	5.0	18,129.3	
1976	33	8.0	18,137.3	549.6

7.3 Overview of Fire History on the Pic River and Big Pic Forests

The current condition of the two Forests is a result of large scale natural disturbances. Within the Boreal forest, the two major sources of natural disturbance arise from forest fires and windthrow, with some stand damage being caused by insects, and these Forests are no exception to this. The natural succession found on the current management unit is common to that of fire, which plays the main role in maintaining the typical even-aged structure in intolerant Boreal species.

The forest sites on the two Management Units have an extensive fire history and evidence of major fire occurrences can be traced back to the 1780's. However, due to the sporadic nature of forest fires and because of the absence of relatively large fires since the mid-1930's, there is a high proportion of stands in the mature and over-mature age classes. Stand history and the silvicultural characteristics of the common tree species have resulted in mainly even-aged, single-storied stands. However, in the many areas of over-mature timber, stands are often developing into two-storied or multi-storied stands (Anon. 1987).

Most of the virgin forests on the Management Units are fire-originated and became established as a result of generally large conflagrations that occurred during periods of drought. These weather conditions were cyclical in nature and resulted in some decades of extensive fires and others with a very low incidence of fire. With the industrial development of the Unit, although a new element of forest fire risk was introduced, this was more than offset by more effective fire prevention and control measures that have greatly reduced the annual area lost to forest fires since the 1930's.

Although control over catastrophic losses is a necessary requisite of effective forest management, it has aggravated the age class distribution problem in that older age classes have not been renewed by forest fire and logging operations have not kept up to the level necessary to develop a normal age class distribution. In addition, the absence of fire has also resulted in an increase in balsam fir, a fire intolerant species, in the Unit's growing stock and this may cause difficulties in the future.

The 1950 Management Plan for the Big Pic Concession (Anon. 1950) described burns that had occurred within the past 25 years (i.e. from 1924 to 1949). These fires had a total area of 50,071 acres (20,263 ha). This was slightly less than the total area cut over within this period and equalled 4.4% of the total productive area. The plan stated that "except where the burns have followed closely a previous one, they are showing satisfactory restocking. Where several burns have followed in fairly rapid succession, there is little or no stocking except along the edges, and instead a dense mat of blueberries and other heath plants has taken over the site. Fortunately, the amount of land subjected to this repeated burning is very small".

Over half of the burned-over area is in the Lower Pic Area. Cirrus Compartment has the largest amount. Marathon, because of its nearness to the railway, has also suffered heavily from fire. Some of these areas have had two or more consecutive fires. As a result, there are areas on which little or no growth has come in, and erosion has been severe. It has been necessary, therefore, to classify these areas as non-productive. Kagiano Compartment has a large area of burn in the southern part, probably as a result of one of the fires which came in from Cirrus Compartment.

Forest losses due to fire were relatively light during the 1982-1987 Plan period with only 336 hectares depleted for that reason. This was primarily from one major fire in the west end of the Unit near Hatley Lake in 1983. Losses from the spruce budworm epidemic which continued to spread over the entire Unit during this time, are not easily quantifiable. While volume losses have occurred, no areas have, as yet, been depleted for this reason. However, significant moves with respect to the salvage of budworm-damaged and susceptible areas of the Unit were initiated during this period primarily in the Caramat area, the Husak Road area and the Olie Lake Road area. The new market for sawlog material was a major factor (Anon. 1987).

The forest landscape pattern within the forest varies depending on the area. Generally, natural disturbance has the largest impacts on the forest pattern at a landscape level. In addition, harvesting in the area has evolved along with forest policy and legislation, changing the look of forest management on the landscape over time. Prior to 1988, harvesting in the forest was done in congregations of larger blocks, mainly to save money on access. The goal of harvest was to take the more mature timber from the forest, and this created large disturbance patches.

In 1988, the Timber Management Guideline for the Provision of Moose Habitat was released by the Ontario Ministry of Natural Resources. This guide legislated the size and rate of occurrence of different cutover sizes in the Pic River and Big Pic Forests management area, directing to cut an increased amount of smaller blocks and a decreased amount of large blocks on the forest, causing fragmentation. This created more edge effect, which is preferred by the Alces species, and subsequently may have had an adverse affect on species that rely on large contiguous patches of mature conifer forest such as the Woodland Caribou. Subsequently, the Forest Management Guide for Natural Disturbance Pattern Emulation was released (OMNR 2002), and this document indicated that disturbance sizes should follow the 80/20 rule, which indicated that 80% of disturbances should be less than 260 hectares and 20% greater than 260 hectares. The NDPE Guide also indicated that forests should move towards a natural disturbance template.

7.4 Richard Fry's 1997 Study of Pre-settlement Forest Conditions

In 1997, a report entitled "A Field Study of the Composition, Structure and Pattern of Original Forests in the Manitouwadge Area" was prepared by Richard Fry (plan author for Management Plans for the Big Pic

Forest from 1977 through to 2002). In the 2007-2017 FMP for the Big Pic Forest (Schwedack 2007), Fry's report was used as a source for establishing historic benchmark levels for several forest attributes that were used in developing the desired future forest and benefits for the Big Pic. The complete text of this report is included in Appendix 1.

The primary objective of Fry's study (Fry 1997) was to establish a snapshot of the species composition at the stand and landscape level, the age class and stand structure of the forests and of the disturbance patterns in the Big Pic Forest prior to the arrival of industrial forestry. To do this, several sources of information were used. Firstly, a literature search was undertaken to obtain relevant scientific publications on the subject-matter. Secondly, old inventory information dating back to the 1940's and 1950's was assembled for analysis. And, finally, old aerial photos taken in the 1940's were assembled for specific study areas on the two forests.

An important information source for the study was forest inventory data that was collected by the former American Can Canada Inc. (ACCI) and its corporate predecessors, Marathon Paper Mills and the Marathon Corporation, over the course of four decades starting in the early 1940's. The inventory system was abandoned in 1986 and replaced by the more universal Forest Resource Inventory (FRI) promoted by the Provincial government.

There were several essential features of the ACCI inventory that proved to be valuable to this study:

- Finer resolution: the inventory was mapped at a scale of 1:7,920 which resulted in a level of detail in stand mapping that recognized finer differences in stand composition and age.
- More precise age estimates: most of the data relevant to stand age came from sets of aerial photography taken in 1943 and 1947. These photos provided very clear delineation and interpretation of most wildfires dating back to the turn of the century that, together with the historical data of the day, permitted a very precise determination of the date of stand origin.
- Successional information: the ACCI inventory provided for the collection and retrieval of a substantial data bank of volumetric information that provides information on changes in species composition and stand structure within stands of similar attributes over time.

To try to determine the characteristics of historic wildfires in the area, a total of five wildfires dating from the period between 1920 and 1936 were selected by Fry (1997). They were chosen to represent several very large fires of greater than 20,000 hectares (the Foch River fire and the Pinegrove fire), one moderately sized fire (Hillsport fire) of about 7,000 hecatares and two of small fires of less than 1,000 hectares (Bullmoose Lake and Twin Falls fires). A large part of the largest fire (the Foch River fire) extended off the study area. The earliest aerial photography available for these areas, usually 1943 or 1947 but sometimes 1962, was used to delineate the boundaries of the fire and any unburned patches within the perimeter of the main body of the fire. The information was transferred from the photographs to maps at the scale of 1:15,840 for the calculation of such things as total area burned/unburned, size of unburned patches, edge/burn ratio, et cetera. To try to get some sort of sense of the scope and pattern of wildfires at the landscape level, an age-class map of the Big Pic Forest at the scale of 1:126,720 (2 miles per inch) was prepared.

7.4.1 Species Composition

A graphical presentation of the changes that occur over time in the relative abundance of tree species is shown in Figure 6. Individual graphs for each cover type in the ACCI inventory portray these changes.

Key observations made by Fry from these graphs and related data include:

- It is important to note that the S cover type is not always considered to be of fire-origin: it is often a late-successional phase of the M cover type that results from the death, due to over-maturity, of the pioneer species. For this reason, care must be taken in interpreting the erratic changes in composition in this cover type.
- The tree species normally considered to be early successional species (spruce, jack pine and trembling aspen) are far-and-away the dominant species in the young forest.
- As stands age, aspen and pine become less prominent while spruce, balsam fir and white birch increase in prominence.
- White spruce is very seldom found in young age classes and, with the exception of the white birch working group, seldom accounts for more than 10 percent of the stand until after the stand reaches 100 years.
- The species composition of stands at the time of harvesting are often not at all the same as their composition in the early stages of their development.
- Observation of prolific levels of tamarack regeneration whenever a seed source is nearby could lead one to believe that this species could be more prominent in early stages of the next forest than in the past. However, given its susceptibility to the larch sawfly (*Pristiphora erichsonii* Hartig), it is doubtful that such levels could be maintained over an entire rotation.
- White cedar could also be expected to increase in the forest in the absence of fire.

The increase in the proportion of white birch as the stand ages is puzzling considering that it is regarded as a short-lived species that is very intolerant of shade (Sims et al., 1990). It may be that this could be attributed to the fact that white birch is a prolific seed producer whose germinants on rotten logs and stumps or on mineral soil exposed by windthrown trees can quickly take advantage of gaps created in the stand as the original stand breaks-up. Whatever the reasons, these findings might explain the substantial increase in the white birch working group from the 1974 FRI to the 1990 FRI on the Black River Forest, as overmature stands dominated by balsam fir and white spruce converted to white birch after the spruce budworm killed most of the conifer.

Table 4 shows changes in the distribution of cover types over a thirty year period, between the 1967 American Can inventory and the 1996 FRI. This shows similar trends in changes to species composition to those described above in regard to Figure 6.

Table 4. Comparison of cover type distributions between the 1996 FRI and the 1967 ACCI inventory.

	American Can Cover Types					
Attribute	Black spruce	Softwood	Mixed Softwood	Jack pine	Mixedwood	Hardwood
Cover Type distribution: 1967	34.0	7.0	9.0	2.0	38.0	10.0
Cover Type distribution: 1996	30.0	14.0	7.0	3.0	31.0	15.0

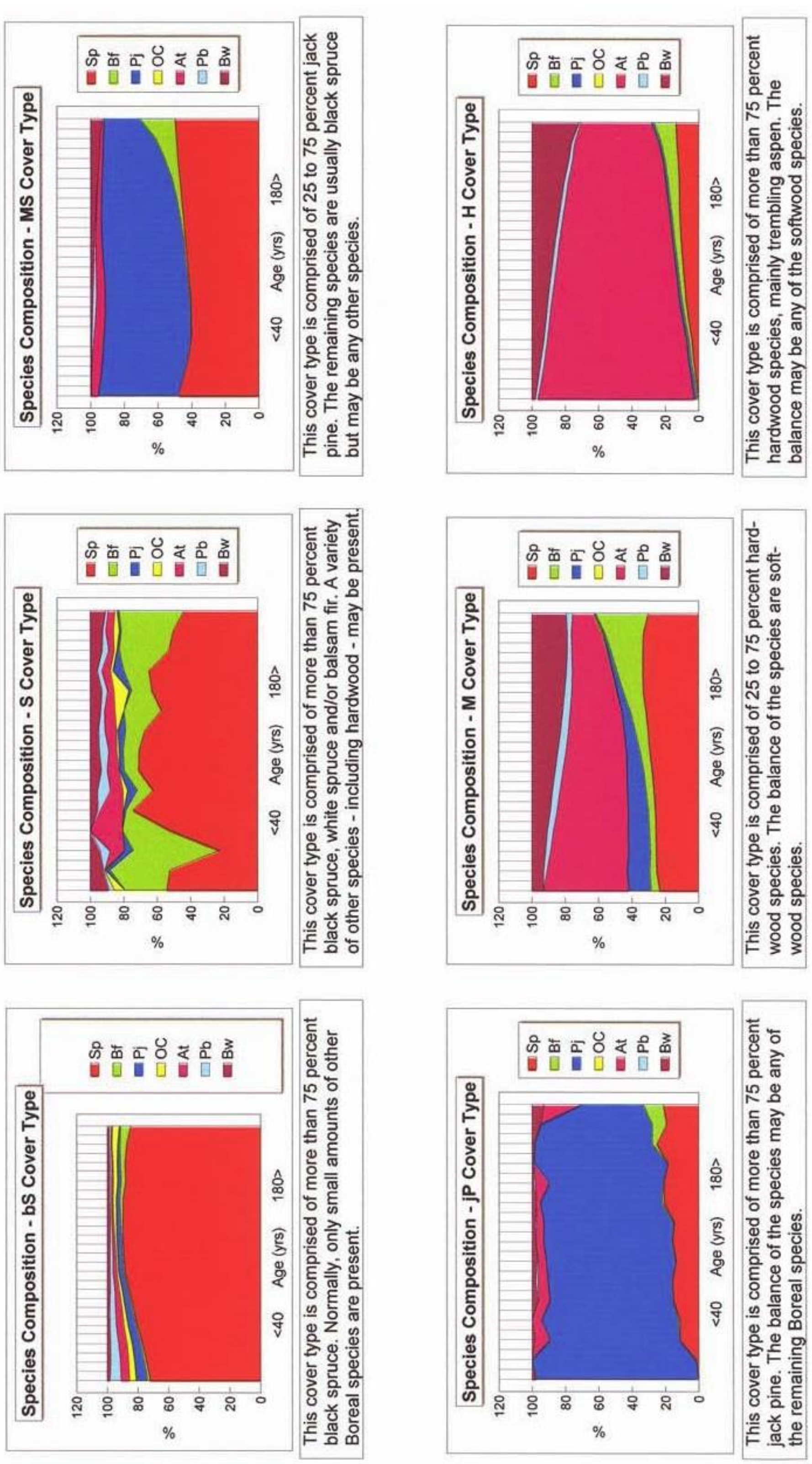


Figure 6. Changes in percent species composition over time for six cover types on the Big Pic Forest.

7.4.2 Age Class Distribution

Figure 7 presents a graphical summary of the age class distribution of the various cover types on the Big Pic Forest. To try to get a picture of the undisturbed forest (one subject to natural fire regimes), the 1976 American Can inventory was used but all stands dating from the decades 1950, 1960 and 1970 were removed. Most of these stands resulted from harvesting activities during that time.

Rather than a negative exponential curve, the picture that emerges from this data relative to the age class distribution of an undisturbed forest in this area is one of a series of peaks and valleys. This fits well with the model described by Suffling (1991) who postulates that wildfire occurrence in northwestern Ontario tends to vary widely over both the short-term and the long-term.

An ecologically-based age class distribution for the Manitouwadge area could, then, be one which is quite variable: age classes - singly or in groups - in which there is much area and others where there is little area. To obtain this type of distribution over the long term in the managed forest, however, means that there would have to be periods extending up to several decades in which there would be little, if any, harvesting activity and others where harvesting activity would be far in excess of annualized sustained yield levels. This is obviously infeasible: to promote the sustainability of local communities, it is desireable that harvesting operations should be conducted annually with minimum fluctuations from year-to-year. Over time, this will result, in theory, in an age class distribution that approximates "normal" forests with more-or-less equal amounts of area in each age class. It would not resemble the peak and valley type of curve that the forests of the area currently exhibit nor would it resemble the negative exponential curve described by Van Wagner.

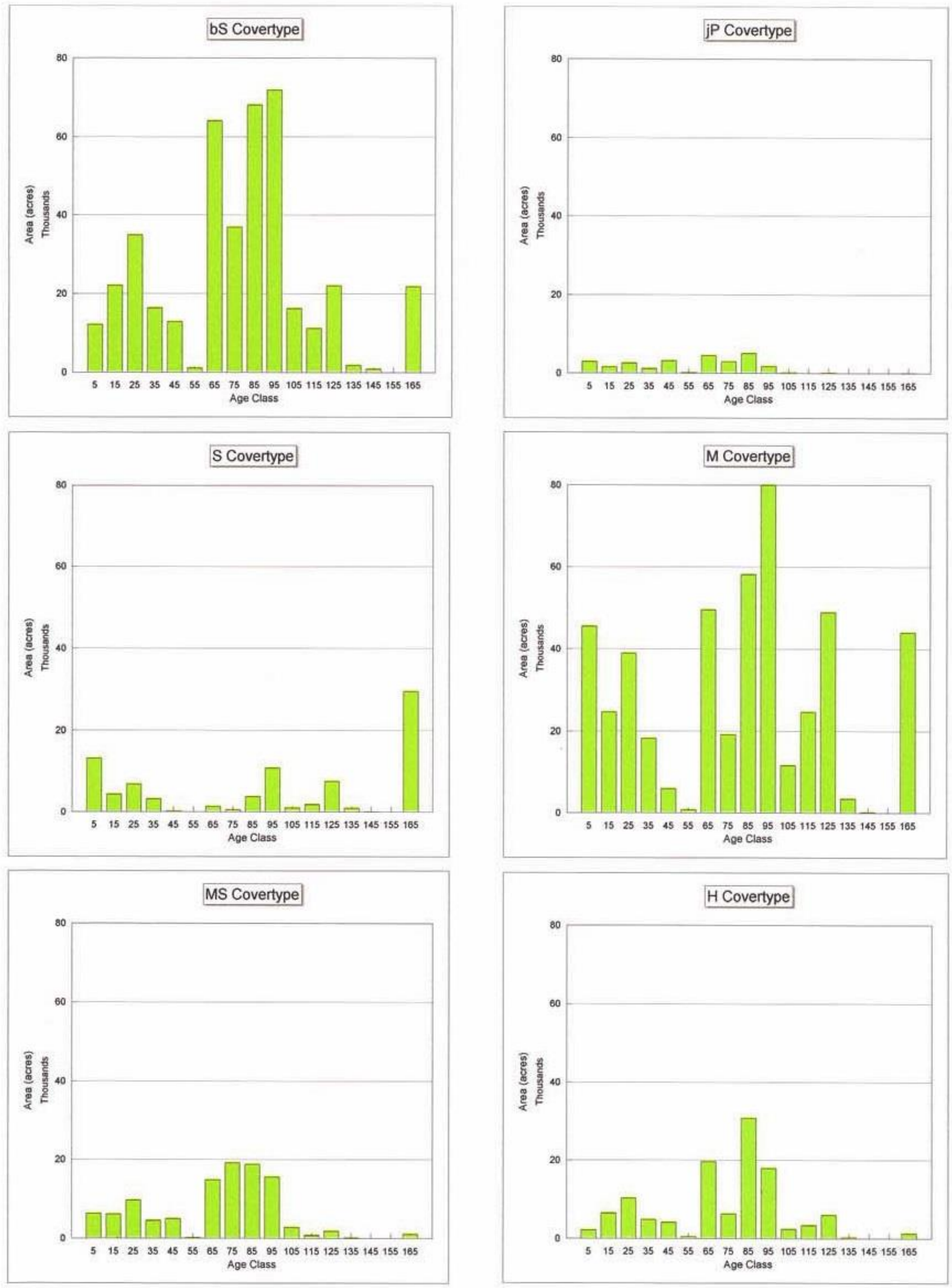


Figure 7. Summary of the age class distribution of the various cover types on the Big Pic Forest.

7.4.3 Old Growth

To try to establish how much old forest one could expect to find in the natural forest, an analysis of the ACCI inventory for the Big Pic Forest was undertaken. In this analysis, overmature forest was considered to be stands that are up to twenty years past their rotation age (at which point net growth rates approach zero), and decadent forest was up to forty years past rotation (at which point they are generally unmerchantable due to low yields and high defect rates). Table 5 presents the results of this analysis.

Table 5. Percent of area by cover type in overmature and decadent age classes on the Big Pic Forest in 1950.

	American Can Cover Types					
Attribute	Black spruce	Softwood	Mixed Softwood	Jack pine	Mixedwood	Hardwood
Overmature %	6.5	n/a	3.8	8.3	13.1	20.2
Decadent %	6.2	n/a	3.4	1.5	8.5	10.9
Total	12.7	n/a	7.2	9.8	21.6	31.1

As discussed earlier, the values for the S cover type have little real meaning because most of this cover type, irrespective of its age, is the result of successional dynamics. For the remaining cover types, it would appear as if fewer conifer stands make it into overmature conditions while mixedwood and hardwood stands are more likely to do so. The same relationship holds true for those stands entering the decadent category.

While a significant amount of area in the natural forest does make it to the overmature category, the area is greatly reduced (probably due to fire) between overmaturity and stand decadence. In a practical sense, it is improbable that many stands that reach the latest stages of decadent age classes will be harvested for timber production purposes. It is even more unlikely that they will be destroyed by wildfire in managed forests as would have eventually happened in the natural forest. Old forest in the managed forest, then, is fundamentally different from old forest in the natural forest. In the latter, fire eventually returns old stands to the earliest stage of forest succession while, in the former, it is mainly successional forces that control stand composition and structure.

7.4.4 Spatial Distribution of Patch Sizes

As important as the statistical distribution of stands of various age classes may be, the spatial distribution is at least equally important. To gain some insight into this, the age class map of the Big Pic Forest was used to display age class patterns for fire origin stands. Because of the small scale of the map, the delineation of age classes was limited to the minimum patch size area that could be measured on a map of that scale (generally 20 to 25 hectares). Patch sizes were determined by electronic planimeter and recorded by age class. The results of this exercise are illustrated in Table 6. This table also summarizes results of measuring actual harvest patterns for two periods, from 1937-59 and from 1960-81, as well as data for the 1982-2002 period, which includes information for both actual harvests to 1996 and probable harvest allocations to 2002.

Table 6. Comparison of patch size distribution for forest areas of fire origin versus areas originating from harvest.

Attribute	Patch Size Class (ha)								
	0-60	**61-130**	**131-260**	**261-500**	**501-1000**	**1001-2500**	**2501-5000**	**5001-10000**	**10000+**
Fire origin forest patches									
No. of patches	44	55	59	46	23	27	19	12	11
Total area (ha)	1,516	4,905	11,363	18,048	16,553	43,932	72,253	83,148	149,220
% of total area	0.4	1.2	2.8	4.5	4.1	11.0	18.0	20.8	37.2
Harvest origin forest patches									
Total area (ha)	1,083	2,388	5,665	13,314	26,671	62,749	46,170	40,983	99,786
% of total area	0.4	0.8	1.9	4.5	8.9	21.0	15.5	13.7	33.4

How does the pattern of patch size classes created by fire compare with what harvesting operations over the past four decades have created? At the outset it is necessary to say that it is very difficult to make a direct comparison because of certain inherent differences between wildfire and harvesting. A visual analysis of this table indicates that harvest allocation practices over the sixty year period have generally created the same kind of patch size patterns as suggested by the fire origin areas. However, there has been a decline in the proportion of area in the largest of patch sizes (which would be consistent with the focus of the Moose Habitat Guidelines in the 1980s and 1990s).

7.5 Fire Disturbance Patch Level Analyses

In developing the NDPE guide, OMNR analysed forty-two fires (1920 to 1960) using historical 1:15,840 scale aerial photography. The result of this analysis (OMNR 1997) provided insight into the amount, size and location of residual patches following fire.

Residual patches were found to be either insular (distinct "islands" within the burn perimeter) or peninsular (live "fingers" extending into the burn boundary but connected to the unburned perimeter). OMNR's analysis indicated that percent residual area varied between 10% and 50% and averaged 24% overall. Reflecting differences in the relative flammability of various forest cover types OMNR has recommended levels of retention to simulate natural conditions. OMNR's suggested levels have been included in this report as Table 7.

Table 7. Suggested residual retention to be left by forest type to simulate fire structural components at the multi-stand level (based on NDPE Guide, Table 3).

Forest Type	Internal Patches % area	Peninsular Patches % area
Conifer Upland (Sp, Pj, Bf)	2 %	8 %
Conifer Lowland (Sp, Ce, La)	4 %	16 %
Upland Mixed (Sp, Pj, Bf, Po, Bw)	6 %	24 %
Intolerant Hardwood (Po, Bw)	8 %	27 %

OMNR also analysed the size distribution of the residual patch areas. Their results indicated the following distribution of residual patches:

- 20 % less than 5 hectares,
- 35 % between 5.1 and 50 hectares, and
- 45 % in patches greater than 50 hectares.

The Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales (OMNR 2010) includes a somewhat different approach to residual retention based on updated research.

Perera et al. (2007) conducted an extensive literature review of post-fire residuals and residual structure. They concluded that overall, the state of published knowledge is relatively rich in estimates of abundance and extent of post-fire residuals. However, because the standards in defining and quantifying residuals are inconsistent and sometimes ambiguous it is difficult to synthesize and generalize this information. Furthermore, most reports lack complete information on methods and results that are critical to determine general patterns and trends in residuals. Therefore, the knowledge about causal mechanisms, spatial associations, and temporal changes of all residual categories is uncertain. While this is the largest gap in published knowledge of post-fire residuals, it is also the area of scientific knowledge most required for translating broad forest policies for emulating natural disturbances into specific forest management directions and practices, as in the Forest Management Guide for Emulating Natural Disturbance Patterns.

The results of their review are summarized below.

7.5.1 What are residuals? Are they described and defined consistently?

Post-fire residuals are commonly described by four standard categories: patches, individual live trees, snags, and downed wood. Patch is always used to denote island (insular) residual clusters, and separation of insular and peninsular patches in the literature is very rare. As well, the minimum number of trees, their proximity and spread, and the degree of greenness required before they are grouped as a patch are rarely defined. Live tree residuals are described broadly as live trees and snags as dead trees. Descriptions of downed wood vary widely depending on the specific study objectives – from wildlife habitat to carbon sequestration values. Overall, no universal definition of residuals exists in the literature and the concept that residuals are a continuum from patches to trees is rarely acknowledged.

For the most part, the functional formation of residuals, i.e., how they came to exist, is not considered in definitions or descriptions of residuals in the published literature. Nor are the definitions necessarily related to the potential function of residuals. As a result, the terms used to describe residuals vary widely and often these terms are not defined. When they are, the definitions are not consistent and rarely are the definitions used in one publication compared with those used in others. Definitions provided are a combination of qualitative and, less frequently, quantitative descriptions. As well, these quantitative descriptions are a mixture of metrics that often are not comparable. Metric categories, such as patch sizes, tree diameter, and downed wood size, also vary widely, often arbitrarily, with little rationale provided for truncations of categories and minimum sizes used to measure abundance.

7.5.2 How much is left behind? Abundance and variability of residuals.

The most prevalent information about residuals in the published literature is abundance estimates. The extent and sizes of post-fire residual patches, live tree density, snag density, and the amount of downed wood vary widely among reports. Insular residual patch extent varies from none to over 20% of fire area and mean patch sizes range from 2 ha to over 40 ha. Live tree abundance reports range from no trees per ha to over 600 trees per hectare and the snag abundance reports vary from 50 stems per hectare to nearly 2,500 stems per hectare. Downed wood volumes reported in burned areas vary from 60 m3 per hectare to 300 m3 per hectare, and downed wood as a percentage of ground cover varies from 0.2% to 43%. However, as mentioned above, it is difficult to compare or generalize these estimates because of unclear or inconsistent definitions of residuals, differences in the metrics used to report abundance estimates, and the variety of size categories used to quantify them. Comparisons are made even more difficult by inadequacies in documenting important information such as behaviour of the fires that caused residuals; the pre-burn cover composition, age, and other characteristics; and site conditions such as soil, terrain, and moisture regime. Abundance estimates are commonly grouped by forest cover types for patches and by species for trees. Generally, snag and downed wood abundance estimates are not differentiated by species. Another logical grouping absent from the literature is the temporal origin of snags and downed wood, i.e., snags and downed wood that pre-date fire are usually included in post-fire residual abundance estimates. In most cases, observations of residuals are based on one or few fires, and as a result within- and among fire variability in residual abundance are not commonly reported. Even when it is reported, variability is rarely attributed to sources such as forest type, geography, age, or time since disturbance with any rigour.

7.5.3 What are the spatial biases and patterns in occurrence and abundance of residuals?

Reports of attempts to associate post-fire residual structure with other factors to explain their occurrence and spatial variability are infrequent in the literature. Even when associations are reported and discussed, these are often based on ad hoc observations rather than results of data analyses. Here we mention only those associations that recur in reports and only when some generalities could be extracted from these observations. For residual patches, some of the reported spatial biases and patterns include the relationship between residual patch occurrence and forest cover type. This relationship was ascribed to relative flammability and probability of crown fires in cover types as linked to site. For example, most reports associate residual patch occurrence with wet areas, lowlands, and proximity to water bodies. As well, residual patch size is considered to be correlated with fire size, because in larger fires the probability for fuel breaks is higher, creating patches in fire skips. However, some consider larger fires to have proportionately less residual area because fire intensity is higher and thus fewer areas will be skipped. Overall, it appears that live tree residual occurrence is associated with certain combinations of cover type and fire behaviour. Live tree residuals are more likely, for example, in conifer than deciduous cover types, in wetter areas, and for larger diameter stems. They are also more likely to occur near the fire perimeter, in night spread areas, and at the fire flanks where fire intensity is lower. Snag occurrence is reported to be associated with pre-fire stand density and cover type, and possibly stand age; the latter may be a function of stem size and density. No associations are reported in the literature for downed wood occurrence.

7.5.4 What happens to residuals? Temporal changes during the first decade and after.

The published literature includes no reports of direct measurement of temporal changes to patches. However, based on studies assessing numbers and sizes of patches many years post-fire and those using a chronosequence approach, it appears that patches can persist for decades. If and how their characteristics, such as shape, size, and density, change over time remains unknown and undocumented. Individual live trees can become snags or fall and become downed wood. In the literature, timing of the latter is not well quantified, but it appears that time to mortality for trees surviving fire may be species dependent. Since no reports directly measured fire intensity and forest cover linked to site conditions, post-fire tree mortality may not be solely species related. Information about how long it takes before snags become downed wood is based mostly on observations and chronosequence studies. Few snags appear to fall within 3 to 5 years after fire, with most falling between 5 and 15 years. However, there are reports of snags remaining standing even after 40 years. These fall rates may be species dependent but, as for live trees, this is uncertain.

Perera et al. (2009) assessed the extent and variability of post-fire residual patches as relevant to directions in Ontario's Forest Management Guide for Natural Disturbance Pattern Emulation (NDPE guide). They mapped 17 unsuppressed natural fires from northern boreal Ontario using IKONOS high resolution imagery. Satellite images were classified to identify burned as well as unburned land cover categories, and fire perimeters were derived using a fuzzy logic mapping technique. Residual areas in study fires were delineated using definitions for insular patches and peninsular patches as outlined in the NDPE guide.

They concluded that the extent of both residual types varied widely among the fires, and large fires contained more patches and higher patch extent. Most insular patches were very small, more common in fire interior, and appeared to be proximal to natural firebreaks. Insular patches were composed mainly of coniferous forest, shrubs, and wetland. Peninsular patch extent also varied widely among fires, with larger fires containing more patches, but not necessarily higher patch extent. No distinct spatial patterns of peninsular patches were associated with either fire geometry or natural fire barriers. These patches also were composed of coniferous forest, shrubs, and wetland. The NDPE guide direction's range for insular patch extent was well within the variability observed in our study fires, but overestimated the expected values in natural fires. The directions for spatial distribution of insular patches also matched the patterns observed within study fires. The NDPE guide direction's range for peninsular patch extent was well below the variability observed in the study fires, and greatly underestimated the expected values in natural fires. As well, the size threshold for insular patches that is imposed by the NDPE guide ignores a vast number of small patches, and thereby much of the extent of insular patch area that occurs in natural fires.

7.5.5 Insular residual patches

All but the smallest study fire had insular residual patches. The number of patches per fire ranged from 1 to 259, with a per-fire mean of 59 ± 17. The percentage insular residual area ranged from 0.25% to 11.7%, with a mean of 3.6% ± 0.7%. The 25th percentile was 0.8%, median 2.6%, and the 75th percentile 7.0%. Most insular patches were small, with a median size <0.5 ha across all study fires, and over 80% of patches were smaller than 1 ha. The largest of all 1007 insular residual patches was 97 ha. Larger fires had higher number of insular patches as well as a higher percentage of insular residual area. Occurrence of insular patches appeared to be spatially independent of one another. However, two trends were observed with respect to within-fire patterns of insular residuals. First, they appeared to be disproportionately common in the interior of most fires, especially the larger ones. Second, they appeared to occur in the proximity of unburnable cover types within fires, especially near the non-vegetated area dominated by exposed bedrock. The deciduous component was very low in all insular patches. The mean insular residual composition was 44% ± 5.4% conifer, 30.5% ± 4% shrub, 23.1% ± 4.4% wetland, and 1.1% ± 0.5% deciduous. Because we could not estimate the pre-burn land cover composition, relative dominance in residual cover does not necessarily imply post-fire survival patterns or biases.

7.5.6 Peninsular residual patches

We treated the two types of peninsulars separately due to their obvious dissimilarity in origin. All fires had both types of residuals patches, including the smallest. The number of patches per fire ranged from 4 to 105 for Type 1 and from 2 to 263 for Type 2. The per-fire mean number of peninsular residual patches was 39 ± 8 for Type 1 and 90 ± 18 for Type 2. The area of Type 1 peninsular residual area, as a percentage of the fire footprint area, ranged from 5.8% to 87%, with a per-fire mean of 37.9% ± 6.1%.

The 25th percentile was 16.6%, median 34.0%, and the 75th percentile 54.4%. The extent of Type 2 peninsular area was much lower, ranging from 1.5% to 20.3% with a per-fire mean of 11.1% ± 1.3%. The 25th percentile was 6.9%, median 10.8%, and the 75th percentile 15.0%. Combined, both peninsular types occupied from a low of 20.5% to a high of 107.2% of the fire area, with a per fire mean of 49.4%±6.6. The 25th percentile was 27.2%, median 41.2%, and the 75th percentile 68.4%. Larger fires had higher number of peninsular residual patches of both types, but fire size was not correlated with peninsular residual patch extent. Type 1 peninsular patches were larger than the Type 2 patches overall. The median patch size of Type 1 peninsulars was <1.5 ha, with over 80% smaller than 10 ha and the largest of all 668 patches was 629 ha. Type 2 peninsular patch median size was <0.6 ha and 80% of patches were smaller than 1.6 ha. The largest of the 1542 Type 2 patches was 220 ha. Occurrence of Type 2 patches within fires extended well inwards, even though their proximal ends were, by definition, within 20 m of fire perimeters. Unlike with insular patches, other patterns were not evident for Type 2 peninsular residual patches, including any association with unburnable cover types. As with insular residuals, composition of both types of peninsular residual patches was dominated by conifer forest cover followed by shrub and wetland cover types. The deciduous component was low in all patches. The mean composition of Type 1 peninsular residual patches was 44% ± 2.9% conifer, 22% ± 2.5% shrub, 26.1% ± 3.1% wetland, and 3.4% ± 1.6% deciduous. The mean composition of Type 2 peninsular residual patches was 41% ± 4.6% conifer, 30% ± 3.7% shrub, 24% ± 3.8% wetland, and 2% ± 0.6% deciduous.

In comparing the study results to Ontario's policy guide directions, we found that the range given for insular residual patch extent is within, but marginally overestimates, the values observed for study fires. In contrast, the guide's direction for range of peninsular residual patch extent is much lower than was observed for study fires. Insular residual patches are well distributed within natural fires, even towards the fire interior, as the policy guide directs. We found that the 0.25 ha size limit for both categories of residual patches underestimates total residual area considerably, especially in fires with low residual extent.

7.6 Background Information on Fire Cycles and Their Calculation

Fire is the most thoroughly documented disturbance in boreal regions. Most attention has been devoted to identifying temporal patterns in fire regimes, comparison of natural temporal regimes with those functioning as a result of fire suppression, the effects of fire on succession, and more recently the landscape-level patterns of fires.

There is a considerable body of literature on boreal fire return times, or fire cycles, (defined by Van Wagner (1978) as "the number of years required to burn over an area equal to the whole area of the forest". Fire cycles from as little as 20 years (Lynham and Stocks 1991) to as long as 500 years (Foster 1983) have been identified for boreal forests. The fire return times for most boreal forests of types similar to those found in northeastern Ontario and northwestern Quebec are in the range of 100-150 years, with some exceptions, which indicate longer cycles. Table 8 describes the natural (i.e. in the absence of suppression) fire return times for a range of boreal and Great Lakes- St. Lawrence transition areas in North America.

Table 8. Fire return times for boreal and Great Lakes-St. Lawrence/Boreal transition areas in North America. All return times are based on natural cycles (i.e. either estimates of pre-fire-suppression cycles, or from areas in which fires are not suppressed).

Location	Forest type and/or dominant trees	Fire Rotation Period (yrs)	Reference
Itasca State Park,	Great Lakes - St. Lawrence /		

Location	Forest type and/or dominant trees	Fire Rotation Period (yrs)	Reference
Minnesota	Boreal Transition - Pinus banksiana, P. resinosa, P. strobes	22	Frissell (1973)
Boundary Waters Canoe Area, Minnesota	Great Lakes - St. Lawrence / Boreal Transition - Pinus banksiana, Picea mariana, Abies balsamea, Betula papyrifera	100	Heinselman (1973)
Boundary Waters Canoe Area, Minnesota	Great Lakes - St. Lawrence / Boreal Transition	60-70	Swain (1973)
Barron Township - Algonquin Park	Great Lakes - St. Lawrence / Boreal Transition	80	Cwynar (1977)
Southeastern Labrador	Boreal - open Picea mariana	500+	Foster (1983)
Newfoundland	Boreal - Picea mariana, Abies balsamea	150	Heinselman (1981)
Quebec	Boreal - Picea mariana, Pinus banksiana	100	Heinselman (1981)
Quebec	Boreal - open Picea mariana	150	Heinselman (1981)
North-central Quebec	Boreal - P. mariana	100	Payette et al. (1989)
Laurentian Highlands, Quebec	Boreal - P. mariana / feathermoss	130	Cobgill (1985)
Hudson Bay Lowlands	Boreal - P. mariana	150	Heinselman (1981)
Northeastern Ontario- Extensive Fire Zone[1]	Boreal – tundra	323	Martell (1994)
Northcentral Ontario - Extensive Fire Zone[1]	Boreal	274	Martell (1994)
Northwestern Ontario - Extensive Fire Zone[1]	Boreal	87	Martell (1994)
Northwestern Ontario	Boreal - Picea mariana, Pinus banksiana	60	Heinselman (1981)
Northwestern Ontario	Boreal - P. mariana	100	Heinselman (1981)
Northwestern Ontario	Boreal - P. banksiana	20	Lynham and Stocks (1991)
Athabasca Plain, Saskatchewan	Boreal - P. banksiana	28-54	Carroll and Bliss (1982)
Prince Albert National	Boreal, mixedwood	45	Thorpe (1996)

Location	Forest type and/or dominant trees	Fire Rotation Period (yrs)	Reference
Park, Saskatchewan			
Prairie Provinces	Aspen parkland	10	Heinselman (1981)
Mackenzie Valley, N.W.T.	Boreal - open P. mariana, near treeline	120	Johnson and Rowe 1977
Mackenzie Valley, N.W.T	Boreal - Floodplain Picea glauca	200+	Rowe et al. (1974)
Mackenzie Valley, N.W.T	Boreal - P. mariana	80-90	Rowe et al. (1974)
Boreal NW Ontario	Boreal NW Ontario	300-406	Bridge, S., et al 2005. For. Sci. 51(1): 41-50.
Boreal NE Ontario	Boreal NE Ontario	527-1735	Bridge, S., et al 2005. For. Sci. 51(1): 41-50.
Boreal NE Ontario, Lake Abitibi Model Forest	Boreal NE Ontario	172	Gauthier (2002)
Boreal NE Ontario, Clay Belt	Boreal NE Ontario	132-521	Bergeron et al. 2001

1 - This is the zone north of commercial forest operations in which fires are only suppressed if they threaten human life or habitation.

There seems to be a general trend in fire return times, decreasing from east to west in the boreal forest, coinciding with continental moisture regimes (Heinselman 1981). In northeastern Ontario, fire cycle estimates range from approximately 100 years to over 500 years. Bergeron et al. (2001) concluded that fire cycles in northeastern Ontario and adjacent parts of Quebec have become significantly longer since the pre-industrial period.

Pastor and Mladenoff (1992) reviewed fire cycles in the Great Lakes-St. Lawrence/Boreal transition forest. They noted that fire cycles in the mixed hardwood-conifer forests of northern Minnesota and abutting regions of Ontario vary greatly. Jack pine-spruce forests and birch-fir forests in this region have fire regimes similar to those in boreal forests of similar longitudes; Pastor and Mladenoff (1992) noted that fire cycles were about 50 and 80 years respectively for these types of upland forests. Forests dominated by white or red pine with an open understory have a more complex fire regime, with light surface fires every 20-40 years that keep the understory open, and more severe fires every 150-180 years (Frissell 1973, Heinselman 1981), although these fires tend to be smaller in areal extent than the more frequent fires in jack pine-spruce and mixedwood types. Northern hardwood-hemlock forests have the longest fire cycle, which is greater than 300 years on average, with the average fire size being an order of magnitude less than that in the pine forests (Heinselman 1981, Pastor and Mladenoff 1992).

Either of two parametric models, the negative exponential and Weibull (of which the negative exponential is one form) are usually used to characterize fire frequency cycles in the boreal forest (Johnson and Van Wagner 1985, Johnson 1992). The negative exponential form is such that all stands in the forest have an equal probability of burning, whereas the Weibull can be constructed, depending on the value of one of the parameters, to dictate that stands have either a greater or lesser chance of burning as they age.

In recent years, more attention has been focused on the negative exponential form as there seems to be extensive acceptance of the supposition that age is not a primary determinant of flammability. Boreal forests older than 10 to 15 years are thought to be equally flammable (Rowe and Scotter 1973, Heinselman 1981, Murphy 1995). There is not, however, universal acceptance of the greater applicability of the negative exponential form. Suffling (1992) suggested than many forests in boreal Canada do not fit the negative exponential distribution.

Under the negative exponential form, the fire return time is the average age of the forest and about 37% of the area of the forest will be in age classes older than the average. Using the negative exponential, one can easily calculate the age-class distribution of the forest under different fire regimes. Such a calculation is useful in identifying target age-class distributions in circumstances where the emulation of natural disturbance patterns in forest management is being attempted (e.g. Weyerhaeuser Canada Ltd. 1998).

Note, however, that the practicality of using the negative exponential as an ideal has limitations in its applicability to very old age classes. For example, under a 100 year fire cycle, the negative exponential predicts that just over 5% of the forest area will exist as forest over 300 years of age. It seems difficult to reconcile this with the apparent lack of area in this age class described in the literature.

It is also prudent to recognize, as Bergeron et al. (1998) point out that there is no single correct fire return time for any region:

> "...the large fluctuations observed in fire frequency during the Holocene limit the use of a single fire cycle to characterize natural fire regimes.... The short fire cycles generally described for boreal ecosystems do not appear to be universal; rather, shifts between short and long fire cycles have been observed."

Bergeron and Archambault (1993) report evidence that the fire cycle in the Lake Duparquet area has increased since the mid 1800s and attribute this to a reduction in the frequency of drought events since the end of the Little Ice Age.

Fire distributions have frequently been modelled based on the Weibull and negative exponential equations, which are shown below.

Cumulative fire interval distribution

$F(t) = 1\text{-}\exp[-(t/b)c]$ Weibull

$F(t) = 1\text{-}\exp[-(t/b)]$ negative exponential

where: t is time;

b is the fire recurrence in years, or the fire interval which will be exceeded 36.8% of the time;

c controls the shape of the distribution and

F(t) is the frequency of having fires with intervals less than age t

and

Cumulative (time-since-fire) distribution

$A(t)=1\text{-}F(t) = \exp[-(t/b)c]$ Weibull

$A(t) = \exp(-t/b)$ negative exponential

where: A(t) is the chance of surviving up to t without a fire

With a value of c=1, the Weibull and negative exponential are the same, meaning that all stands have the same probability of burning. A shape parameter of c>1 indicates that stands have a greater probability of burning as they age, a parameter of c<1 indicates that stands have a smaller probability of burning as they age. Recognizing these caveats does not imply that it is inappropriate to use natural forest fire cycles as a guide for identifying a target age class distribution for boreal forests, only that one should include a reasonable amount of variation around the target age-class distribution to accommodate the factors discussed in the previous paragraphs.

Within a landscape governed by a given fire return time, fire dynamics is influenced at a finer scale by several factors of ecological importance. As Zackrisson (1977), Foster (1983), and Hunter (1993) point out, local topography is important in interrupting the spread of fire and also in creating natural refugia from a prevailing fire regime. It is in these refugia that old forests tend to occur. Rowe and Scotter (1973) note the existence of very old white spruce stands in the midst of landscapes governed by relatively short fire cycles. They attribute the existence of these stands to local topography and moisture regimes.

Fire return times can not only be helpful in identifying a candidate age-class distribution for an area, but also in identifying a candidate working group distribution. As Bergeron and Harvey (1998) noted, different forest types are dominant in an area depending upon the fire regime. As described earlier, in the Lake Duparquet region, they noted that hardwoods dominate the landscape for fire cycles of up to 100 years and that the proportion of softwood-dominated stands increases as the fire cycle lengthens. Bergeron et al. (1998) report that Leduc et al. (1995) have predicted the landscape forest composition according to change in the fire cycle. During short cycles (50-100 years) the landscape is dominated by early successional tree species, such as aspen, birch, or jack pine; during very long cycles (> 300 yrs), balsam fir, black spruce, and white cedar dominate. (However, Bergeron and Dansereau (1993) reported that for fire cycles of longer than 200 years, spruce budworm outbreaks become a major disturbance factor in the forest and mixed-deciduous stands would likely increase in prominence).

Ter-Mikaelian et al. (2009) simulated the long-term forest fire regime for the Moose River Forest Management Unit in northeastern Ontario. The simulated area has not been managed for timber production and fire suppression activity has been minimal. The available data included fire records for 1970–2006 and forest age structure from forest resource inventory completed in 1978. The fire regime was simulated using a simple percolation model driven by three parameters: probabilities of fire spread during low and high fire activity years and of a given year being a low fire activity year. The model successfully generated a long-term fire regime producing age structure and 37-year-long fire records similar to those observed for the Moose River FMU. The simulation results suggest that (a) fire return interval in northeastern Ontario is likely much shorter than indicated by estimates based exclusively on data from the last four decades of fire activity, and (b) it is possible that the fire regime in northeastern Ontario has not changed since mid-1800s but rather is characterized by relatively long periods of low incidence of fire interspersed with pulses of high fire activity.

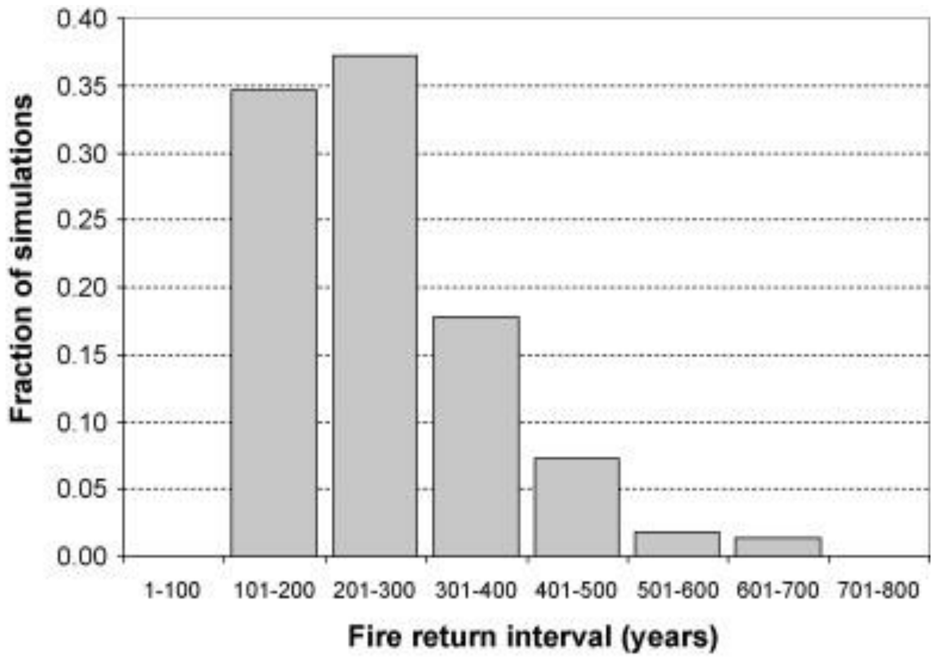


Figure 8. Distribution of simulated fire return interval for the Moose River Forest Management Unit based on individual simulation runs.

In a study of the fire history of the Lake Abitibi Model Forest Gauthier (2002) found that nineteen percent of the land base of the forest originated from fires that occurred between 1910 and 1930. Since then, there has been a general decrease in the area burned. It is worth noting that almost 78% of the forest has not burned for more than 100 years, 31% for more than 200 years and 13% for more than 250 years. The average age of the forest stands is 172 years. This average age is equivalent to the general fire cycle of the study area for the entire period under study, which is longer than what would generally be expected for the boreal forest.

Gauthier (2002) also reported that the jack pine, white birch, and poplar working groups (WG) were most dominant in the stands that have burned within the last 100 years. The black spruce WG occupies an increasingly larger area in older stands that have not burned at least since 1860. There is also a trend towards increasing occurrence of the balsam fir WG with the time since fire, and it is very rare in stands that have burned within the last 100 years. Finally, the white cedar WG is more abundant in the older stands. These results confirm that the dominance of various species changes over time. Exploratory analysis of tree species trends as a function of fire and surface geology revealed that till and sand are more favourable to jack pine than clay or organic deposits, with 44% of jack pine stands located on sand. Only 2% of stands with jack pine are older than 200 years. Balsam fir was found to have a preference for sandy deposits, and analysis confirmed that this species is rare in stands that have burned recently.

Bergeron et al. (2001) assessed fire cycles for the Lake Abitibi Model Forest and adjacent ecoregions in Quebec. Fire cycle estimates are summarized in Table 9.

Table 9. Characteristics and estimated fire cycles for the eastern Clay Belt and adjacent ecoregions.

Region*	Area (km^2)	Mean age (years)	% over 100 years†	Fire cycles (years)‡ 1920–1999	1850–1920	<1850
Lake Abitibi model forest *a*	8 245	172	78	521 (370–733)	234 (171–321)	132 (98–178)
Abitibi west *b*	15 793	139	57	325 (248–424)	146 (114–187)	83 (65–105)
Abitibi east *c*	3 294	111	54	191 (124–294)	86 (56–131)	—§
Central Quebec *b,c*	3 844	127	56	273 (183–408)	123 (83–181)	69 (47–102)

*Regions marked with different letters are significantly different at $p < 0.05$ for the fire cycles of the three periods.
†Percentage of the stands that are older than 100 years in Fig. 1.
‡The three periods are significantly different at $p < 0.001$ for all regions.
§There was not enough data to allow for fire cycle computation for this period.

The results of Bergeron et al. (2001) show that there is considerable spatial and temporal variations in the fire cycles along a large transect in the boreal forest of northeastern Canada. Their results suggest that, in the four studied regions, there is an increase in the fire cycle length since the end of the Little Ice Age. Moreover, these estimated fire cycles are longer than those generally reported for the boreal forest (Heinselman 1981; Johnson 1992). These observations imply that, with long fire intervals, species replacement is likely to occur in large areas of the eastern boreal forest. This would result in an abundance of mature to overmature forests.

Their results and those of other researchers indicate that fire frequency can be highly variable in time and space (Armstrong 1999). Therefore, a target toward a single fire cycle may not be appropriate in forest management. Bergeron et al. (2001) suggested that the current average time since fire (forest stand age), derived from a 300-year fire history, can be used as a baseline in strategic planning of harvesting activities to estimate the desired proportion of even-aged, irregular, and uneven-aged stand types that can be recreated using different silvicultural treatments (Bergeron et al. 1999b). In fact, this value has the advantage of encapsulating the variations in the fire cycles observed here, and also provides an indication of the amount of forest that exceeds the usual rotation age, allowing for an assessment of the risk of losing this component of the landscape diversity.

Their results also indicate a west–east gradient in fire cycle length. These spatial variations suggest that the boreal forest is a complex and variable system, where management strategies have to be developed on a regional basis.

Bouchard et al. (2008) evaluated geographic variations in mean fire return intervals and postfire forest succession within a 66,497 km^2 land area located in the eastern Quebec boreal forest. Fire return intervals were calculated using a time since last fire map for 1800–2000, and forest dynamics were studied by superimposing 3,204 forest inventory plots onto the fire map. Mean fire return interval proved significantly shorter in the western part of the study area, at 270 years, compared with the eastern part, where it was probably more than 500 years. The two main tree species in the study area were balsam fir (*Abies balsamea* (L.) P. Mill.) and black spruce (*Picea mariana* (Mill.) BSP). Balsam fir abundance increased progressively as a function of time since fire, whereas black spruce abundance increased during the first 90 years after fire and then declined. Balsam fir was significantly more abundant in the southeastern portion of the study area, which we attribute to the combined limitations imposed by temperature along the north–south axis and by fire along the east–west axis. Large forest patches (i.e., 200 km^2) dominated by early successional tree species, within a matrix of irregular black spruce – balsam fir mixtures, are an important feature of preindustrial forest landscapes in this region.

Ward and Tithecott (1993) examined Ontario's historical fire data and the age-class structure of much of the intensive protection zone in the fire region in Ontario and concluded that "human activity, both the actions of people in causing forest fires and their actions in managing and suppressing fires, has significantly altered the structure of Ontario's forests." Miyanishi and Johnson (2001) questioned the quality of their data, the way it was analyzed, and their conclusions. They suggested that the perceived change in fire regimes in the boreal forest region of Ontario is not "necessarily attributable to fire suppression" since "changes in fire frequency in the boreal forest have been also attributed to climate change and anthropogenic forest fragmentation." Ward et al. (2001) responded with an expanded version of their analysis that better substantiated their earlier findings. Bridge et al. (2005) then responded with what they describe as a "critical evaluation of fire suppression effects in the boreal forest on Ontario" in which they questioned the validity of Ward et al.'s (2001) findings and concluded "to date, there is insufficient empirical evidence that fire suppression has significantly changed the fire cycle in the boreal forest of Ontario."

Martell (1994) reported that the average annual burn rate (fraction of the protected area burned) in Ontario over the 13 year period from 1976 to 1988 increases as one moves from the intensive protection zone (0.00181), through the measured protection zone (0.00248) to the extensive protection zone (0.00438). Miyanshi et al. (2002) and Bridge et al. (2005) questioned the value of that evidence because forest type, climate, land use, and other potentially confounding factors had been ignored and that the 13 year sample size was, in their judgement, too small. In this paper we use a larger (19 year) sample of fire data and explore the impact of many of those factors on burned area.

Martell and Sun (2008) developed and applied a methodology that can be used to relate spatial variation in lightning-caused fire regimes in Ontario to vegetation, weather, and the level of fire protection. They used the first two variables to develop a FCDI and used the average initial attack response time as a level of fire protection index. Both variables proved to be statistically significant. Their results support the belief that fire suppression does reduce area burned in boreal forests. Furthermore, they support Ward and Tithecott's (1993) conclusion that fire suppression has had a significant impact on area burned in Ontario.

A final topic regarding the temporal aspect of forest fires is the season of burn. Heinselman (1981) notes that normal boreal summers are too wet for major fires, and that vegetation is at its most flammable cured stage only in spring and fall, shortly before and after the season of snow cover. However, major fires do occur during extended summer droughts. Heinselman (1981) also notes that most of the very large fires in the 1800's and early 1900's (attributable at least partly to human land clearing practices) occurred in the fall after a long period of drought.

7.7 Fire Cycles and Forest Management Planning

For the 2007-2017 FMP for the Big Pic Forest, and the 2013-2023 FMP for the Pic River Forest, information regarding fire cycles for use in Forest Management Planning was provided to the planning team by OMNR. This information is based on an analysis of fire data relevant to each Region and provides fire cycles for each forest unit based on their fire hazard characteristics. Local information can be used to modify the suggested regimes, with appropriate analysis.

In developing the Natural Disturbance Pattern Emulation Guide (1998), OMNR produced an unpublished report containing analyses based on the information contained in the fire history atlas (OMNR 1997). Included were statistics on fire frequency and suggested disturbance templates by ecodistrict. In 2009, OMNR completed a study (Perara et al. 2009a) that was focused on assessing distribution of fire sizes and their spatial proximity of occurrence as relevant to directions in Ontario's Forest Management Guide for Natural Disturbance Pattern Emulation. Given the many inadequacies of estimating fire regime characteristics by empirical data of fire history, they used a simulation modelling approach for this assessment. The BFOLDS model, which models fire disturbances mechanistically and forest succession empirically, was used to simulate fire regime scenarios for boreal Ontario. The study area encompassed ecoregions 3E and in which fire regimes were simulated for 200 years. Three potential fire weather scenarios, normal, cold, and warm, and two possible lightning patterns, random and biased, were used as model assumptions to address uncertainties in knowledge of long-term climate and weather patterns. All simulation scenarios were replicated to capture stochastic variability that emerges during modelling. From these results, fire size distributions and probabilities of spatial occurrence of fires were extracted for each simulation scenario. Key results for ecoregions 3E and 3W are summarized below.

7.7.1 Fire Size Distribution

Table 10 summarizes the mean relative proportion (as a percentage of the total) of fires in the six size classes in Ecoregions 3E and 3W under the simulated fire weather scenarios. For example, in Ecoregion 3E, in the cold fire weather scenario, 59.2% of the simulated fires were <1 ha; 10.5% were between 1 and 10 ha; and 2.0% were >10,000 ha. ANOVA test showed that the effect of simulated fire weather on the proportion of fires in the size classes was significant, but varied among ecoregions. For example, proportion of fires in the smallest size class decreased with progressively warmer scenarios of fire weather (cold-normal-warm) in ecoregions 3E, but did not change in other ecoregions.

In ecoregions 3E and 3W, simulated fires comprised mostly very small fires that were ignited but failed to spread beyond 1 ha. These fires (<1 ha) constituted over 50% of simulated fires in ecoregion 3E (57%). In Ecoregion 3W, the smallest fires contributed less (28%). To examine the overall distribution of fire sizes, the simulated fires were categorized into six size classes: <1 ha, 1-10 ha, 11-100 ha, 101-1000 ha, 1001-10,000 ha and >10,000 ha. The limits of size classes were log scale because many suggest, as reviewed by Cui and Perera (2008), that probability distributions of fire sizes are non-linear. About one fourth of simulated fires in 3W were in the largest categories (>1000 ha). Ecoregion 3E had the smallest proportion of large fires. The general trend in both Ecoregions (and we can assume also in the Pic River and Big Pic Forests) closely follows the typical fire pattern; most of the area burned is burned by relatively few large fires.

Table 10. Number of fires in different size classes expressed as a percentage of the total (mean ± SE) under different simulation scenarios of fire weather and ignition patterns for Ecoregions 3E and 3W.

Ecoregion	Fire Weather / Ignition Pattern	Percentage of number of fires in different size classes					
		< 1ha	1-10 ha	11-100 ha	101-1,000 ha	1,001-10,000 ha	>10,000 ha
3E	Cold	***59.2 ± 0.5***	***10.5 ± 0.2***	11.7 ± 0.1	10.1 ± 0.2	***6.5 ± 0.2***	***2.0 ± 0.1***
	Normal	***57.3 ± 0.5***	***9.2 ± 0.1***	10.6 ± 0.1	10.7 ± 0.1	***9.3 ± 0.2***	***2.8 ± 0.1***
	Warm	***54.9 ± 0.6***	***7.8 ± 0.1***	9.7 ± 0.1	12.0 ± 0.2	***12.2 ± 0.2***	***3.5 ± 0.1***
3W	Cold	28.8 ± 0.2	10.6 ± 0.1	***15.5 ± 0.1***	23.6 ± 0.1	***18.4 ± 0.2***	***3.1 ± 0.1***
	Normal	28.1 ± 0.2	10.3 ± 0.1	***14.8 ± 0.1***	23.0 ± 0.1	***20.1 ± 0.1***	3.7 ± 0.1
	Warm	27.3 ± 0.2	10.1 ± 0.1	***14.0 ± 0.1***	22.6 ± 0.1	***21.8 ± 0.2***	4.2 ± 0.1
3E	Random	**60.1 ± 0.2**	**8.5 ± 0.1**	**10.0 ± 0.1**	**10.1 ± 0.1**	**8.4 ± 0.3**	**2.4 ± 0.1**
	Biased	**53.6 ± 0.3**	**9.8 ± 0.2**	**11.3 ± 0.1**	**11.8 ± 0.1**	**10.3 ± 0.3**	**3.1 ± 0.1**
3W	Random	28.1 ± 0.2	10.3 ± 0.1	14.8 ± 0.1	23.1 ± 0.1	20.2 ± 0.2	3.6 ± 0.1
	Biased	28.0 ± 0.2	10.4 ± 0.1	14.7 ± 0.1	23.0 ± 0.1	20.1 ± 0.2	3.8 ± 0.1

Values in bold italic are significantly (n=60; p=0.05) different from corresponding simulation scenario means within a given ecoregion.

7.7.2 Number of Fires

The number of fires simulated under different scenarios (Table 11) varied among ecoregions: In 3E, the fire numbers ranged from 2,458 to 8,110; and in 3W from 7,924 to 13,547. Their sizes ranged from <1 ha to maxima of 83,439 ha in 3E and 83,764 ha in 3W. Because of the differences in extent of forested (i.e., burnable) cover among ecoregions, the expression of fire numbers was standardized as a density value. Fire density is defined here as the number of fires that occurred per million ha of forested area in an ecoregion over a 200-year simulation period (expressed as per million ha to account for differences in extent of forested area among the ecoregions). Overall, ecoregion 3W had a higher simulated fire density than ecoregion 3E. Progressively warmer fire weather scenarios (from cold to normal and from normal to warm) increased fire density in all ecoregions except 3E. Random ignition patterns produced higher simulated fire density in all ecoregions.

Table 11. Fire density per million ha (mean ± SE) under different simulation scenarios of ignition pattern and fire weather for ecoregions 3E and 3W.

Ecoregion	All ignition patterns and fire weather classes	Ignition patterns (across fire weather classes)		Fire weather classes (across ignition patterns)		
		Random	Biased	Cold	Normal	Warm
3E	***364 ± 8***	***451 ± 9***	***277 ± 5***	307 ± 10	352 ± 12	441 ± 15
3W	***1401 ± 13***	***1466 ± 18***	***1338 ± 15***	***1257 ± 14***	***1400 ± 16***	***1549 ± 17***

Values in bold italic are significantly (n=60; p=0.05) different from corresponding simulation scenario means within a given ecoregion.

7.7.3 Fire Size at 80th Percentile Re 260 ha Size Class

Results of examining fire size of the 80th percentile of cumulative fire size distributions (Table 12) showed that 260 ha did sometimes occur at the 80th percentile, but its occurrence varied among ecoregions and simulation scenarios. For example, it occurred in ecoregion 3E under certain simulation scenarios, but not in 3W under any scenario. Table 7 shows that fire sizes at 80th percentile are significantly different from 260 ha in most simulation scenarios. It is also evident that, given the nature of fire size distribution, the magnitude of these differences are not linear, and the fire size deviation from 260 ha could be several fold even though the percentile deviation is minor (e.g., 3E, warm, biased).

Table 12. The fire size (ha) at the 80th percentile (mean ± SE) under different simulation scenarios of ignition pattern and fire weather for ecoregions 3E and 3W.

Ecoregion	Ignition pattern	Fire weather		
		Cold	Normal	Warm
	Random	***56.5 ± 3.5***	***124.1 ± 10.0***	309.5 ± 23.1
3E	Biased	***116.6 ± 10.5***	281.5 ± 21.3	***631.5 ± 38.0***
	Random	***1142.2 ± 24.5***	***1405.4 ± 27.9***	***1683.1 ± 35.3***

3W	Biased	***1163.9 ± 25.5***	***1429.5 ± 32.3***	***1719.2 ± 36.1***

Bold italicized values indicate the means are significantly different (n=30; p=0.05) from 260 ha.

7.8 The BFOLDS Model

More recently, OMNR has used the Boreal Forest Landscape Dynamics Simulator (BFOLDS) (Perera et al. 2008) to provide simulated fire information by management unit, for use by planning teams in preparing forest management plans. This is a fire regime-succession simulation model that can be used to explore long-term forest cover changes at large spatial extents. BFOLDS abstracts forest fire and succession processes quantitatively and stochastically in a spatially explicit manner. It logically combines fire ignition, growth, and extinguishment with forest succession based on input data of weather, forest composition, terrain, and soil. Simulation of these processes is accomplished by two interacting components: a fire simulation module and a forest succession module. The fire simulation module is process-based and primarily founded on published fire science knowledge of Canadian Forest Fire Behaviour Prediction System and Fire Weather Index system and consists of sub-modules for ignition, spread, and extinguishment of simulated fire events.

The forest succession module is empirically based, and driven by a time-dependent Markov model, populated by user-input rules on forest cover transitions specific to a hierarchy of site conditions. BFOLDS is a raster-based model, operating at 1 hectare spatial resolution. Its temporal resolution varies from a day to a year, depending on the simulated process. BFOLDS is designed to discover characteristics of large scale boreal fire regimes, as emerging properties of synthesized knowledge and assumptions of weather, fire behaviour, forest fuel, and forest succession. Thus model users have opportunities to examine effects of their assumptions and input data on characteristics of simulated fire regime. These simulated scenarios of forest landscape dynamics are not meant to reflect the past, present, or future, but are a set of hypotheses extended based on model logic, assumptions, and input.

The average results after multiple runs of the BFOLDS model for Ecoregion 3E and 3W are contained in the documentation associated with the Ontario Landscape Tool (Elkie et al. 2012b). The BFOLDS model was not available for the preparation of the current 2007-2017 FMP for the Big Pic Forest, but will be used as an additional tool to guide objective setting and the determination of forest successional trends for the next FMP.

The Pic River and Big Pic Forests span two Ecoregions, 3E and 3W (Figure 9). These two Ecoregions have very different average fire cycles due to their different climate and topography. Part of the forests' area lies within Ecodistrict 3W-5, which has a moister climate than the rest of the Pic River and Big Pic Forests due to its proximity to Lake Superior. This diversity of ecological conditions may complicate modeling the fire patterns and forest succession of the Big Pic Forest in the future using the BFOLDS model or other models. This will make local calibration and testing of modeling simulations especially important for this forest.

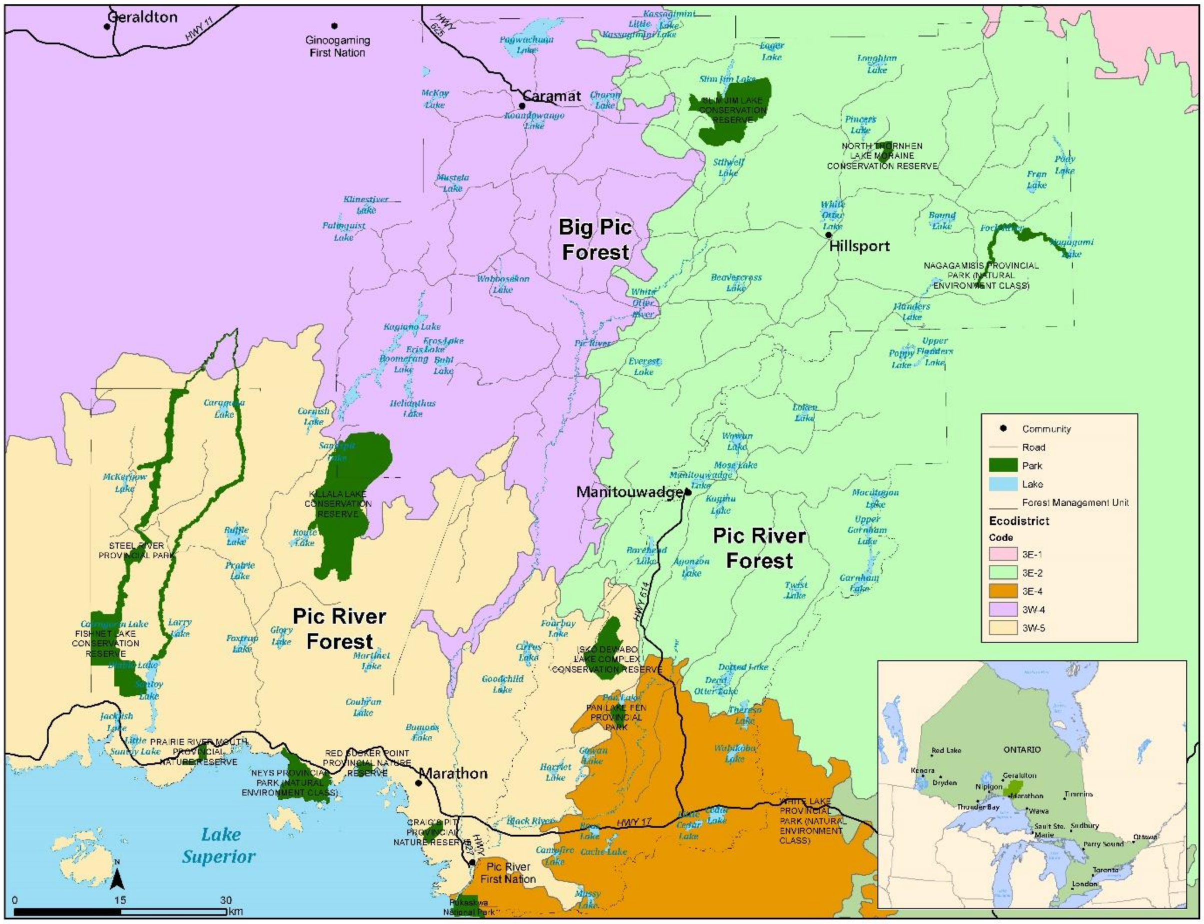


Figure 9. Location of the Pic River and Big Pic Forests within provincial Ecoregions and Ecodistricts.

7.9 Possible Changes to the Forest Resulting from Climate Change

Parker et al. (2012) studied the vulnerability of the forest vegetation of Ontario's northern Clay Belt region to climate change was assessed using forest tree species composition and forest productivity as indicators. Changes in species composition were examined using the modelled bioclimatic niche of 15 tree species under current and future climate projected for three periods (2011-2040, 2041-2070, 2071-2100) using four general circulation models and two emissions scenarios (A2, B1). Using climate projections from an ensemble model for these same scenarios and periods as inputs to climate-based site index and genecological models, changes in height growth were examined for several major tree species of the region as a measure of effects of climate on forest productivity.

Major northward geographic shifts in species bioclimatic niche were projected, resulting in suitable climatic habitat decreasing for boreal forest species of the region, and becoming more favourable for species currently associated with more southern, i.e., Great Lakes-St. Lawrence, areas. In general, results from the site index and genecological models suggest that where soil moisture availability remains relatively unchanged, initial warming over the next few decades will improve the growth of several boreal species. Collectively, these results suggest that assisted migration of seed sources and other climate change adaptation strategies directed specifically at maintaining productivity within the Clay Belt may not be necessary until mid-century.

8 Background Information on Insects, Diseases, and Windthrow

8.1 Insect Infestations on the Pic River and Big Pic Forests

Insects have not, to date, proven to be a major problem on the Pic River and Big Pic Units (Anon. 1987). The spruce budworm epidemic of the 1940s collapsed just as it approached the southwestern side of the Unit. The epidemic of the late 1970s and 1980s caused significant defoliation and mortality to balsam fir and white spruce thoughout the Management Unit. In 1985, the infestation was most intense in patches on or near the southern end of the Unit on an area in the vicinity of Hourglass Lake, and on an area just north of the Unit along the Pagwachuan River. At the time of preparation of the 1987-1992 Plan, the spruce budworm outbreak had resulted in increasing mortality of balsam fir and, to a much lesser degree, white spruce in certain areas. A major aerial spraying program to control the spruce budworm in areas proposed for harvesting over the next 10 years was also initiated in 1986 and continued in 1987. In 1986, harvesting of 2,645 ha of budworm susceptible stands was conducted as part of the Terrace Bay District budworm control strategy (OMNR 1987); harvesting of susceptible areas was continued in 1987.

The large aspen tortrix is a leaf-eating insect that defoliates trembling aspen. In the early 1970s, an epidemic of this insect defoliated large areas of aspen on the Big Pic Unit (Anon. 1987). While no extensive mortality is associated with this insect, it may cause individual decadent trees to die and may decrease growth rates over the three to six years it takes the epidemic to run its course.

The forest tent caterpillar has the potential to develop to epidemic levels on this Unit, however, it had not been a serious factor up to 1987. However, a significant outbreak of forest tent caterpillar occurred in northeastern Ontario from 2005 to 2007.

The larch sawfly developed to epidemic levels in the early part of this century and has undoubtedly been a factor limiting the amount of tamarack in the Unit's growing stock. White pine weevil can cause a small amount of damage on young spruce by killing the terminal leader, which may result in deformity of the tree (Anon. 1987).

In 2009-2010, significant areas affaected by decline of tolerant hardwoods (poplar and white birch) associated with some mortality was noted on the two Forests and was thought at the time to be emerging as a problem on the Forests, but in subsequent years the decline ameliorated and the issue essentially disappeared. Whatever combination of environmental factors lead to the effects on hardwoods, the decline has not re-occurred since 2010.

The total area on the Pic River and Big Pic Forests that was affected by various types of natural disturbances, including insect infestations, tree diseases and wildfires, from the year 1988 to 2010 is shown in Table 13.

Table 13. Total area affected by various natural disturbances in the combined area of the Pic River and Big Pic Forests 1988-2010.

Year	Drought	Fire	Forest Tent Caterpillar	Other Diseases	Poplar-Birch Decline	Spruce Budworm	Weather Damage	Total Area (ha)
1988	0	0	0	0	0	63,975	0	63,975
1989	0	0	0	0	0	78,549	0	78,549
1990	0	10	0	0	0	47,292	0	47,302
1991	46	4,399	0	0	0	141,682	0	146,126
1992	0	0	0	0	0	141,845	0	141,846
1993	0	0	0	0	0	292,354	0	292,355
1994	0	4	29,397	0	0	308,464	0	337,865
1995	31,729	537	0	0	0	308,303	0	340,569
1996	0	12	0	0	0	326,540	0	326,552
1997	584	79	0	0	0	327,596	0	328,259
1998	0	16,077	0	11,073	0	334,037	0	361,187
1999	0	9	0	0	0	333,728	0	333,737
2000	0	6	0	0	0	341,165	0	341,172
2001	15,912	55	0	0	0	0	0	15,967
2002	0	8,570	0	0	0	0	0	8,570
2003	0	27,015	0	0	0	0	0	27,015
2004	0	5	0	0	238	0	0	243
2005	0	100	0	0	0	0	0	100
2006	0	2,835	0	0	0	0	0	2,835
2007	0	9	0	0	0	0	0	9
2008	0	3	0	0	0	0	0	3
2009	0	1	0	0	13,797	0	533	14,331
2010	0	49	0	0	279,480	0	0	279,530
Total	48,271	59,774	29,397	11,073	293,515	3,045,531	533	3,488,093

8.2 Forest Insects and the Effects of Infestations

There are many herbivorous insects which inhabit the boreal and Great Lakes-St. Lawrence / boreal transition forests. Relatively few species have sufficient potential destructive capacity to be called pests. The primary insect disturbance agents in northeastern Ontario are spruce budworm, jack pine budworm and forest tent caterpillar. OMNR, in collaboration with CFS and the forest companies, conduct surveys and map insect occurrences on an annual basis. Following insect infestations and other natural disturbance events, salvage operations are typically carried out in order to remove the dead and damaged stems.

8.2.1 Spruce Budworm (*Choristoneura fumiferana* Clem.)

Spruce budworm exhibits a very cyclic nature. It attacks balsam fir and spruce and, during periods of intense infestation, can kill all or most of the trees in stands dominated by these species. Periods of high populations and heavy defoliation usually last 5-15 years, with populations existing at low endemic levels for periods of 20-100 years between outbreaks (Blais 1985).

Candau et al. (1998) overlaid maps of moderate and severe budworm outbreaks in Ontario from 1941 to 1996 and found that the complex fluctuations in the time series could be decomposed into a basic oscillation of approximately 36 years, modified by secondary fluctuations and occasional sharp drops. Outbreak collapses are generally associated with extensive balsam fir mortality (Sippell 1983); although weather events may also contribute (Howse et al. 1974). Candau et al. (1998) suggest that climatic extremes, such as late spring frosts, appear to terminate the secondary fluctuations ensconced within the broad oscillatory pattern they found in Ontario.

Miller (1975) indicated that it takes several years for an endemic population to grow to the level where it causes noticeable defoliation. Starting from a pre-outbreak density of less than five feeding larvae per tree, the population grows in about 4 years to reach 2000 larvae per tree and causes noticeable defoliation (30%) of the new shoots. Population growth continues in the fifth and sixth years peaking at about 20,000 larvae per tree. In the sixth and seventh years the 20,000 budworms strip all the current needles and some of the old needles from the tree. The tree then declines in vigor and becomes less attractive as an oviposition site, so that many moths disperse from these heavily defoliated stands (Greenbank 1973). However a sufficient population remains to continue to strip the new shoots in the eighth and ninth years. In the ninth year dead tree tops, top-killing, becomes evident, and much of the reproductive understory is also killed as larvae cascade from the defoliated high forest canopy. In the tenth year some dominant trees die, and during the eleventh to fourteenth years mortality increases to include about 80% of the merchantable stand. Occasionally the death of a stand is faster; but quite often, particularly in spruce stands, the damage period may be more protracted and mortality less severe.

Three major outbreaks of the spruce budworm have occurred in North America in the 20th century, starting about 1910, 1940, and 1970 MacLean (1984). These have affected widespread areas of forest; the maximum extents of the three outbreaks have been estimated at about 10, 25, and 57 million hectares, respectively. Areas of forest within all of the eastern Canadian provinces (Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland) and the State of Maine in the U.S.A., have suffered sufficient defoliation in the last decade to kill some or all forest stands in severely affected portions (Kettela 1983).

The impact of defoliation by spruce budworm populations on the growth of balsam fir, the main host species, was reviewed in detail by MacLean (1981). Removal of a portion of the tree's photosynthetic factory results in reduced radial growth, reduction or cessation of height growth, and often death of the uppermost portion of the tree (termed top-kill). Several studies have shown that radial increment is reduced about 50 to 75% by several years of severe defoliation (Craighead 1924, McLintock 1955, Blais 1964, Miller 1977). Although it was believed for many years that there was a lag of several years before the growth response to budworm defoliation occurred, recent research has demonstrated up to a 20% growth loss in the initial year of defoliation (Piene 1980). Because spruce budworm feeding is often most severe near the tops of trees, height growth is either drastically reduced or stopped completely during years of severe defoliation. Baskerville and MacLean (1979) have shown that trees affected by a budworm outbreak can be as much as 3 to 4 m shorter after 10-1 2 years of defoliation than similar trees undamaged by budworm.

Severe defoliation reduces current annual volume increment by up to 20% after one year of defoliation (Piene 1980) and by 25 to 50% after two years of defoliation (Batzer 1973, Baskerville and MacLean

1979, Piene 1980). The volume increment reduction increases further from 50 to 80% after 6 to 10 years of defoliation (Batzer 1973, Baskerville and MacLean 1979), and many trees will die.

Defoliation in mature balsam fir stands initially causes growth loss of trees, but persistent severe defoliation for several years will result in tree mortality. The amount of mortality resulting from budworm outbreaks is a function of several factors, including the severity and temporal sequence of defoliation, the species and age of trees involved, and characteristics of the stand including age-class distribution, species composition, spacing, site, etc. Information available from studies on the vulnerability of stands to mortality during budworm outbreaks indicate that black spruce is less vulnerable than red or white spruce, which in turn are less vulnerable than balsam fir. The timing of mortality has generally been quite consistent among different outbreaks and locations, with trees usually starting to die after 4 or 5 years of severe defoliation in mature stands. In less vulnerable, immature stands it may take 7 or 8 years of defoliation for the first mortality to occur. Mortality is usually complete by about 12 years after start of a budworm outbreak, with 70 to 100% of the trees dead.

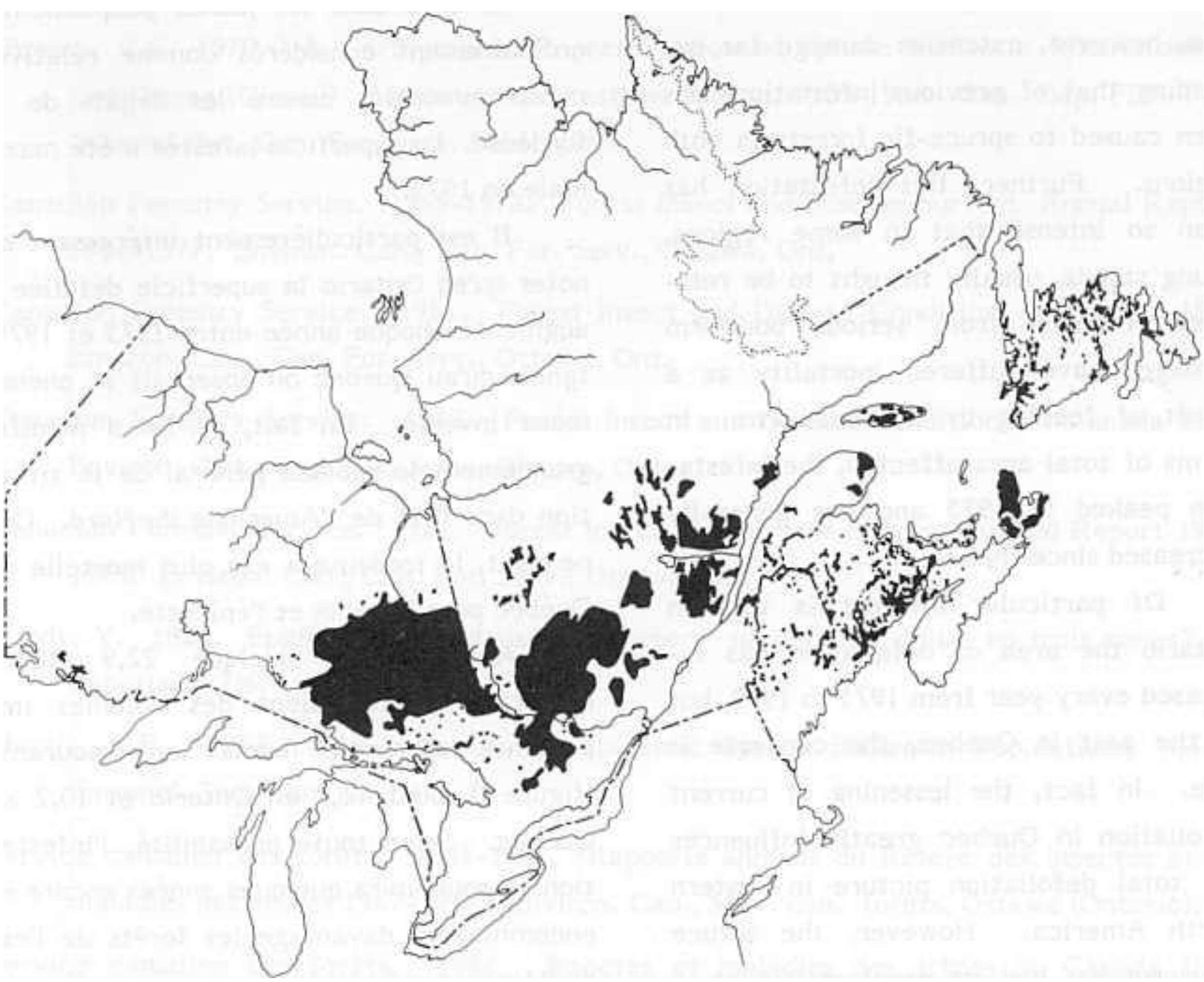


Figure 10. Areas of eastern Canada and Maine, U.S.A., with varying amounts of mortality of balsam fir and spruce caused by spruce budworm, 1981 (Kettela 1983).

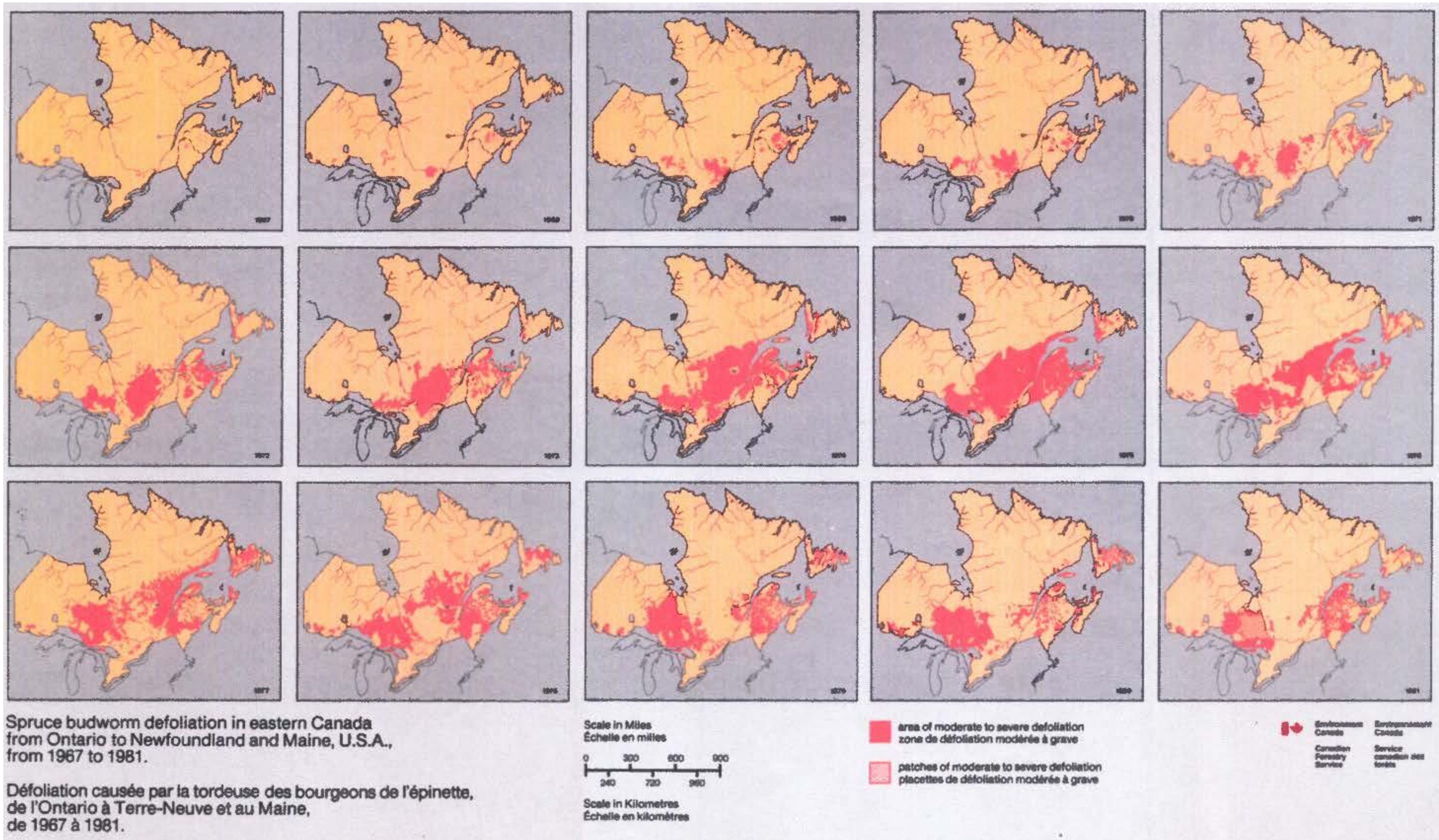


Figure 11. Spruce budworm defoliation in eastern Canada from 1967 to 1981.

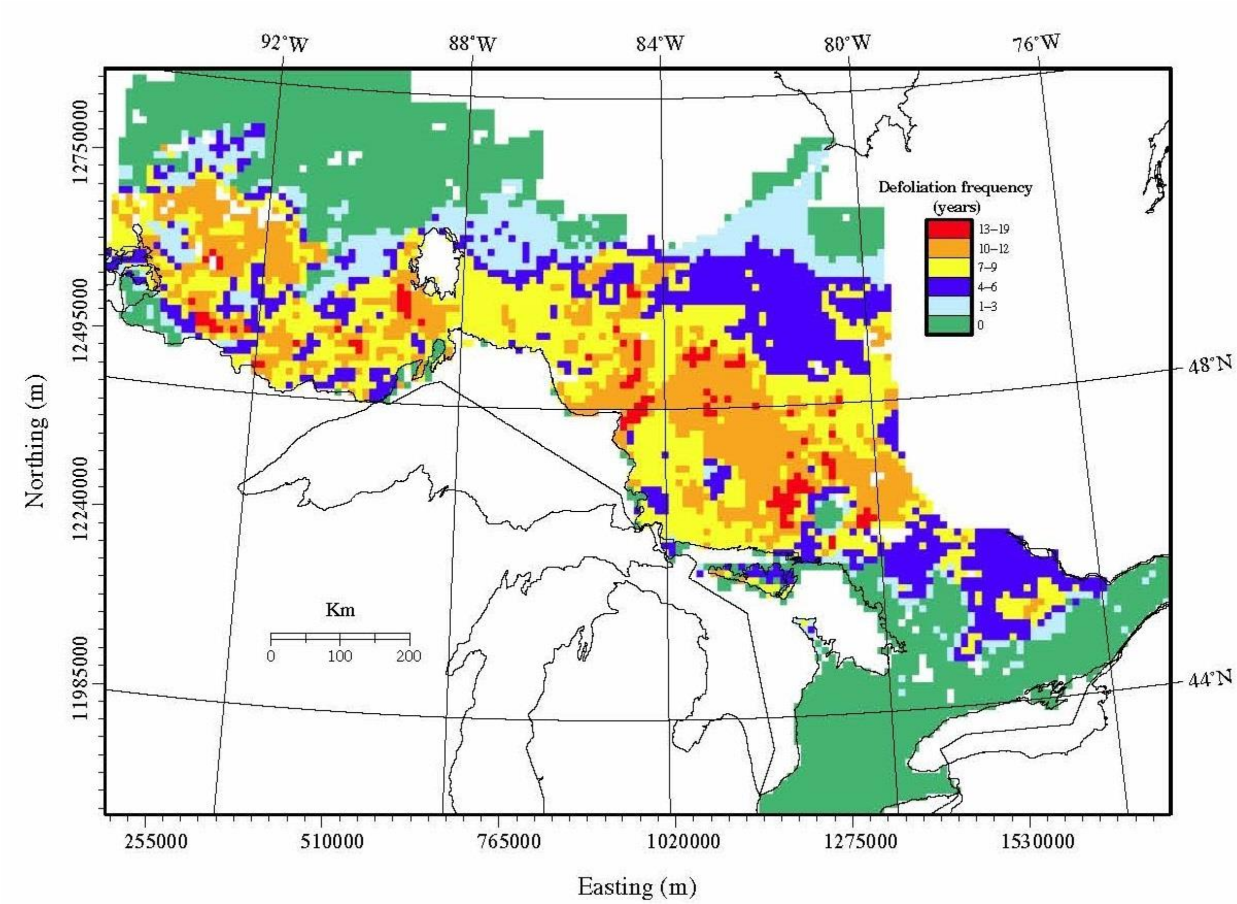


Figure 12. Frequency of moderate-to-severe spruce budworm defoliation in Ontario from 1967 to 1998. The key indicates the total number of years that defoliation was recorded. Three zones of high frequency (western, central, and eastern) are separated by two corridors of less frequent defoliation. Dashes outline the area for which forest composition data are available.

In 1982, major changes occurred in the spruce budworm situation in Ontario (see Figure 10 and Figure 13). The overall area suffering moderate-to-severe defoliation totaled some 8,023,000 ha, a decrease of slightly more than 10 million ha from 1981. As expected, the area within which budworm-associated tree mortality occurred continued to increase in 1982 (Figure 14), and now covers approximately 11.63 million ha. Figure 15 and Figure 16 show the geographic distribution of spruce budworm damage in Ontario from 1937 to 1951, and from 1967 to 1981 respectively.

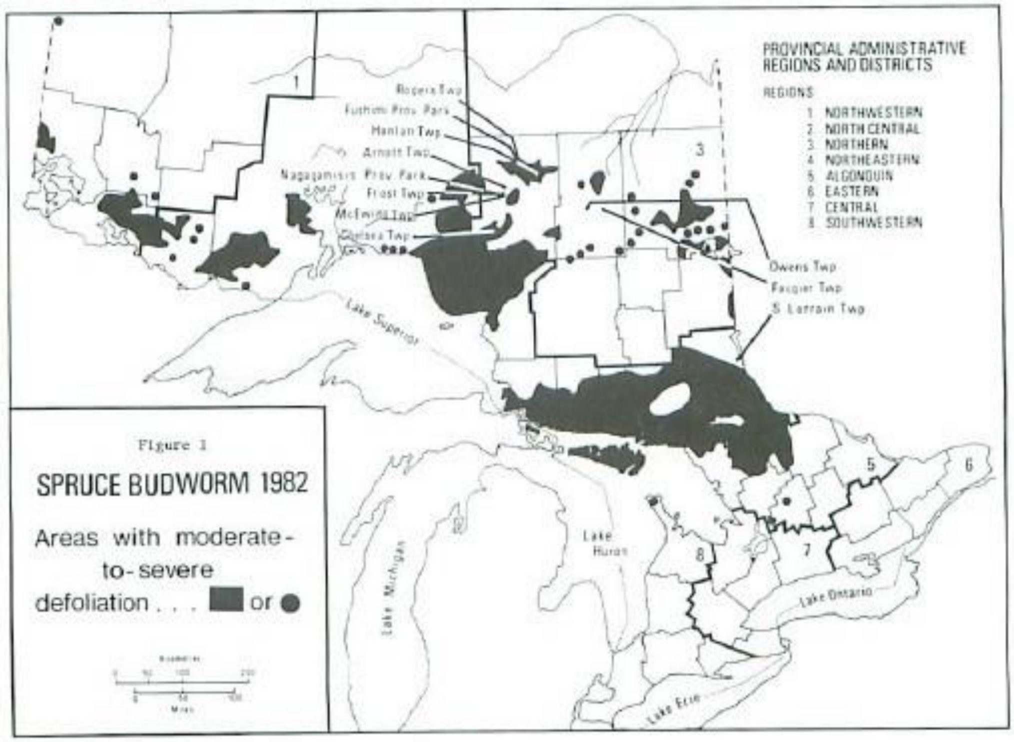


Figure 13. Spruce budworm defoliation in Ontario 1982.

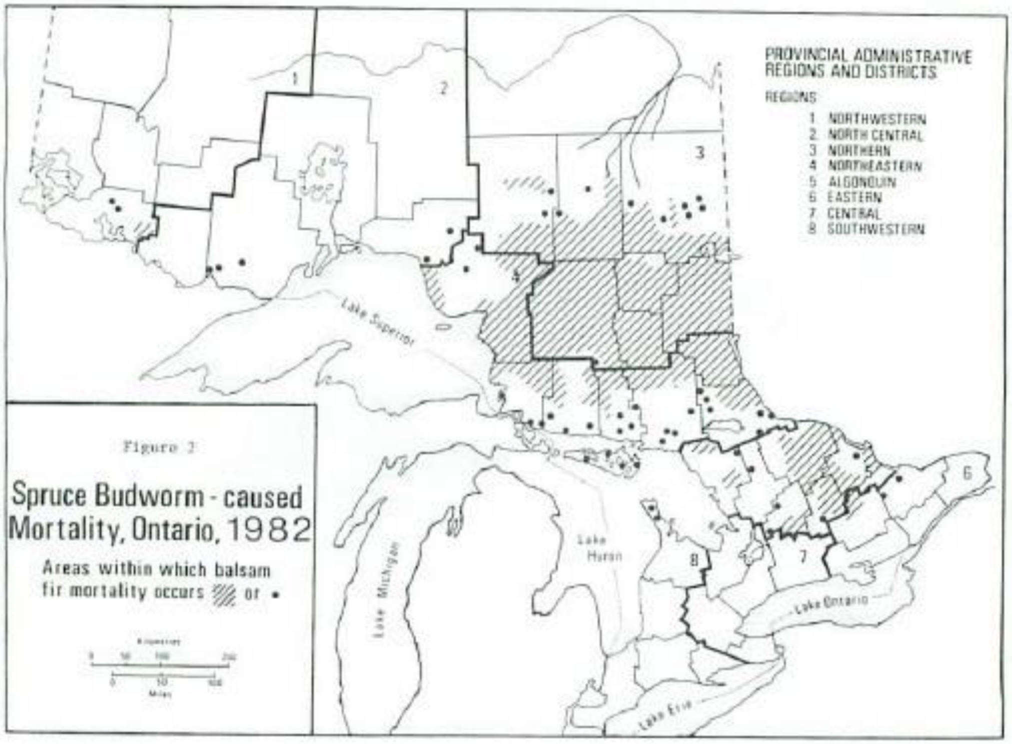


Figure 14. Spruce budworm caused mortality in Ontario 1982.

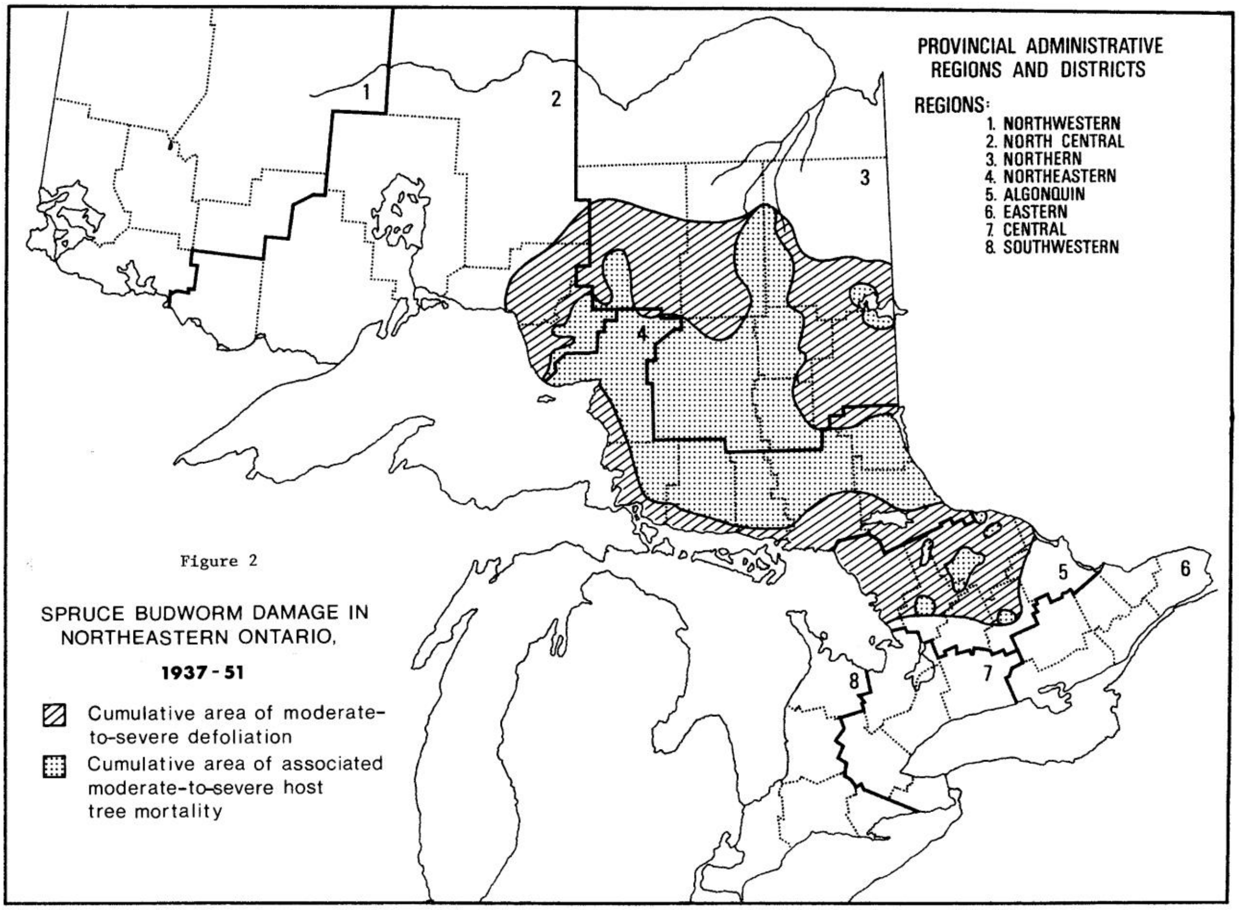


Figure 15. Spruce budworm damage in Ontario, 1937-51 (Sippell 1983).

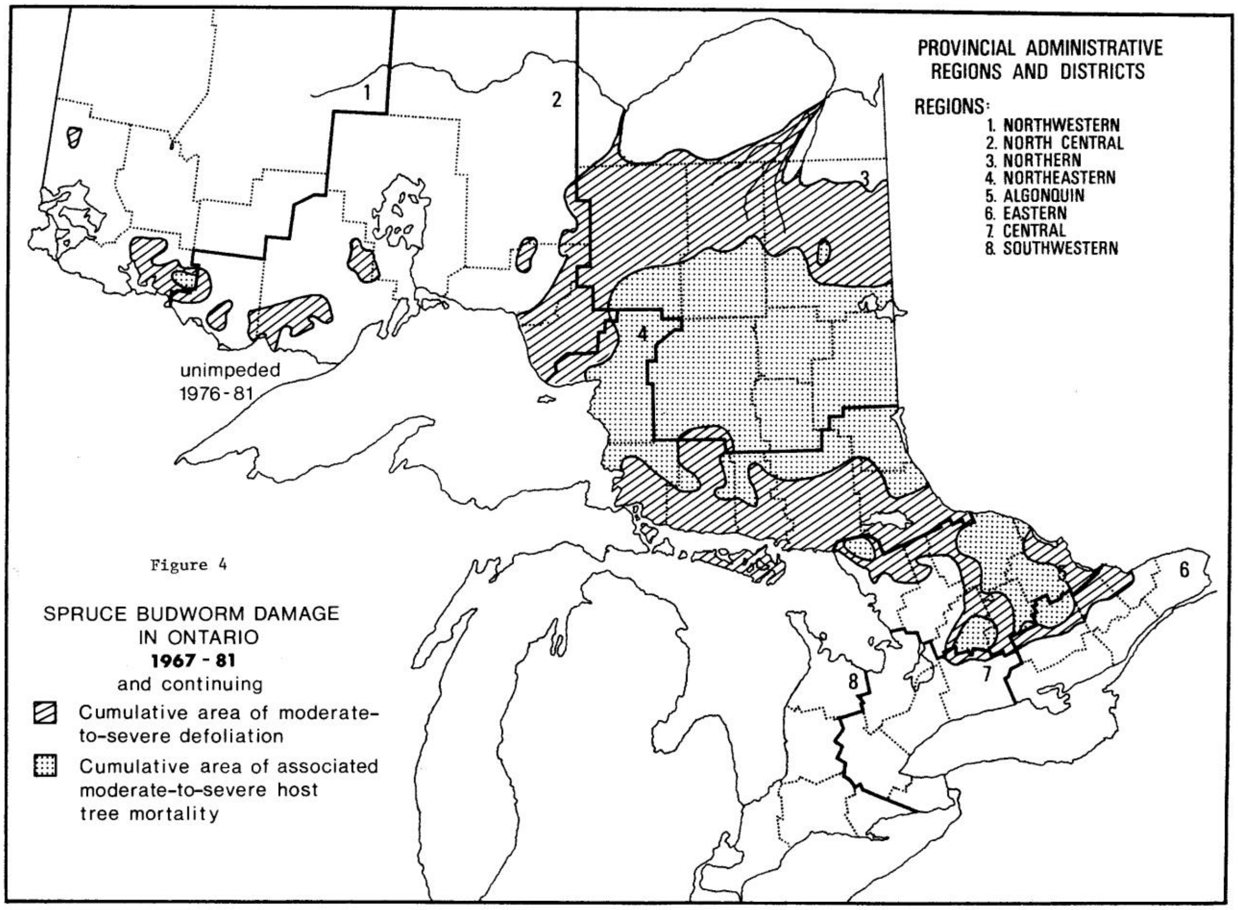


Figure 16. Spruce budworm damage in Ontario, 1967-81 (Sippell 1983).

8.2.2 Jack Pine Budworm (*Choristoneura pinus* Freeman)

Jack-pine budworm is the most serious defoliator of jack pine in central Canada. Local budworm populations are characterized by periodic outbreaks lasting approximately 2-5 years (Clancy et al. 1980, Volney 1988a). Outbreaks probably result from climatic release of endemic populations in susceptible stands (Clancy et al. 1980). Outbreak periodicity is thought to be tied to the prevalence of mature jack pine in a landscape, and by association with a lag time after periods of large fires. As jack pine stands originate simultaneously following years in which large areas burn, and probably flower for the first time about 20 years later, greatest susceptibility to outbreaks over large burnt areas is also simultaneous (Batzer and Jennings 1980, Volney 1988b). As with spruce budworm, meteorological conditions and the exhaustion of food supplies are thought to be responsible for the decline of populations.

8.2.3 Forest Tent Caterpillar (*Malacosoma disstria* Hbn.)

The forest tent caterpillar is a voracious defoliator of hardwood trees throughout North America, exhibiting large-scale, periodic outbreaks on trembling aspen in much of the boreal forest (Witter 1979). During a typical outbreak, detectable defoliation persists for one to many years, with the total length of outbreak varying both spatially, within an outbreak, and temporally, among outbreaks. Different authorities, reporting from different areas and over different time periods, have provided different estimates of the average duration of outbreak; however, it is not clear why these estimates vary.

Infestations of the forest tent caterpillar reached a peak of nearly 18 million ha in trembling aspen and poplar (*Populus* spp.) forest in Ontario in 1978 and declined steadily since then (Howse et al. 1983), until the 1990s. In 1982, approximately 103,700 ha of moderate-to-severe defoliation were mapped in Ontario in comparison with 228,000 ha in 1981.

Beginning in the 1990's and continuing into the 2000's, the forest tent caterpillar has had a major effect on aspen stands within northeastern Ontario. Expected damage from the forest tent caterpillar consists of temporary harm, causing delayed growth from defoliation. When the infestation has been prolonged for more than 3 years in some areas, considerable stand damage has been found. A decrease in annual growth along with stand mortality has caused a loss in merchantable volume.

The most significant insect infestation of the past 20 years on the Pic River and Big Pic Forests was the severe infestation by forest tent caterpillars in the early 2000's. The most severely affected areas on the forest were mapped, using supplementary air photography acquired for this purpose. In the 2005 and the 2010 FMPs, this information (on the location of affected stands, and the extent of mortality resulting from the infestation) was used to refine yield curves for the PO1 and MW1 forest units, resulting in a volume net-down for the affected areas. Tembec conducted additional aerial reconnaissance, in collaboration with hardwood users on the forest, to verify the locations of affected areas and the severity of impacts (i.e., the amount of tree mortality).

Forest tent caterpillar populations are highly cyclic in nature with a mean period of about 10 years with outbreaks typically lasting 4-5 years (Sippel 1983, Peterson and Peterson 1992). Roland (1993) reports that "despite a relatively consistent period of the population cycles over a wide geographical range, the duration of the high-density outbreak phase is as short as two years in some areas and as long as 9 in others".

Roland (1993) found that forest fragmentation increased the duration of forest tent caterpillar outbreaks in Ontario and hypothesized that this could be because natural enemies have poorer dispersal abilities than the pest, and due to the tendency of many lepidopteran species to lay more eggs along edges of host plant patches than in the interior, thereby increasing the spatial variation in egg and larval abundance. Tent caterpillar could suffer lower per capita mortality if they swamp their natural enemies with high density at the forest edge.

Cooke et al. (2009) showed that outbreaks recur periodically and somewhat synchronously in Ontario and Quebec, with six interprovincial-scale cycles having been observed over the period 1938-2002. When the entire spatiotemporal range of observed defoliation is considered, it appears that, at the local stand level, individual outbreaks tend to last for less than a year on average. Within the three core areas where all six cycles were observed (Dryden, Sudbury, Temiscamingue), individual outbreaks tended to last for 2.6 ± 0.5 years. The seemingly small difference between two versus three years of detectable defoliation at the local stand level appears to be critical, as this determines whether annual rates of stem mortality are sufficient to produce obvious signs of forest decline. Infestations lasting three years or longer normally occur in ~45% of the stands within the relatively small core outbreak areas. However not all infestations behave "normally", in the sense of being the product of a regionally synchronized population cycle. For example, a reversing, traveling wave of forest tent caterpillar outbreaks in northern Ontario in the 1990s generated an unusually long-lasting infestation along the Highway 11 corridor – an outbreak which resulted in a regional-scale decline of trembling aspen. This demonstrates how incomplete synchronization of forest insect population cycles can lead to overlapping waves of outbreak that may result in large-scale forest disturbance.

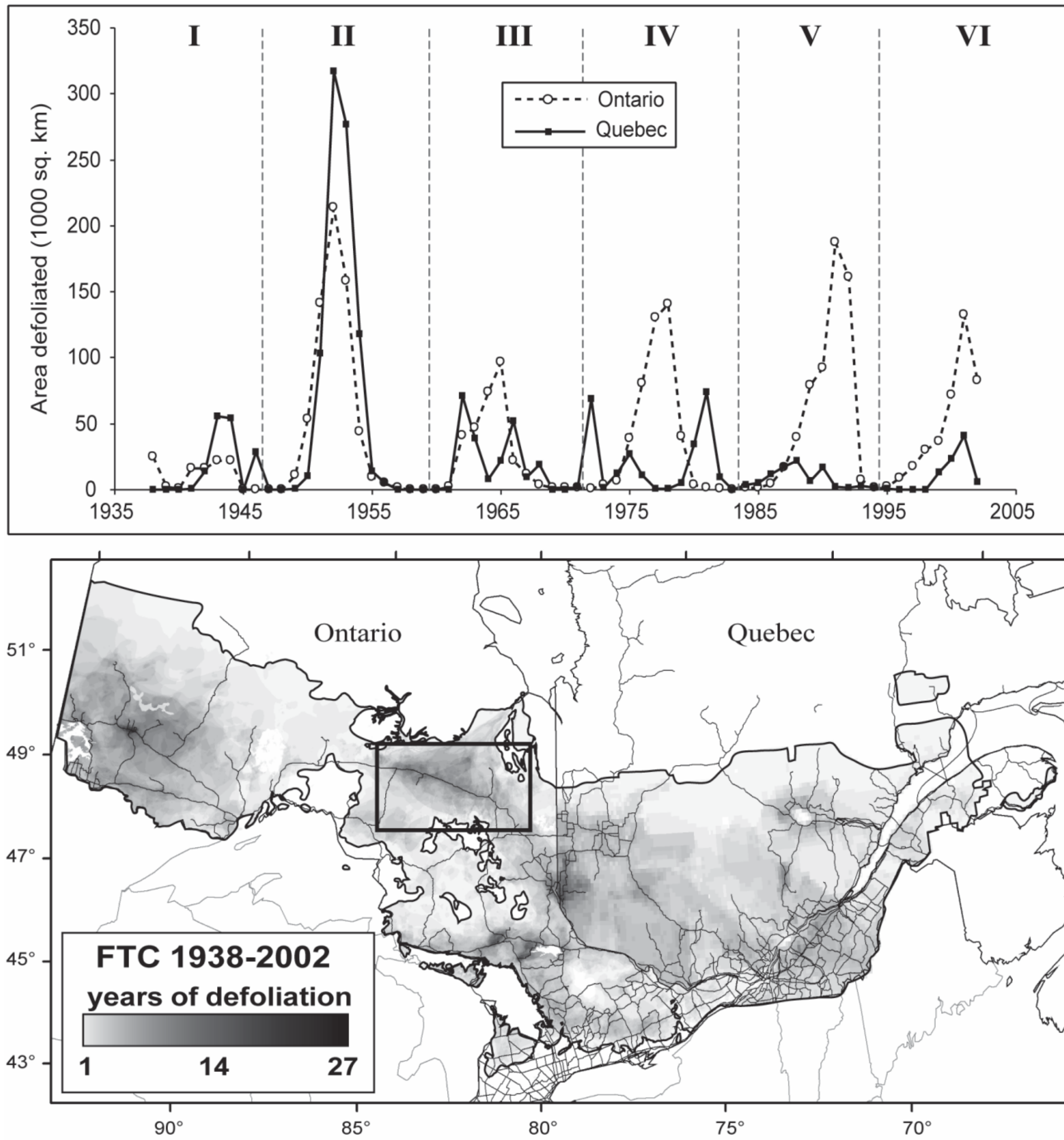


Figure 17. Duration of forest tent caterpillar infestations from 1938 to 2002 in the provinces of Ontario and Quebec.

Top: Outbreak cycles are fairly well synchronized between provinces, although cycles III, IV, and V appear to have been interrupted in the early stages of development in 1963, 1976, 1989 in Quebec, but not in Ontario. Bottom: Note the fairly seamless gradient across the Ontario-Quebec border, despite the different survey and data pre-processing methods. Road density (shown as dark lines) is broadly indicative of the degree of human settlement and forest fragmentation.

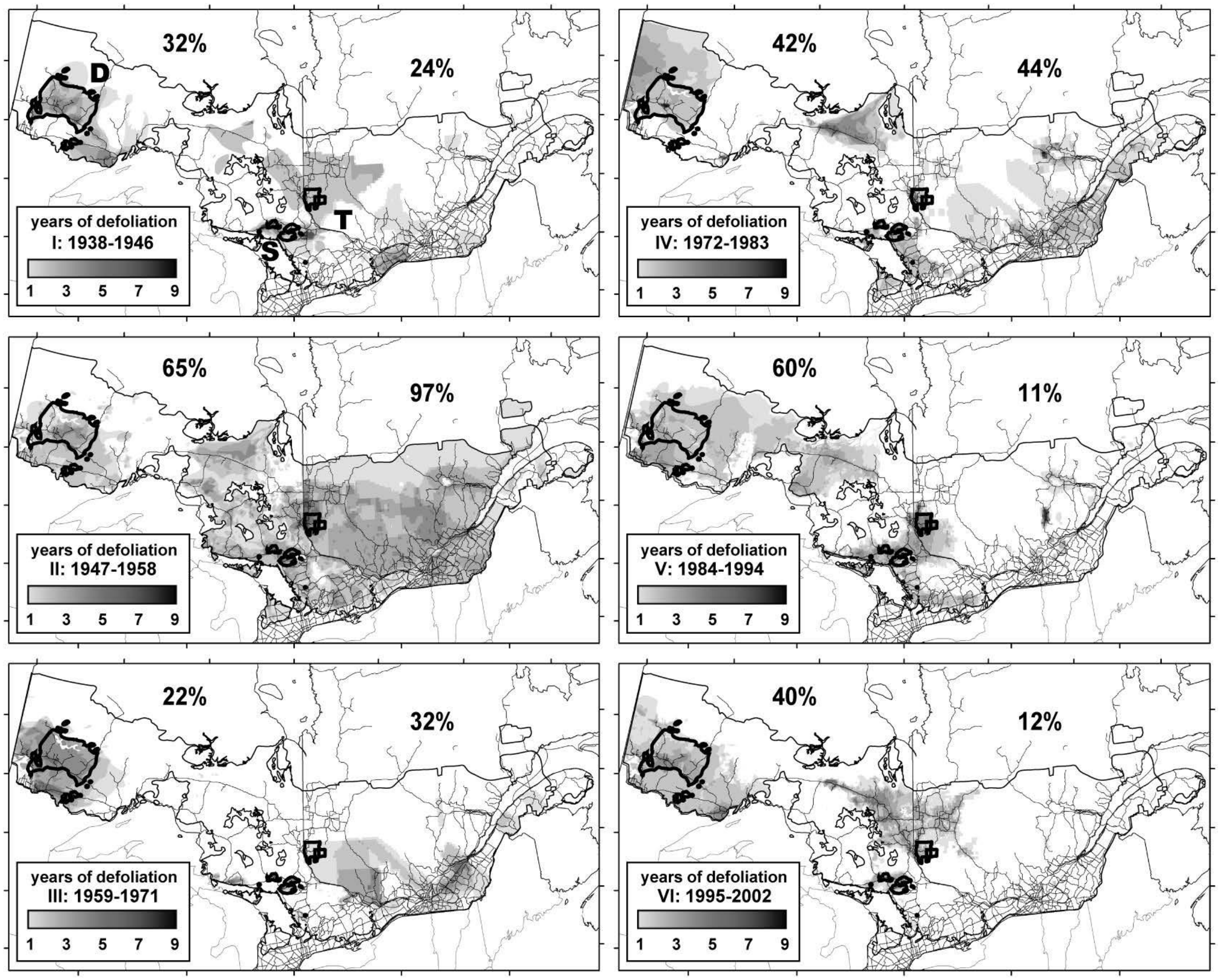


Figure 18. The distribution of forest tent caterpillar defoliation during each of six outbreak cycles in Ontario and Quebec.

In the diagrams above, thin and thick black outlines indicate (i) the entire outbreak range over the period 1938-2002 and (ii) the core areas where at least one year of defoliation occurred during each of all six cycles. Core areas labelled as “D” (Dryden), “S” (Sudbury), and “T” (Temiscamingue). The area between the thin and thick black outlines is referred to as the “fringe” area – the area where “zero values” for local outbreak duration are common. Percentages indicate the mean percentage of the outbreak range defoliated in each province during each cycle.

Although most forest tent caterpillar outbreaks do not last longer than 1-2 years, those rare ones that do last longer tend to result in "significant" (i.e. readily detectable and/or economically important) mortality. The reason that forest tent caterpillars are generally thought of as benign insects is not because they are incapable of destroying a forest. Rather, it is because outbreaks are typically terminated before they reach their third year, but there are usually small areas where outbreaks linger on for 4 years or longer.

Just as meteorologists have difficulty in predicting extreme weather events, so entomologists are likely to find it challenging to obtain any success in predicting extreme entomological events. Predicting animal population fluctuations is an imprecise science. Predicting which of these fluctuations are likely to result in anomalously severe and prolonged population eruptions is going to require continuing research into the fundamentals of population dynamics. Understanding the forces that lead to imperfect synchronization of cyclic population fluctuations is one promising avenue for determining when and where waves of outbreak may overlap to produce unusually long-lasting infestations capable of causing large-scale forest decline.

8.2.4 Larch Sawfly (*Pristiphora erichsonii* Hartig)

In the late 19th and the early 20th century, larch forests were seriously threatened by a severe outbreak of the larch sawfly that destroyed most mature stands in eastern North America (Girardin et al. 2002). This is confirmed in the Ontario Clay Belt by anecdotal evidence from forestry workers who were active in the 1920s.

In the late 20th century, numerous dendrochronological studies have been conducted to reconstruct past outbreaks. Although sawfly populations are currently at endemic levels, outbreaks of this insect remain a potential threat to these forests. While relationships between larch growth reductions, increasing mortality rates, and the occurrence of larch sawfly outbreaks are well described, few studies have examined the impacts of sawfly outbreaks on stand dynamics. This lack of information is even more substantial when the dynamics of wetland stands of the Canadian boreal forest is considered.

A previous study of larch radial growth in the northern Clay Belt region indicated two severe larch sawfly outbreaks during the last 100 years (1895–1912 and 1955–1962) (Girardin et al. 2001b). These were inferred from the occurrences in larch of characteristic rings associated with larch sawfly outbreaks (missing and light latewood rings) (Harper 1913). Growth comparison with a nonhost species also indicated possibilities of less severe outbreaks for the early 1920s, late 1930s, and late 1970s (Girardin et al. 2001b). Although insect surveys (ministère de l'Énergie et des Ressources, Québec, rapports annuels 1937–1982) indicate moderate sawfly outbreaks for these periods, the low presence of characteristic rings made it difficult to confirm them in the studied area.

Girardin et al. (2002) showed that larch sawfly outbreaks are a major factor controlling the dynamics of larch stands in wetlands of the northern Clay Belt boreal forest. Some of Lake Duparquet's larch establishment was associated with the 1895–1912, 1955–1962, and possibly late 1970s sawfly outbreaks. The results of this study also support the hypothesis that the larch sawfly outbreaks, instead of inducing tree mortality across entire larch populations, operate at a smaller scale by creating small canopy gaps. This lead to the discontinuous age-class distributions observed among the plots and stands. In addition, results show a disparity between the timing of an outbreak and the post-recruitment period. The most severe outbreak recorded (1895–1912) was associated with a recruitment peak during and after the outbreak, whereas the less severe outbreaks (1955–1962 and the late 1970s) were associated with a recruitment peak that would have occurred few years before.

Girardin et al. (2002) suggested that, depending on the length of the sawfly outbreak, recruitment may originate from either pre-established seedlings, or greater seed production among surviving trees. This extended period of establishment after an outbreak could also have originated from the underestimation of the age of older larch trees. Further studies should be conducted in the area to characterize the size of canopy gaps and their spatial distribution.

8.3 Effects of Insect Defoliation

Spruce budworm outbreaks are large-scale events, with moderate to-severe defoliation sometimes lasting 5-15 years and populations remaining at low levels for even longer. In 1981, at the peak of the last outbreak, wood volume losses were estimated to be 16 million m^3 for Ontario alone, while the annual harvest rate was 20 million m^3. Balsam fir and white spruce are the preferred hosts, and budworm also occasionally attacks black spruce. A detailed history of spruce budworm outbreaks in Ontario has been collected since 1939 by the Canadian Forest Service, and more recently by the Ontario Ministry of Natural Resources (OMNR); this information has been useful in studying patterns of spruce budworm defoliation. A total of 41 million hectares have been defoliated at least once since 1941. Maps depicting defoliation patterns since that time show three zones of frequent defoliation, separated by longitudinal zones of lower frequency.

Effects on Age Class Distribution

The effects of insect defoliation on age class distribution will vary with the severity of the infestation, and the species mix of the stand, or forest. In light infestations, where none, or only scattered individuals are killed, there will obviously be no effect on the age class distribution. In severe infestations where all, or most, individuals in a landscape are killed, the effect on age class will be similar to that of a fire: the successional process will be re-started. In mixed forests in which only the softwoods are killed (as in instances of spruce budworm infestation) the effect on age class is more difficult to decipher.

Although the age of the stand or landscape may functionally remain the same immediately following the mortality of a significant proportion of the trees, the stands may develop a distinct two- or multi-storied appearance and take on the characteristics of an uneven-aged forest as new individuals become established as a result of reduced competition on the site. In the boreal forest, mixed hardwood/softwood forests often already have a distinct two-or multi-storied appearance because of the later emergence and/or slower growth of spruce and fir trees than the hardwoods. In these circumstances the precise age-class designation becomes more of a nomenclature issue than an ecological issue and is less important than the ecological characteristics of the site.

Effects on Species Composition

The species composition of a mixedwood stand or landscape will change as a result of severe insect infestation. Given that spruce budworm infestations usually occur in stands dominated by balsam fir and/or stands with significant components of fir and spruce, severe mortality can create opportunities for early successional species to re-assert themselves. Bergeron and Harvey (1997, 1998) note that on productive sites, mixedwood stands and early successional species remain abundant even for long fire cycles due to the constant presence and periodic outbreaks of spruce budworm. The canopy gap dynamics that follow after budworm infestation can be complex.

Effects on Growth and Yield

Infestations of tent caterpillar do not normally cause mortality even if trees are completely defoliated, because the trees produce enough new leaves to carry on essential photosynthesis (Peterson and Peterson 1992). Mortality in aspen occurs only after several successive years of severe defoliation. There is likely not much change in species composition as a result of tent caterpillar infestation, except following prolonged severe infestations, especially when accompanied by other stresses, such as drought conditions.

Defoliation caused by jack pine budworm is accompanied by decreases in radial increment of individual trees, some killing of tree tops, and occasionally by tree mortality (Volney 1988). Therefore, it does not generally result in significant shifts in species composition. Canopy gaps may be created which may be filled by other species, but at a landscape scale, little change in species composition is likely to result.

Effects on Gap Dynamics

The effect of insect infestation on patch size will depend upon the severity of the infestation, and the existing patchiness of forest cover. In severe infestations where whole stands are killed, the patch distribution of the forest may not be altered, as new patches will be created according to the size and shape of the existing stands which have been killed, so while the age class distribution will be altered, the patch distribution will not. If distinct portions of a mixedwood stand are killed, then smaller patches will be created. Similarly, if individual trees are killed that were scattered through the forest, as may be the case in disease-caused mortality and light insect infestations, then canopy gaps may be created, increasing the patchiness and structural diversity of a forest at a fine scale. On the other hand, if neighbouring patches exist defined only on the basis of differences in age class rather than species composition, and if mortality occurs in both of the adjoining patches, the effect may be to eliminate patch boundaries and create larger patches. Thus in many cases the effects of insect and disease infestations will depend upon how patches are defined. The ecological effects on patch size distribution may not be same as the statistical effects, underlining the importance of employing an appropriate mechanism and scale for designating patches (Doyon et al. 1997).

The same dynamics relevant to patch size distribution will influence patch shape and edge. Severe infestations that cause mortality of whole stands will reinforce existing stand shapes. The edge dynamics may change significantly if abutting stands of similar age, but different species composition exist (as occurs in fire-created landscapes with patchy soil regimes), in which one stand dominated by a host species is defoliated and the neighbouring stand (dominated by a non-host species) is not. Here, the edge may change ecologically as it will become defined on the basis of age rather than on the basis of (or in addition to) species composition.

In large and severe infestations, distinct patches inside disturbances may be created if islands of dissimilar species exist within a landscape dominated by host species. Kneeshaw and Bergeron (1996, 1998) describe the patchy manner in which spruce budworm infestations affect mixedwood forests. The species makeup of small, recolonized patches are different from those of large patches, which will significantly change the patch dynamics of the forest.

Insect Infestations and Coarse Woody Debris

When insect- and disease-killed trees fall, the amount of coarse woody debris is increased (David et al. 1993), and the ecological attributes of these structures come into effect. Because killed trees do not fall immediately, and because trees may not die immediately, both disease and insects facilitate temporal continuity in the supply of coarse woody debris in a stand.

The propensity of defoliated stands to be prone to fire complicates the interpretation of the ecological effects of budworm and other forest insect pests.

8.4 Possible Impacts of Climate Change

In Canadian forests, outbreaks of insects and diseases cause significant losses to the quantity and quality of available wood (Candau and Fleming 2012). These losses are estimated to be 80-110 million m^3 of timber per year, which is more than half the annual rate harvested of 160-180 million m^3 per year. Large outbreaks that result in significant tree mortality also increase the risk of fire and susceptibility of the forest to other insects and diseases. Changes in forest composition can also affect wildlife populations by altering habitat and food sources. The changing climate – average temperatures in North America are predicted to increase by 5-10º C by the end of the century – will accentuate the impacts of pest infestations even more. This warming trend will lead to changes in the geographic distribution of tree species and alter the frequency and intensity of pest outbreaks. Although the degree of change is unclear, the resulting impacts will affect forest management planning, wood supply projections and pest protection programs. In light of these expected changes, scientists Jean-Noel Candau and Richard Fleming of GLFC are developing models to predict how impacts of spruce budworm outbreaks may change in the future, based on historical records of past outbreaks and climate scenarios over the next 30 years.

Candau and colleagues predicted the effects of climate change on the frequency and spatial pattern of spruce budworm defoliation for the period 2011-2040 by applying their bioclimatic model to 6 future climate scenarios. Researchers expected that the model would show an increase in frequency and duration of outbreaks as temperatures rise, because a warming climate would improve spruce budworm growth, survival and reproduction. All of the climate scenarios projected broadly similar changes in the patterns of defoliation: (1) an extension of the northern limit of defoliation; (2) a decrease in the frequency of defoliation in the center of the historical defoliation belt; (3) persistence of the southern limit of defoliation. These changes will cause an overall increase in the total area of expected defoliation compared to the previous period (1967-1998). However it appears that the mean frequency of defoliation calculated over the whole study area would decrease or only slightly increase compared to 1967-1998.

8.5 Wind and Windthrow Effects

Age is a main consideration in the susceptibility of boreal forest stands and trees to windthrow. Generally, old stands and trees are thought to be more susceptible (Attiwill 1994), although Kimmins (1997) suggests that large trees in multi-canopy forests tend to be windfirm because they have been exposed to wind stress for much of their life. In the boreal forest, mature black spruce is generally thought of as particularly susceptible to windthrow due to its shallow rooting habit and form, however, jack pine on shallow soils is also very susceptible. On a landscape scale, topography is a significant factor influencing blowdown. Hilltops, ridges, and other more exposed places are more likely to incur blowdown damage than are valleys or protected sites (Kimmins 1997).

There have been few attempts to calculate a return time for catastrophic windthrows (in contrast to the scores of attempts to calculate fire return times). Canham and Loucks (1984) and Frelich and Lorimer (1991) calculated a return time of 1,000-2,000 years for pre-settlement forests in northern Wisconsin, and for hardwood-hemlock forests of the Upper Great Lakes Region (northeastern U.S.A.) respectively. Frelich and Lorimer (1991) estimated that hardwood forests within the range of white pine experience (non-catastrophic) windthrow mortality of 10 percent every 70 years on average.

Disturbance by wind occurs over a size continuum. In instances in which small numbers of trees are blown over in one or a few stands, the age class distribution of the forest will not change. In multi-canopied forests, blowdown is one mechanism by which the all-aged configuration is maintained. At the other extreme, in large areas which are flattened by windthrow, the age class distribution will be reset to early successional stages. In mixed forests where susceptible species succumb, but windfirm species hold, the age class distribution will be changed to reflect the variable effects. This might occur, for example, in landscapes with an intermingling of poorly drained sites dominated by black spruce, and upland sites on which aspen or other deep-rooted species were more prevalent.

The effect of windthrow on species composition of the forest will depend on the sites affected. Mixedwood sites severely affected by windthrow will likely revert to early successional stages and undergo successional processes similar to those described above if most or all trees are affected. However, the successional pathways will be different if the effects vary by species, for example, if conifer species succumb to wind, but hardwoods do not, the same ecological conditions fostering root suckering by aspens will not exist, as they would following a fire. Furthermore, windthrow can create good conditions for conifer establishment if areas of exposed mineral soil are created by upturned roots, fostering regeneration of conifers in gaps. Frelich (1992) indicated that catastrophic windthrow is generally not favorable to white pine establishment, although a few white pine generally occur in post-blowdown stands; he reports only one documented instance of heavy white pine recruitment after windthrow.

The effect may also depend somewhat on the age of the stands. In old mixedwood forests with a significant shrub component, a windthrow event could create circumstances in which re-establishment of tree cover is impaired if shrubs are firmly established and do not succumb to the wind. Clearly, windthrow effects on species composition at the stand level will vary and are site-specific, depending on the initial stand structure and species composition, the windfirmness of the various stand structural elements (e.g., overstorey versus understorey), the severity of the windstorm, and the local topography.

The effect on patch size distribution will depend on the extent and nature of the windthrow event and on the substrate and edaphic nature of the forest. If all trees in a large area succumb, existing patch configurations will be obliterated. However, given that patches are often a function of substrate, one would expect regeneration patterns to again reflect the substrate and the eventual patch size distribution may reflect that of the original blown down forest. In the interim, however, until species differences in patches are evident, the patch configuration of the forest may be different or indistinct.

If the blowdown is of a patchy nature either due to topography of the patchy coverage of stands of varying susceptibility, the resulting forest cover will reflect the patchy nature of the blowdown event. In a situation in which a monotypic pattern of stands exists in spite of differences in topography, a patchy forest may result if exposed stands experience blowdown and protected ones do not.

The same dynamics which affect patch size distribution also affect the shape of patches. In areas in which some stands are not affected, either by virtue of their safer topographic setting, or differences in tree species composition and structure, a greater amount of edge, and/or more distinct edges may be created.

Isolated or single-tree blowdowns will not affect the amount of edge, since the edge concept is used to define the area of abutting stands of ecosystems. In cases where a single tree or small groups of trees blow down, the affect will be the creation of intra-stand gaps.

The likely effects of blowdown on stand species and age mixtures can be summarized as follows:

- the age of a stand will not be affected by the blowdown of a single tree, although such events may be important in maintaining the multi-layered features of some stands;
- the age mixture of a mixed species stand could change if susceptible species are blown down and windfirm ones are not; and
- large scale blowdowns will initiate successional processes in a stand, although the successional pathways may be different from those which follow fire.

In the eastern boreal forest of Ontario and Quebec, ecosystems can be affected by several episodes of windthrow, both partial and stand-replacing, which make windthrow one of the most important types of natural disturbance in the region (Waldron et al. 2013). The higher occurrence of windthrow in the eastern compared to the western part of the boreal forest can be explained by the longer fire cycle in the former (Bouchard et al., 2008).

Windthrow creates attributes and biological legacies within ecosystems, including dead wood, pit-and-mound microtopography, and seedbed diversity (Beatty and Stone, 1986; Schaetzl et al., 1989; Ulanova, 2000). The ecological importance of snags and woody debris on the ground has been demonstrated repeatedly (Siitonen, 2001; Jonsson et al., 2005). Moreover, organisms that use dead wood are associated with either one or with many specific categories of dead wood and, thus, decay class and size both play a role from an ecological standpoint (Caza, 1993; Siitonen, 2001; Jonsson et al., 2005). Pit-and-mound microtopography refers to the slight surface elevations and depressions that are formed by tree uprooting. Uprooting mixes the soil, increasing nutrient element availability (Beatty and Stone, 1986; Ulanova, 2000). In certain forest ecosystems, these features can cover a relatively high proportion of the forest floor (Ulanova, 2000). This particular form of microtopographic disturbance also exposes or creates a variety of seedbeds, thereby promoting the germination and the growth of different plant species (Peterson and Campbell, 1993; McCarthy, 2001). Highly decomposed downed CWD is used by many deadwood-dependent organisms (Siitonen, 2001; Vaillancourt et al., 2008; Jacobs and Work, 2012) and, thus, the substantial amounts of wood occupying advanced decay classes after windthrow could have a major ecological role.

Pham et al. (2004) conducted studies to characterize gaps and examine patterns of species replacement in gaps in old conifer stands. Line intersect sampling was used to sample stands dominated by balsam fir (Abies balsamea (L.) Mill.) and (or) black spruce (Picea mariana (Mill.) BSP). Results show that 54% of the forest was in expanded gaps and that canopy gaps were relatively small, since 87% of them were smaller than 100 m^2. The majority (94%) of the openings were caused by the mortality of less than 10 gap makers. Replacement probabilities show self-replacement of A. balsamea in Abies stands and of P. mariana in Picea stands. However, in Abies–Picea stands, there seems to be a reciprocal replacement of the two species. These results provide knowledge of the disturbance dynamics of the region as a basis for development of silvicultural practices that preserve the structural components of older forest stands.

White spruce (Picea glauca (Moench.) Voss.) is frequently found in association with balsam fir (Abies balsamea (L.) Mill.) in virgin stands. However, its regeneration is less aggressive than that of balsam fir. The persistance of white spruce in the canopy might be explained by differential mortality and windthrow. Windthrow could play an important role in creating favourable seedbeds and providing increased light.

Ruel et al. (2002) examined the contribution of windthrow for white spruce regeneration in balsam fir-dominated forests. Experimental windthrows were created and regeneration establishment monitored for three seasons. Windthrow greatly modified the availability of seedbeds and enhanced white spruce establishment. Older natural windthrows were sampled to conclude that this effect was still evident more than five years after windthrow occured. They also noticed that white spruce benefited more from the disturbance than did balsam fir. Finally, sampling conducted in mature stands showed that mature white spruce stems were more abundant on the mounds created by old uprootings, indicating that this effect is maintained in the long term. Even though balsam fir also benefited from windthrow, the benefit was proportionally greater for white spruce.

Ruel (1995) reviewed forest characteristics that promote resistance to windthrow. Climate affects the severity and frequency of storms. However, wind speed in a particular stand is influenced strongly by local topography. Soil and root characteristics determine the sturdiness of the anchoring system. Many stand-related factors, such as stand height, age, density and stem form, can also exert an influence on the resistance to uprooting. Silviculture can modify the vulnerability to windthrow by acting on these factors. In stands at risk, stripcutting, thinning or the creation of new margins can cause important losses. The impact of stem form also indicates the need for an early control of stand density.

8.6 Recorded Windstorms, Blowdown and Frost Events on the Pic River and Big Pic Forests

Wind damage has from time-to-time caused minor timber losses on the Big Pic Unit. Often such damage is associated with old, decadent stands. However, on occasion, healthy mature stands can be affected. About 1948 a severe windstorm caused extensive wind damage particularly in portions of Kagiano Working Circle. In 1973 a severe windstorm that crossed northwestern Ontario resulted in numerous small patches (up to 100 acres or so) of windfall throughout the northern portions of Stevens, Hillsport and Nagagami Working Circle. Other small areas of windfall can be found throughout the Unit. Although wind damage results in a loss of merchantable timber, windfall areas quickly regenerate, often to balsam fir with some spruce mixed in, or to white birch with some aspen. When windfall occurs on black spruce sites, regeneration of these areas may be slower and the trees more scattered.

Wind damage to forest stands can be found throughout the forests of the Unit but it has been significant only in one location near Kagiano lake. There, a large windstorm in the late 1940s caused heavy blowdown that rendered large areas unmerchantable. Since then, these areas have regenerated mainly to balsam fir. These dense stands of young fir would be susceptible to further damage by any future outbreak of spruce budworm. Extensive blow down in burned areas has also been a common occurrence on the Big Pic[1].

The most important abiotic damage encountered on the Unit is the mortality of new shoots resulting from late spring frosts. This is most serious on young, open-growing white spruce and balsam fir that usually start growing prior to the time when all danger of killing frost is gone. The other tree species are only

[1] Personal communication, Alex Blakie, 2013.

infrequently affected in this way. The fact that frost damage has so frequently occurred on young white spruce regeneration in the past has management implications on this Unit.

8.7 Forest Diseases and Their Effects

The boreal forest is host to a wide variety of tree diseases (Davis and Meyer 1997). Although some diseases have a periodicity associated with their occurrence, most exist continuously at endemic levels, causing local or gap effects in the forest. For two reasons, forest diseases rarely have landscape-scale age-class effects similar to those of fire and insect infestation. First, they rarely occur in a contiguous fashion over large sections of the landscape, and second, the effects of most diseases are insidious, causing altered growth, deformation characteristics, and injury rather than sudden death. Yield curves prepared for forest modelling, which are usually calibrated with local data, generally take into account the “normal” effects of forest diseases on stand volume losses over time.

Whitney (1989) investigated the prevalence of root rot and but rot in 165 spruce and balsam fir stands across boreal Ontario. He found that 16, 11, and 6% respectively of balsam fir, black spruce, and white spruce trees were killed, or experienced premature windfall as a result of root and butt rot, and that 87, 68, and 63% of dominant or codominant trees of these species showed signs of root decay. The death of these trees will contribute to the nutrient cycling of the forest and to the volume of coarse woody debris.

Impact of Tree Diseases

Damage by tree diseases includes mortality, growth reduction, decay, deformation, and predisposition to windfall or to other pests (Whitney 1983). Several of these conditions can be present simultaneously, and they usually intensify over time. Other losses caused by tree diseases include delayed regeneration, stocking deficiencies, changes in stand composition, degeneration, and reduced management options through the loss of disease-susceptible species such as white pine, American elm, and American chestnut.

Quantifying these damage factors as losses is often very difficult, and calculating economic loss is even more difficult. Also, the economic loss in productivity, e.g., when a stand has to be liquidated before reaching maturity and the resultant product has a lower value, should be taken into account. However, except possibly in the case of Dutch elm disease and white pine blister rust, there has been little or no perceived effect of tree diseases on Canada's economy or standard of living. This is because much of Canada's timber harvesting has been in virgin stands. Dead or defective trees, lost increment and poor stocking attributable to diseases or other causes have accounted for little economic loss in these cases because there has been no investment in the stands. Only harvesting and transportation costs increase if more trees have to be harvested to offset volumes lost to diseases. As pointed out by Stiell (1976), "[the intensification of forest management is inevitably accompanied by a sharper awareness of forest enemies."

Where money has been spent on plantations, the potential impact of any pest is important. Unfortunately, many forest managers are unaware of disease losses until they are catastrophic. It is therefore imperative that the effects of tree diseases on present and future volumes be accurately assessed and the information published. Anomalous situations must be clarified. For example, a conspicuous disease such as aspen shoot blight causes little loss, while an inconspicuous disease such as *Armillaria* root rot causes large losses. "The most urgent need in forest pathology today is improved understanding of the magnitude of losses. . . only in this way can appropriate guidelines be provided for our forest research and advisory services." (Horsfall and Cowling 1977). It is also likely that climate change will affect the prevalence and impacts of forest diseases in the boreal forest in the future.

8.8 Tree Diseases on the Pic River and Big Pic Forests

To date, tree diseases have not been an obvious factor on the two Management Units and there are no tree diseases currently found on or near the Forests that are liable to build up to epidemic levels (Anon. 1987). There are, however, a number of tree diseases that do cause minor problems from time to time. *Fomes igniarius* is a very common cause of stem rot in aspen and the presence of fruiting bodies on the stem usually precludes the use of that tree for veneer. It is a disease impossible to control, but since studies by Basham in 1960 show that its incidence and severity increase with stand age, slower growth rates and with lower site quality management techniques can be developed which should minimize the effects of the disease. Balsam fir has been recognized as a short-lived tree that develops root and butt- rot at an early age. Three commonly occurring fungi cause the bulk of this rot: *Armillaria mellea*, *Stereum sanguinolentum* and *Polyporus tomentosus*. These diseases can be found on black and white spruce but are not quite as virulent as on balsam fir. Since they are indigenous organisms that become more serious with increasing tree and stand age, management techniques such as harvesting at an earlier age or substituting the more susceptible trees with species that are more resistant should minimize effects of the diseases.

During the 1960's *Gremeniella abietina* (*Scleroderris* canker) was identified in several locations on the Big Pic as causing serious mortality to young planted and naturally originated jack pine regeneration. As the trees in these locations grew larger, it became evident that, once the regeneration reached about six feet in height, it had largely outgrown the serious effects of the disease. Although there is considerable debate as to whether the disease is indigenous to the Big Pic or was introduced by infected nursery stock, it appears that it is now well established and may pose serious problems from time to time on young (up to five year old) jack pine regeneration, particularly nursery stock that are characteristically weakened for a time following outplanting and may, therefore, be more susceptible to infection.

Armillaria mellea has been identified as the most serious cause of root and butt rot in Ontario. On mature timber it may result in lower merchantable volumes resulting from butt rot or in losses due to windfall. On young regeneration it can result in stocking reductions to undesirable levels and it may turn out to be particularly serious in plantations where some root deformation and mortality usually result from the outplanting operation. *Hypoxylon* canker of poplar, while occurring in poplar stands throughout the Big Pic, is not thought to be an important volume-reducing disease.

9 Documenting the Historical Ranges for Red Pine and White Pine, and the Locations and Status of Specific Occurrences

The history of forestry in Ontario, during the nineteenth and twentieth centuries, can be traced directly to the harvesting of red pine (*Pinus resinosa* Ait.) and white pine (*P. strobus* L.). The importance of these two species in the province is evidenced by the number of studies that have been initiated by the Ontario Ministry of Natural Resources (OMNR) to address the knowledge gaps relating to the occurrence and distribution of the species. As a result of these studies, there is a general perception that the present range of the two species is somewhat narrower within the province than it was historically, with the erosion of the distribution occurring mainly in the north, along the edge of their natural ranges.

Documentation of the historical and present-day ranges of red pine and white pine was accomplished by conducting a literature search and review of publications related to the historical ranges of red pine and white pine; and a review of historical government and industry records (e.g., scaling records, harvest records, forest resource inventory maps) related to the occurrence and management history of the two species.

Initially, a search of published literature related to the ecology, management history, and historical ranges of white pine and red pine was conducted. This material provided background information that assisted in the location of present-day occurrences of pine. Of particular value was the work of Haddow (1948a; 1948b) who developed range limits for red pine and white pine, approximately fifty years ago. Haddow's work was comprehensive, providing an excellent basis for historical range mapping. He also documented specific occurrences of the two pine species at the northern limit of their ranges, including those located north of the range limit. These records were also used to provide an initial database for checking present-day pine occurrences.

The locations of Haddow’s pine occurrences were transferred to a set of 1:250 000 scale National Topographic Series (NTS) base maps. Locations were determined for each occurrence, in decimal latitude and longitude units, and in grid (UTM) coordinates. The pine occurrence record data were then entered into a computer database, which includes notes on each site (size, number and distribution of pine trees, whether it still exists.

9.1 Ecological Characteristics of Red and White Pine Related to their Potential Ranges

The western range limit of white pine occurs approximately at the point where precipitation equals evapotranspiration (Jacobson 1992). West of this isoline, conditions are too dry for adequate white pine regeneration. The species also does not perform well where conditions are too moist or too cold, essentially restricting its present potential range to the Great Lakes-St. Lawrence Forest Region and to the southern part of the Boreal Forest in Ontario. In the Boreal Forest, white pine typically occurs on warmer than normal ecoclimates. The northern botanical limit of white pine occurs where the mean length of the frost-free season drops below 2400 degree-days (Horton and Bedell 1960).

The northern distribution of red pine is determined by a deficiency of summer heat. Its northern botanical limit roughly parallels the 2ºC mean annual isotherm (Anon. 1974). Cold temperatures restrict the development of red pine at all ages. Excessive heat restricts the development of young seedlings. These characteristics of white pine and red pine raise the possibility of predicting the potential range for each species by mapping the limiting bio-geoclimatic factors.

9.2 Post-glacial Changes in Pine Distribution

The distribution and abundance of white pine has varied greatly across northeastern North America since the most recent glaciation. The earliest post-glacial fossil pollen records for white pine date to approximately 13,000 years ago in the Shenandoah Valley of Virginia (Craig 1969), and it is assumed that the species spread northwards from that region.

White pine reached its northernmost extent about 4,000 years ago, when it was present across much of Ontario, including the James-Hudson Bay lowlands area. Since then, the range of white pine has steadily decreased. This decline has been related to climatic changes over the same period (Jacobson 1992). The advent of cooler, moister conditions allowed the spread of boreal tree species southward, supplanting pine on many sites.

9.3 Pine Harvesting History

The history of the province of Ontario is closely related to the harvest of eastern white pine and red pine (Aird 1985). Beginning in the late 1700's, the pine square timber trade forged important commercial and political links with Quebec and England, and later with the United States, European countries, and South America. This generated the capital and jobs needed to support the development and settlement of Ontario. The peak year for the square timber trade was 1864.

After 1867, the square timber trade declined and the trade in sawlogs increased. The market gradually shifted from the square timber trade with Britain to trade in sawlogs with the United States. High U.S. demand for Canadian pine lumber and logs promoted a new boom in the pine harvest. The peak year was 1896, when over 4 million m^3 were harvested in Ontario. In 1898, the Ontario government prohibited the export of sawlogs harvested on Crown lands. All logs harvested on Crown lands had to be sawn in Canada. This promoted the establishment of new mills, jobs and towns in northern Ontario.

The annual harvest from the pine forest has declined steadily ever since the peak years just prior to 1900. The harvest has declined for a number of reasons, including the dwindling supply of virgin pine stands. The 19th century loggers removed the prime pine first, returning later for a second cut. Almost all stands had been cut at least once by the turn of the century. The combination of logging, destruction by fire, and, until recent years, the lack of reforestation efforts has led to a decline in the supply of pine in Ontario. In recent years, the sawlog production levels for red pine and white pine have fluctuated about a level approximately one-fifth that of the peak levels in the late 1900's (Aird 1985).

9.4 Summary of Historical Range Mapping Efforts

The first attempt at mapping the northern limits for principal timber trees in Canada was completed by Robert Bell in 1880. Robert Bell was the Assistant Director of the Geological Survey of Canada and received a Diploma at the International Forestry Exhibition in Edinburgh for the production of this map. The map showed the general northern limits of the principal forest trees of the Dominion of Canada and was the result of observations made chiefly by Bell himself, as well as botanists and lumbermen, over the previous 25 years. Members of the Geological Survey also contributed to the data set as nearly all reports of the Survey between 1857 and 1879 contained information on forest trees.

The map prepared by Robert Bell was accompanied by a report (Bell 1882) that outlined the methodology utilized to derive the northern limits of the species. A.T. Drummond (1879) presented an earlier version of the same map in lectures delivered before the Montreal Natural History Survey and the Montreal Horticultural Society and Fruit Growers Association in 1873 and 1879 respectively. Bell claimed that the northern limit line presented in his 1882 document were corrected and revised compared to the earlier mapping attempts by Mr. Drummond. Bell suggested that the lines were meant to indicate the area in which the species were known to exist, and therefore, represented general boundaries. He acknowledged that occasional or chance trees and poor representations occurred beyond these limits.

In describing the northern limit for occurrences of red pine and white pine, Bell noted that in Ontario the line closely followed the height of land dividing the waters of the Great Lakes-St. Lawrence and the Hudson Bay watersheds. He speculated that this was not the result of great elevation changes but that it might be coincident upon isothermal lines. Bell indicated that white pine had been found at the head waters of all the principal branches of the Moose River and speculated that at one time it occurred further north along these rivers and streams but had been removed by forest fires. The principal reserve of white pine in 1886 occurred between the Lake Timiskaming region and the eastern shore of Lake Superior and had been virtually untouched at this time. Bell described the area north of Lake Superior to have very scattered populations of red pine and white pine as far north as the line indicates, but forest fires were again blamed for removing these species from the landscape. In the area between Lake Superior and the Winnipeg River, populations were said to be scattered and the trees small in size.

The early efforts at mapping the northern limits of the two species by Bell and Drummond represent important information on the historic occurrences of red pine and white pine. It is difficult however, to assess the reliability of the information (i.e., the location of the northern limit line) because the line itself is the only data provided. The number of stations used to estimate the limit is not stated nor is any indication given of the size of the populations observed. Although the authors state that occasional or chance trees or poor representations are not included within these boundaries, it is conceivable that disjunctive populations were included. Therefore, the line purported by Bell and Drummond may not be a true representation of the historic range of red pine and white pine in the late 1800's. In addition, the technology available for mapping at this time did not provide the standards of accuracy that are demanded today.

W.R. Haddow (1948a) indicated that little accomplishment had been made to further define the northern limits for red pine and white pine in Ontario since Bell's map was produced in 1880. Since the turn of the century, exploration and development had occurred at a great rate in Canada and new and appropriate observations were not incorporated into the forest geography literature (Haddow 1948a). Haddow speculated that exploitation of pine timber in Ontario over the 200 years previous to 1948 greatly modified the natural distribution of species, but that the northern limit in Ontario had remained comparatively undisturbed, until recent to 1948.

Haddow chose a base line for the northern limit of red pine and white pine in northern Ontario from "common knowledge" for his study. The base line was said to separate the general population of red pine and white pine from areas where occurrences were considered local, sporadic or rare. The line chosen was as follows:

> *From the Quebec boundary westward along the height of land portage on the Michipicoten-Missinabi route to Moose Factory; thence southwesterly along that route to Michipicoten and westerly along the shore of Lake Superior to the head of Black Bay; thence along the northern boundary of the township of Dorion and its projection due west through Dog Lake to the Canadian National railway, and along that line through Sioux Lookout and Kenora to the Manitoba border.* (Haddow 1948a).

The base line chosen by Haddow was located further south than the northern limit estimated by Bell (1882), especially in the north-central portion of Ontario directly north of Lake Superior. Bell (1882) did indicate that the populations found in this area were sparse and scattered so the location of the base line along the north shore of Lake Superior by Haddow (1948a) is likely justifiable.

Haddow (1948a) sought to record all occurrences of red pine and white pine north of the baseline described above. His data was collected primarily from reports of land surveyors of the Office of the Surveyor General of Ontario in addition to personal and correspondents observations. Land surveyors conducted explorations, meridian and base line surveys, created township subdivisions and conducted lake and river traverses. In their reports, they regularly described the forest conditions they encountered and particularly noted the occurrence of red pine and white pine, largely due to their conspicuous nature and their importance to the forest industry at the time. The dates of these survey reports ranged from 1881 to 1946, and for the most part, pre-date forest harvesting in the area. The results of Haddow's research includes a list of stations where red pine and white pine occurred, by township (Haddow 1948b), and three maps detailing the location of these occurrences within the municipal districts of Algoma, Cochrane, Sudbury, Timiskaming, Thunder Bay and Kenora.

Maps indicating the botanical ranges of red and white pine have been presented more recently in a number of documents (e.g., Fowells 1965; Hosie 1990), but these maps have been based on the previous work of Haddow and Bell.

9.5 Ranges Maps and Notes for Other Species

Bell (1882, 1886) and Drummond (1879) conducted surveys and compiled information from other sources to map the ranges of all tree species they encountered in Ontario. Copies of these maps and the supporting documents are provided in Appendices (i.e., scans of documents and maps on CD). Of particular interest are the northern limits of the ranges of the less common tree species in boreal Ontario: black ash, white elm, large-tooth aspen, sugar maple, and yellow birch. Figure 19 is a map provided by Haddow (1948a) showing the locations of red and white pine occurrences along the northern limit of their range that were confirmed to exist in the field in his 1947 study.

The current FRI for the Big Pic and Pic River Forests lists a number of stands containing components of tree species that are uncommon on the land base, including white pine, red pine, maples, and black ash. These are shown in Table 15. For stands containing at least 10% of these species, there are 2 stands with white pine, 12 with red pine, 1 with sugar maple, 2 with red maple, and 41 with black ash. Total area occupied by these stands is shown in Table 14. Note that list includes a number of plantations of red pine and that have also been established on the Pic River and Big Pic Forests.

Table 14. Total Area of stands containing uncommon species within the Pic River and Big Pic Forests.

Species	Area (ha)
Pw	24.0
Pr	77.1
Mh	0.7
Ms	22.9
Ab	459.5
Total	584.2

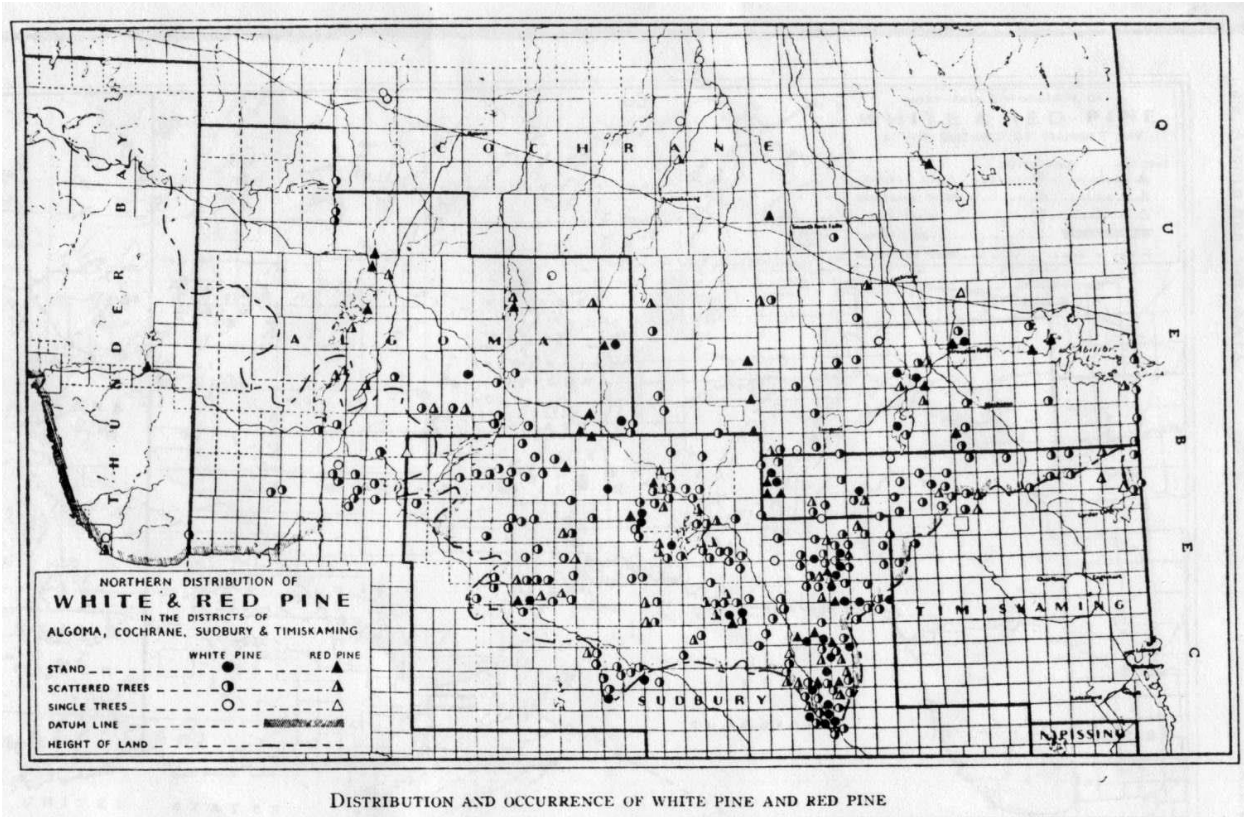


Figure 19. Haddow's 1948 map showing the location of red and white pine occurrences confirmed to exist, from Bell and Drummond's original reports.

Table 15. List of stands containing uncommon tree species (red pine, white pine, maple, black ash) occurring on the Big Pic and Black River Forests, sourced from the current eFRI (2016 update).

OBJECTID	POLYID	DEVSTAGE	Year of Origin	Age (yrs)	Species Composition	Species of Interest	Lead Species	Height (m)	Crown Closure	Site Class	Primary Ecosite	Stocking	Area (ha)
60867	165605430-0117	FTGNAT	1878	129	Sb 50Pt 30Pw 20	Pw	Sb	24	60	0	B099TtD n	0.6	21.9
74275	165705490-0391	LOWNAT	1868	139	Pw 60Sb 30Sw 10	Pw	Pw	15	25	3	B070TtD n	0.2	2.1
58656	165205400-0601	FTGPLANT	1962	46	Pr 100	Pr	Pr	14	80	2	B033TtD n	0.8	2.7
58657	165205400-0602	FTGPLANT	1962	46	Pr 100	Pr	Pr	14	80	2	B033TtD n	0.8	8.3
58667	165205400-0612	FTGPLANT	1962	46	Pr 90Sb 10	Pr	Pr	14	80	2	B033TtD n	0.8	7.4
58669	165205400-0614	FTGNAT	1962	46	Pr 90Sb 10	Pr	Pr	14	80	2	B033TtD n	0.8	10.4
58670	165205400-0615	FTGPLANT	1962	46	Pr 80Sb 10Bw 10	Pr	Pr	14	90	2	B033TtD n	0.9	4.8
58671	165205400-0616	FTGPLANT	1962	46	Pr 80Sb 10Bw 10	Pr	Pr	14	90	2	B033TtM n	0.9	4.1
58673	165205400-0618	FTGPLANT	1962	46	Pr 80Sb 10Bw 10	Pr	Pr	14	90	2	B048TtM n	0.9	1.8
58676	165205400-0621	FTGNAT	1934	74	Bw 50Sb 30Pr 20	Pr	Bw	15	70	3	B040TtD n	0.7	6.7
58677	165205400-0622	FTGNAT	1934	74	Bw 60Sb 20Pr 20	Pr	Bw	15	80	3	B055TtM n	0.8	3.8
61384	165605440-0013	FTGNAT	1968	39	Pr 60Bw 20Sb 10Pj 10	Pr	Pr	14	100	2	B055TtD n	1.0	16.0
82193	165905460-0680	NEWPLANT	1991	16	Sb 70Pr 20Bw 10	Pr	Sb	2	50	1	B050TlD n	0.5	2.5
82367	165905460-0857	FTGNAT	1905	102	Bw 30Bf 30Sb 20Pr 10Sw 10	Pr	Bw	18	60	2	B050TlD n	0.6	8.6
51168	165505420-0716	FTGNAT	1953	55	Mh 50Bw 40Pt 10	Mh	Mh	15	85	1	B058TtM n	0.8	0.7
1416	165405400-0890	FTGNAT	1933	75	Bw 70Ms 20Sb 10	Ms	Bw	15	75	3	B016TtVSn	0.7	4.1
1551	165405400-0844	FTGNAT	1893	115	Bw 50Sb 10Sw 10Bf 10Pt 10Ms 10	Ms	Bw	14	55	3	B040TtM n	0.5	18.8
14727	165205420-0596	FTGNAT	1927	80	Bw 70Ab 20Cw 10	Ab	Bw	14	75	3	B119TtM n	0.7	2.1
29586	165905410-0049	FTGNAT	1927	80	Pt 40Pb 40Sw 10Ab 10	Ab	Pt	25	50	2	B114TtD n	0.5	4.5
32843	166105440-0403	FTGNAT	1927	80	Pt 40Bw 30Sw 20Ab 10	Ab	Pt	26	80	2	B055TtM n	0.8	22.7
37199	166105450-0600	FTGNAT	1924	83	Ab 50Pt 30Sw 10Pb 10	Ab	Ab	26	90	0	B071TtD n	0.9	12.8
37317	166105450-0567	FTGNAT	1927	80	Pt 50Ab 20Bw 10Sw 10Sb 10	Ab	Pt	26	60	2	B070TtD n	0.6	32.7
37319	166105450-0694	FTGNAT	1922	85	Pt 60Bw 20Bf 10Ab 10	Ab	Pt	26	70	2	B055TtM n	0.7	18.5
37369	166105450-0568	FTGNAT	1927	80	Bw 50Pt 20Ab 10Sw 10Sb 10	Ab	Bw	18	80	2	B055TtD n	0.8	61.4
37491	166105450-0264	FTGNAT	1924	83	Pt 40Bw 30Sw 10Ab 10Bf 10	Ab	Pt	25	90	2	B055TtM k	0.9	13.5
37542	166105450-0215	FTGNAT	1922	85	Pt 90Ab 10	Ab	Pt	25	80	2	B055TtD k	0.8	12.9
37669	166105450-0116	FTGNAT	1922	85	Pt 60Bw 20Ab 20	Ab	Pt	25	60	2	B055TtD k	0.6	63.4
37844	166205450-0073	FTGNAT	1887	120	Sb 50La 30Ab 20	Ab	Sb	17	50	1	B128TtD n	0.5	3.9
40790	165005400-0008	FTGNAT	1908	100	Sb 50Bw 30Ab 20	Ab	Sb	11	60	3	B012TtVSn	0.6	4.0
41498	165005400-0739	FTGNAT	1895	112	Bw 50Pb 20Sb 20Ab 10	Ab	Bw	10	90	4	B133TlD n	0.9	1.5
41969	165105400-0445	FTGNAT	1898	110	Sb 70Bw 20Ab 10	Ab	Sb	12	70	3	B012TtVSn	0.7	7.5
41974	165105400-0450	FTGNAT	1908	100	Sb 70Bw 20Ab 10	Ab	Sb	15	40	2	B128TtD n	0.4	2.6
41984	165105400-0460	FTGNAT	1898	110	Sb 60Ab 10Bw 10La 10Bf 10	Ab	Sb	12	35	3	B128TtD n	0.3	9.8
42034	165105400-0510	FTGNAT	1918	90	Sb 60Bw 30Ab 10	Ab	Sb	12	70	2	B065TtD n	0.7	8.7
42181	165105400-0657	FTGNAT	1888	120	Bw 50Sb 30Sw 10Ab 10	Ab	Bw	14	70	3	B055TtM n	0.7	8.0

OBJECTID	POLYID	DEVSTAGE	Year of Origin	Age (yrs)	Species Composition	Species of Interest	Lead Species	Height (m)	Crown Closure	Site Class	Primary Ecosite	Stocking	Area (ha)
42855	165305450-0447	FTGNAT	1923	84	Cw 40Bf 30Sb 20Ab 10	Ab	Cw	11	40	2	B128TtD n	0.4	9.8
44349	165305470-0786	FTGNAT	1967	40	Pt 50Sb 20Cw 20Ab 10	Ab	Pt	15	75	3	B104TtM n	0.7	11.9
44360	165305470-0798	FTGNAT	1897	110	Cw 40Bw 20Sb 20Pt 10Ab 10	Ab	Cw	17	50	1	B100TtM n	0.5	9.3
47176	165405450-0801	FTGNAT	1897	110	Sb 40Bf 20Ab 20Sw 10Bw 10	Ab	Sb	12	60	3	B114TtD n	0.6	5.3
48774	165405470-0719	FTGNAT	1967	40	Pt 30Sb 20Bf 20Cw 10Bw 10Ab 10	Ab	Pt	16	50	2	B055TtM n	0.5	6.9
48783	165405470-0728	FTGNAT	1957	50	Bw 30Sb 30Pt 20Cw 10Ab 10	Ab	Bw	16	75	2	B055TtM n	0.7	4.1
48798	165405470-0743	FTGNAT	1952	55	Bw 30Sb 30Cw 10Sw 10Ab 10Pt 10	Ab	Bw	16	60	2	B055TtM n	0.6	9.0
49044	165405470-0997	FTGNAT	1897	110	Cw 50Sb 20Ab 20Pt 10	Ab	Cw	11	35	3	B100TtM n	0.3	1.7
49154	165405470-1109	FTGNAT	1972	35	Bw 40Sb 30Pt 10Pj 10Ab 10	Ab	Bw	11	75	2	B104TtM n	0.7	9.5
49885	165405480-0544	FTGNAT	1887	120	Cw 50Sb 30Ab 10Bw 10	Ab	Cw	14	55	2	B129TtD n	0.5	18.4
50683	165505420-0230	FTGNAT	1952	55	Bw 50Sb 40Ab 10	Ab	Bw	10	40	4	B070TtD n	0.4	6.7
53977	165505450-0571	FTGNAT	1858	149	Sb 40Bf 30Bw 20Ab 10	Ab	Sb	7	60	4	B065TlD n	0.6	8.7
54079	165505450-0674	FTGNAT	1895	112	Sb 70Pt 10Ab 10Bw 10	Ab	Sb	17	40	1	B114TtD n	0.4	6.0
58077	165205400-0017	FTGNAT	1936	72	Bw 70Sb 20Ab 10	Ab	Bw	14	50	3	B070TtD n	0.5	1.5
62029	165605440-0664	FTGNAT	1980	27	La 40Sb 20Pt 20Pb 10Ab 10	Ab	La	4	50	2	B128TlD n	0.5	10.1
69362	165705440-0108	FTGNAT	1970	37	Sb 70La 20Ab 10	Ab	Sb	7	80	1	B114TlD n	0.8	3.7
80064	165805490-0808	FTGNAT	1848	159	Sw 40Sb 40Ab 10Cw 10	Ab	Sw	22	30	0	B115TtD n	0.3	7.2
85143	165905490-0609	FTGNAT	1923	84	Sb 60Ab 30Bw 10	Ab	Sb	9	60	3	B127TtD n	0.6	3.2
85517	165905490-0985	FTGNAT	1883	124	Cw 50Ab 30Sb 20	Ab	Cw	12	26	3	B129TtD n	0.3	2.5
87119	165305400-0937	FTGNAT	1933	75	Bw 40Pt 20Ab 20Sb 10Bf 10	Ab	Bw	15	70	3	B055TtM n	0.7	13.7
105116	166305500-0409	FTGNAT	1876	130	Sb 30Cw 30Bw 20Ab 20	Ab	Sb	13	70	3	B129TtD n	0.7	17.4
105887	165305440-0697	FTGNAT	1848	159	La 80Ab 20	Ab	La	9	70	4	B136TlD n	0.7	0.7
106686	165505420-0269	FTGNAT	1972	35	Bw 60Sb 30Ab 10	Ab	Bw	8	26	4	B136TlD n	0.3	1.7

10 Historical Forest Resources Inventories

Efforts at inventorying Ontario's forests began in the 1920s, but by the end of World War II the information accumulated offered only a general picture of conditions and was not detailed enough to enable the creation of forest management plans for specific areas. Early surveys mapped the forest using broad classes of species composition (conifer, mixedwood and hardwood) and age classes (mature and immature). Definitions for the classes varied somewhat from area to area depending on local conditions, since these were developed by the surveyors “on the fly” as they gained knowledge of the area they were working in. In reviewing the reports from these early surveys, we discovered that a consistent definition of the classes is not always documented (e.g., conifer class = greater than 75% composition to conifers). In the case of the 1922 James Bay survey, the forest classes seemed to reflect ecosite conditions as well as tree species composition, i.e., stands occurring on uplands as opposed to lowlands. The definitions of the age classes, too, seem to vary from time to time in the documentation without explanation. Stand ages were determined visually by the interpreters, based on the tree size distributions and site types. Field work was done in accessible locations, often near the survey base camps, or near accessible waterways and lakes. This situation continued through the 1940’s and in some cases into the 1950s.

Before 1974, the licence holders on the Pic River and Big Pic Forests utilized a cover type index system for classification of forest land. The total forest was divided up into broad age classes, with the level of recorded detail increasing with each age class. The oldest age class (70 years +) was comprised of softwood/hardwood content, crown density level, acres and stand number. The forest attribute classes and legend for this inventory system is shown in Figure 20.

This system was adequate for its day, but as time progressed the level of detail required increased and, therefore, a new system or inventory control needed to be instigated. In 1946 the production of a more detailed forest resources inventory commenced when the Photographic Survey Company and Department of Lands and Forests staff began to produce aerial photographs and planimetric maps of a 140,000 square mile area of northern Ontario. Armed with these photographs and maps, working teams of foresters laid out tenth-of-an-acre plots in the field, measuring trees and tallying species. Information on stand content was recorded on the aerial photographs; subsequently, it was classified and typed onto 4 inch = 1 mile scale planimetric maps. The late 1940’s through to the mid 1950’s is the period during which our present-day inventory system was developed and implemented. In this period Plonski’s work on provincial yield tables was completed, and the practice of mapping species composition, more accurate ages, and other attributes became formalized. The first “modern” FRI maps were produced in the 1950’s. From that time to the present, the FRI system has undergone a number of refinements, mainly in the level of precision to which forest stands are delineated and in the attention paid to non-commercial species. Thus, more recent inventories tend to have more stands, and better describe the occurrence of non-commercial species (the two are related).

In 1974, the Ministry of Natural Resources photographed the Black River Forest at a scale of 1:15,840, and it was then agreed that the Company and the Ministry would enter into a joint venture to re-inventory the Black River Forest. The Company would be responsible for the cruising and interpretation of the photos, with the Ministry transferring the information onto maps and producing ledgers for the area. The project was started in 1974 and the maps and ledgers were completed by 1978. The new mapping was based on the Ministry’s Forest Resources Inventory system which gives species composition by percent, age and height of the working group species, stocking and site class. This was a vast improvement over the old cover type index in that the species were accurately identified, and the system was being used almost province wide, thereby making comparisons between working circles far easier.

THE ONTARIO PAPER COMPANY, LIMITED
HERON BAY LIMITS

FOREST MAP LEGEND – LITTLE PIC DISTRICT

Cover Types	% Softwood
S	75%+
SH	50-75%
HS	25-50%
H	0-25%

Age Classification

Class	Years	Description
1	90+	Mature & Overmature
11a	60-90	Immature
11b	30-60	Young Growth
111	< 30	Reproduction, Burn Cutover

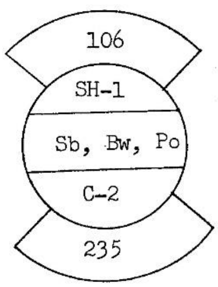
Height Classification

Class	Feet
A	90'+
B	60'-90'
C	30'-60'
D	< 30'

Crown Density Classification

Class	%	Description
1	90-100%+	Fully Stocked
2	60-90%	Stocking Normal
3	30-60%	Medium Density
4	<30%	Open & Scattered

TYPE CLASSIFICATION STAMP



Type Number	106
Cover Type - Age Class	Softwood-Hardwood with 50-75% Softwood
Principal Species	Black Spruce, White Birch, Poplar
Height Class - Crown Density	Height 3C-60', Density 60-90%
Type Area in Acres	235 Acres

Species Symbols

Softwoods

Sb - Black Spruce
Sw - White Spruce
Ba - Balsam Fir
Pj - Jackpine

HARDWOODS

Bw - White Birch
Po - Poplar

Other Symbols

Cutover
Rock Outcrop
Swamp or Treeless Muskeg
Treed Muskeg
Cliff or Bluff
4900 Photo Line No.
31 Photo Print No.
Major Height of Land

Manitouwadge, Ontario

November 12, 1971

Figure 20. Attribute classes and map legend for industrial forest inventory prior to 1974.

The FRI ledgers of the new inventory system proved useful in developing an allowable cut on a per acre basis but fell short when it came to predicting volumes, thus the decided to create a method to reinterpret the average height for each species within each stand. The re-calculated volume predictions proved to be within plus or minus 10% which was deemed accurate enough to be useful to the Company.

These inventory refinements over time complicate attempts to compare inventory of different vintages from the same area, and to evaluate changes in the nature of the forest over time, since in most cases the fundamental definitions of the mapped attributes, and the precision to which the mapping was conducted, have changed. In order to compare inventories of different ages, the more detailed inventory must be aggregated to the level of the earlier, broader inventory. Thus a number of assumptions must be made during the aggregation process about the relationship between the two (or more) inventories. Nonetheless, the attempt is worthwhile since the early inventories are the only large-scale record of the forest's historical condition. Differences must be interpreted cautiously since there are a number of sources of error associated with making "compatible" summaries between successive inventories.

We acquired as many historical forest inventories as could be found for the Pic River and Big Pic Forests. Most of these were summarized in the management plans that were prepared for the respective management units over time. We also collected information provided in historical government reports (e.g., annual reports of forest resources, "state of the forest" reports, and the like). These provide forest inventory summaries on a regional basis – by Regions, Districts, Inspectorates, and similar administrative areas. One problem with these summaries is that the boundaries of the Regions and District have frequently changed over time, even though retaining the same name, so a direct comparison between these larger areas is usually not possible over time. Nonetheless, the information does provide valuable historical context and can be used to infer aspects of the historic forest condition.

It should be noted that the most consistent and detailed source of information from the pre-settlement era for northeastern Ontario are the records of the Ontario Land Surveyors (OLS) from the surveys of baselines, rivers, and the boundaries of geographic townships (surveyor notes and maps). Fred Pinto (OMNR, Southern Science and Information, located at North Bay), was responsible for a project to compile and digitize the OLS records for the township surveys for northern Ontario, and to compare the historic forest condition described by the township survey data with the current forest condition. He has completed draft reports for the Big Pic, Black River, and White River Forests (Pinto et al. 2007). More recently, OMNR used the collated OLS information to characterize the pre-industrial forest on a larger scale, for Ecoregion 3E (Pinto et al. 2008). Unfortunately, a similar analysis is not available for Ecoregion 3W due to the lack of OLS township survey data in northwestern Ontario.

10.1 Historical Inventory Summaries

The following series of tables present examples of summary and comparative information derived from the sources described above. Paper and/or digital copies have been provided to AV Terrace Bay Inc. for archiving. These same documents are secured, since they are stored at the Ontario Archive, OMNR's Northeast Science and Information offices located at 25th Sideroad in Thunder Bay, and at the offices of the Nawiinginokiima Forest Management Corporation at Marathon.

10.2 The Forest Resources of Ontario 1930

The earliest provincial reporting of forest resources in Ontario dates from 1930 (Department of Lands and Forest 1930). The following series of tables are derived from information presented in that report. The Regions that are relevant to the Pic River and Big Pic Forests are the Clay Belt and Central Divide. Although broad in classification, they provides context for the overall species composition and age distribution at the time.

Table 16. Summary of timber resources of Ontario 1930.

FOREST REGION	TOTAL Forest (acres)	Spruce Cords, 4 inches DBH and up	Balsam Cords, 6 inches DBH and up	Jack Pine Cords, 6 inches DBH and up	White and red pine board feet (Doyle Rule), 8 inches DBH and up	Maple board feet (Doyle Rule)	Yellow Birch board feet (Doyle Rule)
Ottawa-Huron (a)	9,089,1l7						
Algoma Extension	4,930,71O	6,395,484	2,459,801	4,919,603	231,262,203	86,335,00	335,445,000
Sudbury	10,451,245	11,921,374	4,698,603	11,290,755	5,855,529,181		
Rainy River	7,059,567	6,964,376	609,501	7,193,920	928,273,72		
Lake Superior	5,956,139	8,079,590	952,767	994,628			
Central Divide	**22,871,410**	**51,576,545**	**7,311,154**	**26,462,594**			
Kenora Extension	33,193,910	43,678,866	4,363,085	26,685,504			
Clay Belt	**14,566,539**	**44,028,092**	**4,655,593**	**906,186**			
Nipigon Extension	1,753,718	7,913,317	730,559	636,825			
Coastal Plain (b)							
Central Patricia (c)							
Grand Total	109,872,355	180,557,644	25,731.06	79,090,015	7,015,065,256	86,335,400	335,445,000

(a) No estimate made. (b) Low yield and inaccessible. (c) Conditions unknown.

Table 17. Forest type and age class distribution 1930 (percent).

	Mixed				Coniferous				Non-forested		
FOREST REGION	**Mature**	**Second Growth**	**Young growth**	**Total**	**Mature**	**Second Growth**	**Young growth**	**Total**	**Barren and Scattered**	**Water**	**Recent Burn**
Ottawa-Huron (a)	30	38	31	83	41	56	3	4	11		2
Algoma Extension											
Sudbury	56	16	28	45	70	15	15	38	2	10	5
Rainy River	11	35	54	16	35	25	40	34	2	19	29
Lake Superior											
Central Divide	**43**	**23**	**34**	**52**	**87**	**8**	**5**	**26**	**6**	**10**	**6**
Kenora Extension	24	19	57	19	53	22	25	18	39	23	1
Clay Belt	**57**	**1**	**42**	**19**	**94**	**1**	**5**	**33**	**19**	**5**	**24**
Nipigon Extension	54	7	39	36	99		1	45	7	10	2
Coastal Plain (b)	100			2	100			6	88	4	
Central Patricia (c)											
Province	**34**	**26**	**40**	**39**	**69**	**15**	**16**	**22**	**19**	**12**	**8**

(a) Land area only.
(b) No available data.
(c) Insufficient data.

Table 18. Forest age class distribution 1930 (percent).

FOREST REGION	Mature	Second Growth	Young growth	Recent Burn	Barren and Muskeg
Ottawa-Huron (a)	22	31	34	2	11
Algoma Extension					
Sudbury	58	14	21	5	2
Rainy River	17	17	28	36	2
Lake Superior					
Central Divide	**53**	**16**	**20**	**5**	**6**
Kenora Extension	38	7	20	1	34
Clay Belt	**47**	**3**	**9**	**24**	**17**
Nipigon Extension	72	3	16	2	7
Coastal Plain (b)	7				93
Central Patricia (c)					
Province	33	15	23	9	20

Table 19. Listing of forest resource surveys completed for Ontario 1922-1928.

Class A: Forest Type And Age Class Distribution Mapped; Timber Estimated By The Ontario Forestry Branch.

Region	Year of Survey	Area (acres)
1. James Bay	1922	8,641,036
2. Missinaibi	1922	2,554,156
3. Mississagi	1923	2,659,228
4. Nipigon (East)	1924	1,772,835
5. Nipigon (West)	1924	5,129,942
6. Groundhog	1925	1,347,982
7. Opasatika	1925	628,080
8. Kabinakagami Lake	1925	466,560
9. Pic and Pagwachuan	1925-26	1,585,390
10. English River	1926	1,323,337
11. Bruton Township	1926	40,965
12. Rainy River	1927-28	4,050,941
13. Timagami West	1928	732,638
14. Loch Lomond	1928	18,462
Total area		30,951,552
By Private Agencies		7,129,449
Total area		38,081,001

Class B: Forest Type And Age Class Distribution Mapped; No Estimate; Aerial Sketching By Ontario Forestry Branch.

Region	Year of Survey	Area (acres)
15. Lake St. Joseph	1921	2,220,000
16. Kapuskasing-Missinaibi	1925	1,478,220
17. Hayward Block	1926	373,366
18. Grant-Jobrin Area	1926	257,240
19. Nipigon	1924	1,152,000
Total area		5,480,826

Table 20. Summary of timber licensed area, May 1, 1929.

FOREST REGION	Areas under timber licence	Areas under pulp license	Total Area (acres)
Ottawa-Huron (a)	3,393,920		3,393,920
Algoma Extension	2,081,280	599,040	2,680,320
Sudbury	2,380,160	5,388,800	7,768,960
Rainy River	1,446,400	281,600	1,728,000
Lake Superior	321,920	4,821,120	5,143,040
Central Divide	2,177,280	7,301,120	9,478,400
Kenora Extension	1,125,120	7,114,880	8,240,000
Clay Belt	708,480	6,936,960	7,645,440
Nipigon Extension	10,240	1,522,560	1,532,800
Coastal Plain (b)			
Central Patricia (c)			
Province	13,644,800	33,966,080	47,610,880

10.3 Comparison of Current FRI for the Pic River and Big Pic Forests with Historical Inventories, 1949 to 1996

Records of historical Forest Resource Inventories were obtained over time for management units (MU) whose boundaries fall within the current boundary of the Pic River and Big Pic Forests. Summaries of the distribution of forest units or working groups, and age class distributions were prepared for each MU. Summaries of the current FRI for the Big Pic Forest (2007 FRI, updated to 2012 for the preparation of the 2012-2017 Phase 2 FMP) were prepared using the lowest common denominator of the historical data, so the format was common to all. For example, the American Can inventory system used cover types and age classes that were different than those used by the provincial FRI system. The Pic River Forest has recently (2016) acquired an updated eFRI based on 2009-10 digital imagery, and summaries of this inventory were used to compare equivalent land base areas and forest characteristics that were summarized from historical inventories of the Black River Forest, Pic River Ojibway Forest, Steel River Crown Management Unit, and the Little Pic Concession area. Because these historical inventories were completed at different times, and classified forest characteristics such as stand types (forest units) and age classes differently, it is not possible to compare current vs. historical inventories over the entire land base of the Pic River and Big Pic Forests. Rather, forest characteristics and land areas corresponding to the land bases of the historical Management Units and their respective inventory attributes were gleaned from the current FRIs for comparative purposes.

Sources for the historical inventory summaries for the Pic River and Big Pic Forests include:

- 1949 - Management Plan for the Big Pic Concession. Marathon Paper Mills of Canada Limited, Forestry Section, Woodlands Division.
- 1950 - Management Plans for the Pic Area Comprising the Big Pic Concession - Schedule A, Parcels I & II - Schedule B, and Parcels III & IV - Schedule B. Marathon Paper Mills of Canada Limited, Forestry Section, Woodlands Division.
- 1951 – Management and Operating Plans for the Little Pic Concession of the Ontario Paper Co.
- 1960 - A Management Plan for the Pic Area, Schedule A, Licence No. D-1673. Marathon Corporation of Canada Limited, Woodlands Division, Port Arthur, Ontario.

- 1977 - A Management Plan for the American Can Management Unit for the Period From April 1, 1977 to March 31, 1998. Part I: The Report, and Part II: Forest Inventory. American Can of Canada Ltd., Marathon, Ontario.
- 1975 – 1981 Management Plan for the Black River Forest made use of the first FRI completed for the area by MNR, which was completed using 1974 imagery.
- 1976 - 1981 Management Plan for the Steel River CMU made use of the first FRI completed for the area by MNR, which was based on 1976 imagery.
- 1987 - Timber Management Plan for the Big Pic Management Unit for the 20-year period from April 1, 1987 to March 31, 2007. Crown Timber Licence No. 330200. James River-Marathon Ltd., and Ontario Ministry of Natural Resources, Terrace Bay District, North Central Region.
- 1992 - Timber Management Plan for the Big Pic Management Unit for the Twenty-year Period From April 1, 1992 to March 31, 2012. James River-Marathon Ltd., Marathon, Ontario, and Ontario Ministry of Natural Resources, Terrace Bay District. 22p. + Append.
- 1992 – Forest Resource Inventory pForest files for the Black River Forest and the Pic River Ojibway Crown Management Unit, updated to 1992, obtained from the MNRF FRI Section Provincial inventory data archive
- 2007 - Forest Management Plan for the Big Pic Forest Management Unit, Wawa District, Northeast Region, for the 10-year period from April 1, 2007 to March 31, 2017. Ontario Ministry of Natural Resources, Northeast Region, South Porcupine, ON.
- 2012 – updated FRI database file for the Big Pic Forest.

10.4 Big Pic Forest

From 1947 to 1986, forest inventory on the Big Pic area was conducted using an inventory system devised by American Can Inc. This system used classes of species composition classes (cover types) and age classes, which was a different approach than that taken by the provincial Forest Resource Inventory (FRI) system. The FRI system mapped the species composition of commercial tree species, in 10% classes, along with stand age, and other volumetric information that was based on the work of Plonski in the 1940s. The first provincial FRI for the Big Pic Management Unit was completed in 1973, although the American Can inventory continued to be used, and was in fact used as the basis for the preparation of the 1977 Timber Management Plan for the Unit. Over time, the provincial system became standardized throughout Ontario, and in 1986 maintenance of the American Can inventory for the Big Pic area was discontinued. The cover type and age classes used by the American Can system are described below.

Cover Types

The forest stands on the Pic Area were divided into three main cover types:

- CONIFEROUS (C): Of the total volume of these stands hardwood species form less than 25%
- MIXED (M): In these stands, hardwoods form more than 25% but less than 75% of the total volume
- HARDWOOD (H): Hardwood species form at least 75% of the total volume in these stands.

For management purposes, the coniferous cover type was subdivided into four smaller subtypes because of the wide variation in cutting age of the different conifers and because of the difference in the time of the year at which the various subtypes can be most economically logged. These subtypes are:

- SOFTWOOD (S): The coniferous content of these stands is made up of spruce usually with balsam fir.
- MIXED SOFTWOOD (MS): A mixture of spruce and/or balsam and jack pine. Jack pine by volume forms not less than 25% nor more than 75% of the total volume of the stand.

- BLACK SPRUCE SWAMP (Sb): Practically pure stands of black spruce, usually on wet sites, are classified in this type.
- JACK PINE (Pj): In this cover type over 75% of the total volume is jack pine.

This resulted in six cover type classes: Hardwood, Mixedwood, Softwood, Mixed Softwood, Black Spruce Swamp, and Jack Pine.

The five age classes used by the American Can system were as follows:
- Overmature, greater than 125 years old
- Mature, 75-124 years
- Immature, 50-74 years
- Young, 25-49 years
- Reproduction, 0-24 years. The reproduction class consisted of areas types as either “Recent Burn” or “Cutover“.

The following tables contain summaries of the cover types or working group distributions as well as summaries of age class distributions of historical and current forest inventories for the Big Pic Forest.

Table 21 to Table 25 were derived from information contained in the 1949-1950 Management Plan Table 26 was derived from information in the 1960 Management Plan, Table 27 was derived from the 1977 Management Plan, Table 28 and Table 29 were derived from the 1987 Management Plan, and Table 30 was derived from the 1992 Management Plan.

Table 31 and Table 32 summarize attributes from the 1950 and 1960 American Can inventories, for comparison with the equivalent from the current (2007) FRI.

Table 33 summarizes attributes from the 1977 and 1987 FRI for comparison with equivalent attributes derived from the current (2007) FRI, while Table 34 summarizes attributes from the 1987 and 1992 FRI for comparison with the current (2007) FRI.

The age information available for the American Can inventory in 1949-1950 is not reliable. This is because at the time, air photos from 1943 and 1947 had been delineated into polygons by cover types, but field checking to date was limited, and at this stage the cover type polygons had only been sorted into broad age classes for the purposes of stratifying the field work (Anon. 1950, Fry 1997). By 1960, extensive cruising had been conducted, and the age classes of the polygons had been re-interpreted based on an extensive field sample and was much more reliable. This accounts for the large difference in the area by age classes between the 1950 and 1960 American Can inventories (e.g., compare the area contained in overmature and mature age classes between Table 21 (1950) and Table 26 (1960)).

Despite this shortcoming in the inventory at the time, the 1949-1950 Management Plans contain much valuable information about the nature of the historical forest. Table 21 shows that approximately 4.3% of the production forest area was in recent burns. Table 22 shows differences in species composition between the two ecological regions comprising the Big Pic concession. Table 24 provides an estimate of the relative proportions of tree species in the management unit. Table 23 shows broad succession trends between mature and overmature stands, with toterant species such as balsam fir and white spruce increasing in abundance in the older stands, and intolerant, early successional species such as jack pine and aspen decreasing.

The 1960 inventory provides a more accurate estimate of the distribution of age classes based on a robust field sample (Table 20). In 1960, the area in the overmature age class (approximately equivalent to "old growth") was approximately 9.7% of the production forest area.

Table 27 through Table 30 provide snapshots of the cover type, working group, and age class distributions of the forest through time from 1977 to 1992. Beginning in 1987, the American Can inventory system was no longer used in management planning and has been replaced with the provincial inventory system. Thus Table 27 through Table 30 present data in 10-year age classes and working groups (i.e., the lead species in the stands).

Unfortunately, the cover type classes and the 25-year age classes used in the American Can inventory system are not easily comparable with the age and species composition attributes used in the provincial FRI system (i.e., 10% classes for species composition and exact ages). This complicates any comparisons between the two systems. Nonetheless, algorithms were developed and applied to the current FRI (2007, updated to 2012) to approximate the American Can attributes. Because species composition alone is not sufficient to allocate stands into the Black Spruce Swamp category, provincial Ecosite attributes in the current FRI were used to differentiate uplands from lowlands to more accurately assign stands to this cover type.

Table 31 and Table 32 compare the distribution of the American Can cover types and age classes between the 1950 and 1960 inventories and the 2007 FRI. As previously mentioned, the age class distribution associated with the 1950 inventory is not accurate due to lack of field work to verify the interpretation of age classes (which was completed for the 1960 inventory). The relevant comparison, between the 1960 and 2007 inventories, shows an increase in the youngest and oldest age classes at the expense of the mature timber. Table 31 shows a trend towards an increase in the pure cover types (i.e. predominantly hardwood or softwood) at the expense of the mixedwood cover types.

Table 33 and Table 34 compare the distribution of 10-year age classes and working groups between the 1977, 1987, and 1992 FRIs, and the current 2007 FRI. Trends in changes in age class distribution are somewhat unclear, but there appears to be a decrease in older age classes, and an increase in middle (60 to 90 years) and the youngest age classes (0 to 20 years). The latter can be attributed to ongoing harvesting of the forest and natural disturbances. The decrease in older stands could be the result of decadence and breakup in these older stands, which are then re-typed as middle age or young stands depending on the successional trends, i.e., the nature of the advance growth and the development of the secondary canopy in older stands. Stand development is likely dependant in part on the ecosite conditions.

The proportions of age classes in the current FRI fall within the ranges of values derived from the historical inventories. In the current FRI, the proportion of "old growth" stands greater than 100 years old is 26.3% while the average of the historical inventories is 27.7%, suggesting a small decrease in proportion of old forest in the current FRI; however, this difference is not statistically significant.

Table 34 shows a trend towards a decrease in balsam fir and spruce (black spruce and white spruce were not separated in the 1987 and 1992 inventory records) which can likely be attributed to the spruce budworm epidemic of the late 1970s and 1980s. These species also tend to be more abundant in older stands due to their successional status, thus are being reduced commensurate with the decline in older age classes. This latter may be attributed in part to preferential harvesting of older stands before they experience significant volume declines. There is also a trend towards an increase in the relative abundance of white birch and other conifers (cedar and larch) which may be the result of successional trends in harvested stands, since these species are prolific seeders and are associated with early successional status. There is also a trend towards an increase in jack pine. This may be the result of renewal efforts which have tended to favor jack pine as a valuable and fast-growing species. The relative abundance of poplar species has remained consistent over time.

These summaries of historical inventories provide a series of snapshots of the forest condition over time, which indicate broad trends in changes to the forest, and may also serve as benchmarks for future management planning.

Table 21. Summary of Forest Inventory for the Big Pic Area, 1950 Management Plan.

		Area (ha) by Compartments								
Age Classes	Age Ranges	Caramat	Kagiano	Stevens	Rocky	Hillsport	Manitou	Cirrus	Marathon	Total
Overmature	125+	34,961	31,233	10,661	17,397	16,422	15,732	20,677	24,044	171,128
Mature	75-124	24,158	44,495	46,710	16,381	0	59,242	5,961	0	196,947
Immature	50-74	1,351	0	244	2,376	0	0	0	0	3,971
Young	25-49	4,049	9,570	12,525	2,045	3,855	5,657	9,876	37	47,614
Reproduction	0-24	490	6,027	4,938	2,409	278	2,888	12,693	11,332	41,055
Recent burn		99	6,027	0	0	278	2,387	7,435	4,037	20,263
Cutover		391	0	4,938	2,409	0	501	5,258	7,294	20,792
Rock		372	367	1,325	46	3	717	3,846	2,114	8,789
Muskeg		6,570	2,983	4,966	1,921	4,248	3,382	1,756	350	26,176
Water		4,912	6,920	3,082	1,662	828	2,191	1,783	1,601	22,979
Reserved		0	0	0	0	0	0	0	798	798
Total Forest Area		65,010	91,325	75,078	40,608	20,556	83,519	49,206	35,413	460,715
Total Non-forest Area		11,854	10,269	9,373	3,628	5,079	6,289	7,386	4,865	58,744

Table 22. Classification of merchantable area by cover type and Rowe's Forest Section for the Pic Area, 1950 Management Plan.

	Area in Rowe's Forest Sections (ha)		
Cover Type	Superior	Central Plateau	Total
Softwood	18,355	29,405	47,759
Mixed Softwood	608	29,078	29,686
Black spruce swamp	4,614	63,535	68,149
Jack pine	31	5,487	5,518
Mixedwood	52,961	150,242	203,203
Hardwood	4,599	9,160	13,759
Total	81,167	286,907	368,074

Table 23. Classification of merchantable area (ha) by cover type and age class for the Pic Area, 1950 Management Plan.

Cover Type	Mature	Overmature	Total
Softwood	19,128	28,631	47,759
Mixed Softwood	23,051	6,634	29,686
Black spruce swamp	41,603	26,546	68,149
Jack pine	4,445	1,072	5,518
Mixedwood	99,522	103,681	203,203
Hardwood	9,197	4,562	13,759
Total	196,947	171,127	368,074

Table 24. Estimate of merchantable volume by tree species, for the Pic Area, 1950 Management Plan.

Species	Merch. Volume (000s cords)	% of Total Volume
White spruce	2,658	12.3
Black spruce	6,349	29.3
Balsam fir	1,623	7.5
Jack pine	2,330	10.7
Trembling aspen	5,453	25.2
Balsam poplar	636	2.9
White birch	2,626	12.1
Total	21,675	100.0

Table 25. Estimate of merchantable species composition (percent of total area) by age classes for the Pic Area, 1950 Management Plan.

Species	Mature	Overmature	Difference
White spruce	9.9	15.6	5.7
Black spruce	31.3	26.7	(4.6)
Balsam fir	4.1	11.7	7.6
Jack pine	12.4	8.5	(3.9)
Trembling aspen	28.5	20.6	(7.9)
Balsam poplar	3.5	2.1	(1.4)
White birch	10.3	14.8	4.5
Total conifer	57.7	62.5	4.8
Total hardwood	42.3	37.5	(4.8)
Total	100.0	100.0	0.0

Table 26. PIC Area Forest Inventory Summary, area by age classes and cover types, 1960 Management Plan.

	Area by Cover Type (ha)						
Age Class	S	MS	Sb	Pj	M	H	Total
Overmature	10,649	196	153	8	38,314	2,267	51,586
Mature	14,147	31,792	111,157	6,713	107,809	31,612	303,231
Immature	406	1,885	7,265	428	9,004	4,256	23,244
Young	1,972	1,618	6,494	359	48,561	3,368	62,372
Recent burn	2,364	1,187	4,694	208	8,716	1,739	18,907
Cutover	2,661	2,901	15,728	4,307	22,926	5,474	53,996
Total	32,200	39,578	145,491	12,023	235,330	48,715	513,336

Table 27. Total productive area of cover types by age classes (ha) for the Big Pic MU, 1977.

Decade of Origin	Age Class	Sb	S	MS	Pj	Total Conifer	M	H	Total
pre-1800	180+	8,834	11,928	452	49	21,262	17,809	522	39,593
1800	171-180	340	9	0	0	349	92	2	443
1810	161-170	696	369	90	17	1,174	1,433	129	2,735
1820	151-160	8,910	3,072	745	58	12,784	19,791	2,414	34,990
1830	141-150	4,517	754	340	21	5,632	9,957	1,353	16,942
1840	131-140	6,566	413	1,118	110	8,207	4,729	943	13,879
1850	121-130	29,096	4,379	6,288	706	40,469	32,742	7,220	80,432
1860	111-120	27,563	1,518	7,600	2,027	38,708	23,544	12,447	74,699
1870	101-110	14,933	195	7,749	1,194	24,070	7,768	2,538	34,377
1880	91-100	25,932	559	5,997	1,825	34,313	20,041	7,931	62,285
1890	81-90	445	0	76	92	613	321	198	1,132
1900	71-80	5,193	79	2,025	1,287	8,583	2,439	1,679	12,702
1910	61-70	802	304	404	459	1,969	15,835	1,781	19,585
1920	51-60	5,842	507	2,359	552	9,260	32,092	431	41,783
1930	41-50	2,601	2,818	252	195	5,866	20,533	76	26,474
1940	31-40	4,889	5,337	2,557	1,217	14,001	18,416	849	33,266
1950	21-30	10,077	2,022	3,574	1,036	16,709	11,098	1,755	29,562
1960	11-20	9,400	1,324	4,007	1,553	16,284	8,299	4,365	28,948
1970	0-10	6,136	594	2,671	680	10,082	3,734	3,717	17,533
Total		172,771	36,181	48,305	13,077	270,334	250,673	50,351	571,358

Table 28. Summary of Crown production forest area (ha) by cover type and age class, Big Pic MU, AmCan Inventory 1987.

Age Class	Sb	S	MS	Pj	M	H	All
0-10	6138	595	2,672	681	3,736	3,719	17,541
11-20	9,404	1,325	4,009	1,553	8,303	4,366	28,960
21-30	10,081	2,023	3,576	1,036	11,103	1,755	29,574
31-40	4,891	5,340	2,558	1,217	18,424	850	33,280
41-50	2,602	2,819	252	195	20,542	76	26,486
51-60	5,845	507	2,360	552	32,106	431	41,801
61-70	802	304	404	459	15,842	1,782	19,593
71-80	5,195	79	2,026	1,287	2,440	1,680	12,707
81-90	445	0	76	92	321	198	1,132
91-100	25,943	559	6,000	1,826	20,049	7,935	62,312
101-110	14,939	195	7,752	1,194	7,771	2,539	34,390
111-120	27,575	1,518	7,603	2,028	23,554	12,453	74,731
121-130	29,109	4,381	6,291	706	32,756	7,223	80,466
131-140	6,569	413	1,119	111	4,731	943	13,886
141-150	4,519	755	340	21	9,962	1,353	16,950
151-160	8,913	3,073	745	58	19,800	2,415	35,004
161-170	697	370	90	17	1,433	129	2,736
171-180	340	9	0	0	92	2	443
181+	8,837	11,933	452	49	17,817	522	39,610
Total	172,844	36,198	48,325	13,082	250,782	50,371	571,602

Table 29. Summary of Crown production forest area (ha) by working group and age class, Big Pic Management Unit FRI, 1987.

Age Class	Spruce	Bf	Pj	OC	Po	Bw	All
0-10	6	69	0	0	1,338	102	1,515
11-20	1,833	366	419	0	9,464	1,692	13,774
21-30	5,605	3,265	1,948	0	6,956	5,154	22,928
31-40	5,862	4,604	5,643	0	5,338	4,496	25,943
41-50	11,764	3,892	2,780	0	5,403	2,646	26,485
51-60	7,123	4,135	10,802	9	15,281	10,428	47,778
61-70	5,916	3,632	2,657	15	39,744	2,628	54,592
71-80	18,294	6,214	1,171	183	10,625	7,512	43,999
81-90	42,949	3,917	396	178	21,536	2,122	71,098
91-100	56,349	56	24	302	98	104	56,933
101-110	96,711	0	0	156	0	0	96,867
111-120	48,889	0	0	91	0	0	48,980
121-130	4,451	0	0	628	0	0	5,079
131-140	0	0	0	0	0	0	0
141-150	0	0	0	0	0	0	0
151-160	0	0	0	0	0	0	0
161-170	0	0	0	0	0	0	0
171-180	0	0	0	0	0	0	0
181+	0	0	0	0	0	0	0

Total	305,752	30,150	25,840	1,562	115,783	36,884	515,971

Table 30. Summary of Crown production forest area (ha) by working group and age class, Big Pic Management Unit FRI, 1992.

Age Class	Spruce	Bf	Pj	OC	Po	Bw	All
B & S	92,533	4,760	6,419	5	22,840	1,806	128,363
0-10	188	0	246	0	0	0	434
11-20	841	0	320	0	0	0	1,161
21-30	6	0	69	0	1,337	102	1,514
31-40	1,796	419	366	0	9,450	1,691	13,722
41-50	5,517	1,948	3,265	0	6,954	5,136	22,820
51-60	5,862	5,202	4,604	0	5,309	4,496	25,473
61-70	11,764	2,497	3,877	0	5,397	2,646	26,181
71-80	6,995	7,515	3,609	9	11,964	10,367	40,459
81-90	5,629	2,199	2,900	15	32,566	1,664	44,973
91-100	16,812	969	4,107	183	9,242	7,340	38,653
101-110	37,387	391	2,517	178	17,412	2,056	59,941
111-120	50,132	24	0	300	0	42	50,498
121+	123,526	0	0	872	0	0	124,398
Total	358,988	25,924	32,299	1,562	122,471	37,346	578,590

Table 31. Comparison of the Distribution of Age Classes from the 1960 American Can inventory, with the current (2007) FRI.

Age Class	1960 Management Plan	%	Current FRI (2007)	%	Age Range
Overmature	51,586	10%	133,140	23%	125+
Mature	303,231	59%	162,405	28%	75-124
Immature	23,244	5%	60,948	11%	50-74
Young	62,372	12%	58,929	10%	25-49
Reproduction	72,903	14%	157,582	28%	0-24
Total	513,336		573,004		

Table 32. Comparison of the Distribution of Cover Types from the 1950 and 1960 American Can inventories, with the current (2007) FRI.

Cover Types	1950 Management Plan	%	1960 Management Plan	%	1977 Management Plan	%	Current FRI (2007)	%
Softwood	47,759	13%	32,200	6%	36,181	6%	56,154	10%
Mixed Softwood	29,686	8%	39,578	8%	48,305	8%	119,758	21%
Black spruce swamp	68,149	19%	145,491	28%	172,771	30%	168,463	29%
Jack pine	5,518	1%	12,023	2%	13,077	2%	15,471	3%
Mixedwood	203,203	55%	235,330	46%	250,673	44%	118,039	21%
Hardwood	13,759	4%	48,715	9%	50,351	9%	94,546	17%
Total	368,074		513,337		571,358		573,004	

Table 33. Comparison of the total productive area of age classes (ha) for the Big Pic Management Unit from the 1977, 1987 and current (2007) FRI.

Decade of Origin	Age Class	1977	%	1987	%	2007	%	Trend
1970	0-10	17,533	3%	17,541	3%	95,667	17%	increase
1960	11-20	28,948	5%	28,960	5%	53,836	9%	increase
1950	21-30	29,562	5%	29,574	5%	16,158	3%	none
1940	31-40	33,266	6%	33,280	6%	29,110	5%	none
1930	41-50	26,474	5%	26,486	5%	21,740	4%	none
1920	51-60	41,783	7%	41,801	7%	24,849	4%	decrease
1910	61-70	19,585	3%	19,593	3%	24,459	4%	none
1900	71-80	12,702	2%	12,707	2%	23,279	4%	increase
1890	81-90	1,132	0%	1,132	0%	44,957	8%	increase
1880	91-100	62,285	11%	62,312	11%	26,188	5%	decrease
1870	101-110	34,377	6%	34,390	6%	17,411	3%	decrease
1860	111-120	74,699	13%	74,731	13%	38,398	7%	decrease
1850	121-130	80,432	14%	80,466	14%	47,622	8%	decrease
1840	131-140	13,879	2%	13,886	2%	42,327	7%	increase
1830	141-150	16,942	3%	16,950	3%	40,818	7%	increase
1820	151-160	34,990	6%	35,004	6%	17,826	3%	decrease
1810	161-170	2,735	0%	2,736	0%	1,612	0%	none
1800	171-180	443	0%	443	0%	814	0%	none
1790	180+	39,593	7%	39,610	7%	5,932	1%	decrease
Total		571,358		571,602		573,003		

Table 34. Comparison of the total productive area of working groups (ha) for the Big Pic MU between the 1987, 1992 and current (2007) FRI.

Working Group	1987	%	1992	%	2007	%	Trend
Bf	30,150	6%	25,924	4%	15,619	3%	decrease
Bw	36,884	7%	37,346	6%	85,286	15%	increase
OC (Ce, La)	1,562	0.30%	1,562	0.27%	11,632	2%	increase
Pj	25,840	5%	32,299	6%	48,964	9%	decrease
PO	115,783	22%	122,471	21%	115,214	20%	none
Spruce (Sb, Sw)	305,752	59%	358,988	62%	288,110	51%	decrease
Grand Total	515,971		578,590		564,824		

The present Pic River Forest was formed from the amalgamation of the Black River Forest and the Pic River Ojibway Forest, which was in turned formed from the amalgamation of the Steel River CMU, the Little Pic Concession of Ontario Paper Co., and areas associated with Gravel River Townships.

10.5 Black River Forest

Table 35 summarizes attributes from the 1976 FRI for comparison with the equivalent land base from the current (2016) FRI. Figure 21 and Figure 22 compare the proportions of area in different forest types and age classes respectively. Forest types are based on combinations of working groups (lead species) and FRI site classes. The most apparent change in forest types is the reduction in the balsam fir forest type, likely due to the long-term spruce budworm infestations on the forest, and corresponding increases in hardwood types (white birch and poplar) and higher site class spruce forest types. The age class distribution between the two time periods looks quite similar, except for a shift out of the 41-60 year class into the 61-80 year old class. There is also an increase in stands greater than 120 years old on the forest.

Table 35. Comparison of 1976 FRI with 2016 eFRI for the Black River Forest.

Summary - 1976 FRI (updated to 1978)

Forest Unit	1-20 yrs	21-40	41-60	61-80	81-100	101-120	121+	Total	% of Total
Sp-x,1,2	8,723	5,436	11,785	13,188	14,233	14,407	5,990	73,762	37.4%
Sp-3	870	48	470	489	1,503	2,803	1,673	7,856	4.0%
B	1,243	5,599	14,412	12,173	4,523	1,857	929	40,736	20.7%
Pj	5,261	6,369	8,145	3,075	1,188	535	27	24,600	12.5%
Po-x,1,2	130	1,401	3,902	3,143	2,782	1,769	543	13,670	6.9%
Po-3	101	418	3,186	2,352	1,817	824	35	8,733	4.4%
Bw-x,1,2	230	4,492	4,519	1,924	2,416	1,525	244	15,350	7.8%
Bw-3	19	889	2,338	2,911	3,909	1,625	40	11,731	6.0%
Other Conifer	0	0	13	29	137	221	202	602	0.3%
Total	16,577	24,652	48,770	39,284	32,508	25,566	9,683	197,040	
Percent of total	8.4%	12.5%	24.8%	19.9%	16.5%	13.0%	4.9%		

Summary - 2016 eFRI

Forest Unit	1-20 yrs	21-40	41-60	61-80	81-100	101-120	121+	Total	% of Total
Sp-x,1,2	13,306	7,115	8,466	30,630	14,292	11,624	10,824	96,256	51.4%
Sp-3	44	68	570	2,057	1,499	1,601	1,914	7,753	4.1%
B	217	1,156	1,219	355	29	90	7	3,072	1.6%
Pj	4,991	3,705	2,573	4,782	2,235	195	99	18,580	9.9%
Po-x,1,2	1,936	2,320	2,416	8,926	3,005	648	769	20,020	10.7%
Po-3	174	397	450	1,524	435	291	105	3,374	1.8%
Bw-x,1,2	3,002	3,255	1,896	8,419	2,509	2,930	3,169	25,180	13.4%
Bw-3	177	384	1,354	3,320	1,226	462	184	7,107	3.8%
Other Conifer	86	213	524	1,080	1,056	856	2,108	5,922	3.2%
Grand Total	23,932	18,613	19,468	61,093	26,284	18,697	19,178	187,265	
Percent of total	12.8%	9.9%	10.4%	32.6%	14.0%	10.0%	10.2%		

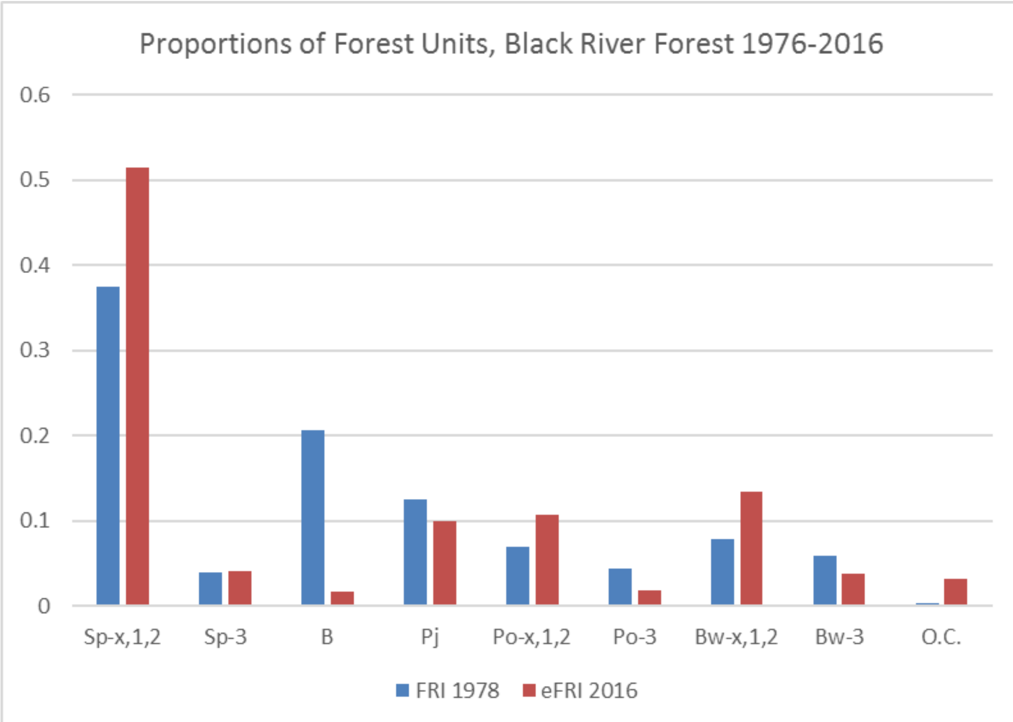


Figure 21. Comparison of the proportion of area in forest types in the Black River Forest, 1976 and 2016.

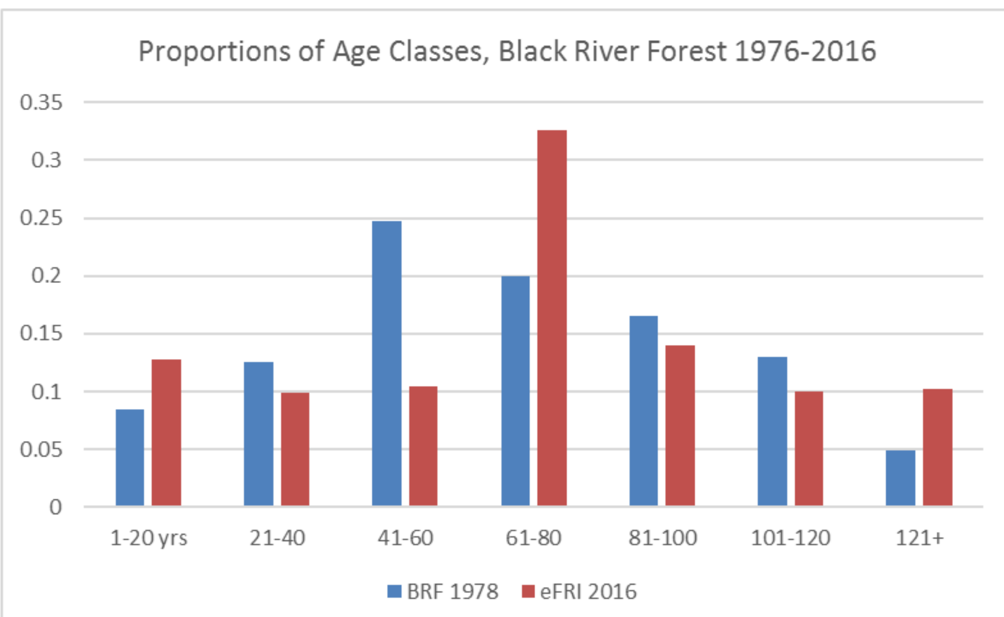


Figure 22. Comparison of the proportion of area in age classes in the Black River Forest, 1976 and 2016.

10.6 Pic River Forest – Steel River CMU

Table 36 Table 31summarizes attributes from the 1975 FRI for comparison with the equivalent land base from the current (2016) FRI. Figure 23 and Figure 24 compare the proportions of area in different working groups and age classes respectively. Working groups refers to groups of stands with the same lead species. Overall, the composition of the forest based on working groups is little changed since 1976. There is a small reduction in balsam fir and spruce working, likely due to the long-term spruce budworm infestations on the forest, and corresponding increases in hardwood working groups (white birch and poplar) and jack pine. The age class distribution looks quite similar between the two time periods, except for a shift out of the 61-100 year class into the 101-120 year old class (due to aging of the forest) and into the 1-20 year age class (due to recent cutover and natural disturbances).

Table 36. Comparison of 1975 FRI with 2016 eFRI for the Steel River CMU: Summary of Productive Forest Area for all Crown Land.

Summary - 1975 FRI

Working Group	1-20 yrs	21-40	41-60	61-80	81-100	101-120	121+	Total	% of Total
Bf	819	327	3,291	5,672	736	634	0	11,479	5.5%
Pj	1,563	17	2,574	3,793	768	431	218	9,364	4.5%
Spr	10,114	234	7,550	16,721	18,610	23,672	27,008	103,909	50.2%
OC	0	0	25	11	0	0	111	147	0.1%
Bw	2,656	631	6,848	10,530	35,341	1,322	920	58,248	28.1%
Po	2,041	179	3,017	6,196	9,690	2,841	0	23,964	11.6%
Total	17,193	1,388	23,305	42,923	65,145	28,900	28,257	207,111	
Percent of total	8.3%	0.7%	11.3%	20.7%	31.5%	14.0%	13.6%		

Summary - 2016 eFRI

Working Group	1-20 yrs	21-40	41-60	61-80	81-100	101-120	121+	Total	% of Total
Bf	5,206	450	654	590	267	109	30	7,307	3.5%
Pj	3,979	1,016	625	4,028	2,176	464	14	12,302	5.9%
Spr	25,471	2,415	2,364	10,045	12,968	28,994	15,496	97,751	47.2%
OC	0	16	42	183	354	428	678	1,700	0.8%
Bw	3,553	1,739	6,739	7,701	11,436	20,728	8,734	60,629	29.3%
Po	6,652	1,371	5,060	12,161	5,670	3,707	556	35,178	17.0%
Pr			40					40	0.0%
Grand Total	44,860	7,006	15,524	34,708	32,871	54,430	25,508	214,907	
Percent of total	20.9%	3.3%	7.2%	16.2%	15.3%	25.3%	11.9%		

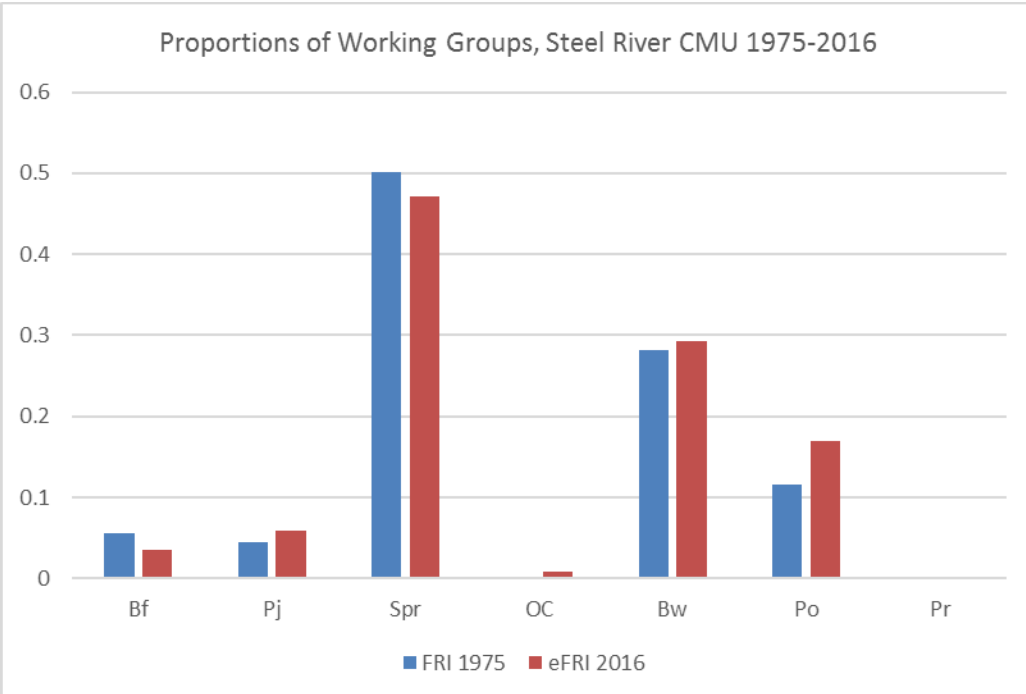


Figure 23. Comparison of the proportion of area in working groups in the Steel River CMU, 1975 and 2016.

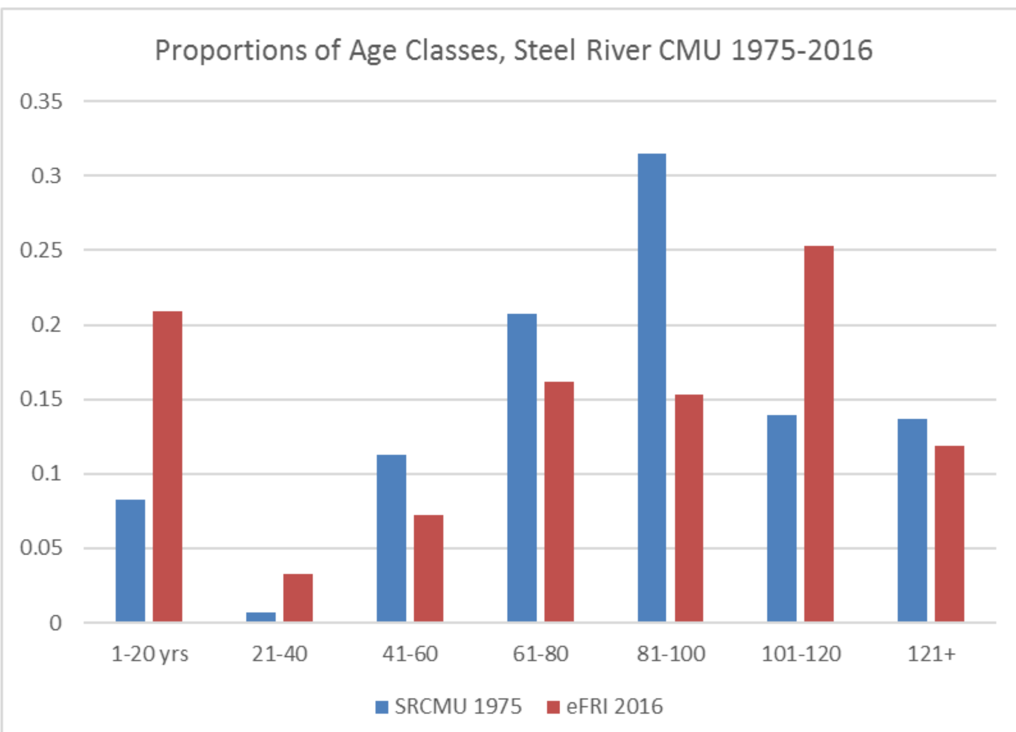


Figure 24. Comparison of the proportion of area in 20-year age classes in the Steel River CMU, 1975 and 2016.

10.7 Pic River Forest – Little Pic Concession, Ontario Paper Company

The 1951 Management and Operating Plans for the Little Pic Concession (Anon. 1951a, 1951b) contain summaries of the Company Forest Inventory which was completed in the same year. Table 37 is a summary of the 1951 land base classification, in terms of forested and non-forested types, and age classes for the productive forest lands. Note the total area of 137,058 ha, which is approximately one-quarter of the present-day Pic River Forest, or one-half the area of the former Pic River Ojibway Forest (the Little Pic occupied an area equivalent to roughly the eastern half of the Pic River Ojibway Forest).

Table 37. Little Pic Concession, Summary of Forest Inventory Survey: Land Base 1951.

Area Classification	Area (ha)	Percent
Water	11,379	8.3%
Open muskeg	1,021	0.7%
Brush, alder, flooded land	66	0.0%
Rock outcrop	481	0.4%
Unclassified	2,125	1.6%
Total non-forested	3,694	2.7%
Treed muskeg	1,180	0.9%
Barren and Scattered	109	0.1%
Total non-productive forest	1,288	0.9%
Total non-productive area	16,361	11.9%
Logging	7,332	5.3%
Reproducing burn	3,690	2.7%
Age class IIa (60-90)	5,569	4.1%
Age class IIb (30-60)	5,734	4.2%
Age class III (1-30)	12,982	9.5%
Total immature forest area	35,307	25.8%
Unmerchantable mature forest area (Age class I)	28,044	20.5%
Merchantable mature forest area (Age class I)	57,347	41.8%
Mature forest area	85,391	62.3%
Total productive forest area	120,698	88.1%
Total concession area	137,058	

Table 38 summarizes the forest inventory data from the 1951 Plans for the Little Pic Concession. This forest inventory was completed using methods pre-dating the development of government-sponsored FRI, as described in Section 10. Only volume estimates are available from the 1951 plans, however, as these would be based on methods equivalent to prism cruising, which determines basal area by species, they would be approximately equivalent to species composition values in forest inventories of more recent vintages, which are based on air photographic interpretation of crown closure and basal area. Regardless of this interpretation, they are presented as context and for their historical value.

Table 38. Summary of 1951 Forest Inventory Data for the Little Pic Concession.

Species	Bf		Sb		Sw		Pj		Bw		Po		
Size class	5-9"	10" +	5-9"	10" +	5-9"	10" +	5-9"	10" +	5-9"	10" +	5-9"	10" +	Total
Total Volume on Concession Area (cords)	335,941	104,220	762,311	246,688	148,872	297,840	175,147	143,011	538,708	452,626	343,648	650,513	4,199,525
Percent of Total Volume	10.5%		24.0%		10.6%		7.6%		23.6%		23.7%		100.0%
Volume in Unmerchantable Types													
S4C	1,056	0	20,068	528	528	528	1,056	0	1,056	0	0	0	24,820
SH4C	12,149	2,700	21,596	4,049	6,749	10,798	0	0	18,898	4,049	1,349	1,349	83,686
HS3B	5,858	1,457	1,944	485	5,343	2,914	0	0	15,059	27,204	4,858	14,089	79,211
HS3C	12,519	1,044	16,692	1,044	9,388	7,303	1,044	2,087	32,340	17,734	16,692	22,951	140,838
HS4C	6,749	0	12,374	5,625	6,749	1,124	0	1,124	30,375	11,250	6,749	6,749	88,868
H (all classes)	17,583	5,718	10,413	1,498	11,100	13,150	0	1,299	92,846	52,820	81,908	144,207	432,542
Total unmerchantable volume	55,914	10,919	83,087	13,229	39,857	35,817	2,100	4,510	190,574	113,057	111,556	189,345	849,965
Volume in Merchantable Types													
Age Class IIb	1,159	0	27,496	0	67	0	2,927	0	7,730	0	29,634	753	69,766
Age Class IIa	19,128	2,614	25,292	7,263	21,447	23,118	1,762	957	44,257	28,456	39,940	56,021	270,255
Total Volumes in Mature Merchantable Types	260,740	90,687	626,436	226,196	67,501	238,905	168,358	137,544	296,147	311,112	162,518	404,394	2,990,538
Species % of mature merchantable volumes	11.8%		28.5%		10.2%		10.2%		20.3%		19.0%		100.0%
Volumes in mature merchantable types	351,427		852,632		326,406		305,902		607,259		566,912		3,010,538
Species % of total volumes	11.7%		28.3%		10.8%		10.2%		20.2%		18.8%		100.0%

Table 39. Species proportions in the Black River and Pic River Ojibway Forest areas based on area-weighted species composition, calculated from the 2016 eFRI and the 1992 FRIs. Species proportions for the 1951 timber inventory for the Little Pic Concession were calculated from volume estimates for individual tree species.

eFRI 2016	Sb	Sw	Pj	Bf	La	Cw	Pw	Pr	Bw	Pt	Pb	Ab	Mr	Total
Black River Forest	82,190	9,645	19,370	8,395	5,570	4,623	0	0	33,384	23,548	529	10	0	187,265
Pic River Ojibway Forest	85,490	4,246	12,609	16,870	1,957	2,249	0	38	55,945	35,322	168	8	5	214,907
Big Pic Forest	276,085	14,368	58,164	34,402	18,106	13,190	6	11	67,284	126,314	2,267	19	0	610,215
Black River Forest %	43.89%	5.15%	10.34%	4.48%	2.97%	2.47%	0%	0%	17.83%	12.57%	0.28%	0.0051%	0%	100%
Pic River Forest %	39.78%	1.98%	5.87%	7.85%	0.91%	1.05%	0%	0.0176%	26.03%	16.44%	0.08%	0.0037%	0.0023%	100%
Big Pic Forest %	45.24%	2.35%	9.53%	5.64%	2.97%	2.16%	0.0009%	0.0018%	11.03%	20.70%	0.37%	0.0031%	0.00%	100%

FRI 1992	Sb	Sw	Pj	Bf	La	Cw	Pw/Pr		Bw	Po		Ab	Ms	Total
Black River Forest	92,974	13,295	30,592	5,469	2,328	2,620	0		36,306	31,689		45	0	215,317
Pic River Ojibway Forest	68,170	6,699	8,044	26,207	454	678	7		47,675	19,608		2	10	177,555
Big Pic Forest	299,289	10,291	46,851	50,798	2,029	7,799	5		58,028	109,812		19	0	584,922

Black River Forest %	43.18%	6.17%	14.21%	2.54%	1.08%	1.22%	0%		16.86%	14.72%		0.0207%	0%	100%
Pic River Forest %	38.39%	3.77%	4.53%	14.76%	0.26%	0.38%	0.0040%		26.85%	11.04%		0%	0.0058%	100%
Big Pic Forest %	51.17%	1.76%	8.01%	8.68%	0.35%	1.33%	0.0008%		9.92%	18.77%		0%	0%	100%

Little Pic Concession, % Volume by Species 1951	24.00%	10.60%	7.60%	10.50%	na	na	na	na	23.60%	23.70%	na	na	100%

Table 39**Error! Reference source not found.** summarizes area-weighted species composition for the Pic River Ojibway and Black River sections of the Pic River Forest, calculated from the 2016 eFRI. For comparison, area-weighted species composition derived from the historical inventories (FRIs updated to 1992) for the Black River Forest and the Pic River Ojibway Crown Management Unit are shown below. Volume-based estimates of species composition, calculated from data included in the 1951 Management Plan for the Little Pic Concession are also included. In general, species proportions are similar between management units and time periods, and differences through time are fairly small in magnitude. The general trend for all management units is a decrease in balsam fir, along with small increases in poplar, white birch, and jack pine.

Overall, the general trends regarding changes in species composition and age class distribution, as determined from historical inventories, are quite similar among the former management units that correspond to the modern-day land base of the Marathon Block, i.e., the Black River Forest, Pic River Ojibway Crown Management Unit, and the Big Pic Forest.

These comparisons between different vintages of inventories, while fraught with difficulties in interpretation, illustrate a method by which equivalent forest parameters can be compared between different time intervals. It is difficult to assess whether the apparent trends are real or whether they are simply a function of changing inventory methods and levels of precision. Still, they are useful as benchmark information provided the limitations of the data are understood.

11 Trends in Species Composition and Age Class Distribution

11.1 Historical versus Modern Species Composition Trends - Ontario Land Surveyor Records

Pre-industrial forests (also referred to as pre-settlement forests) are those forests that existed just before or during the early stages of their industrial use. Preindustrial forest information serves an important role in improving the understanding of natural forest patterns and processes to aid in the management of forestry activity. To compare and develop strategies for implementing ecosystem management, preindustrial forests also provide a template for conservation and restoration of forest biodiversity by revealing the processes by which the forests were established.

The Ontario Crown land survey (OLS) data from early township surveys contain geographically referenced forest stand descriptions along a survey line and witness trees at the intersection of boundaries. Unlike the public General Land Office surveys in the United States, the density of witness trees recorded in most of Ontario is quite low. In most of central and northeastern Ontario, the OLS usually recorded witness trees only at the corners of each township, limiting their use to describe past forest conditions. However, the methods used and transect descriptions by early land surveyors to collect and record their data in Ontario have generally been consistent (Canada Department of Crown Lands 1862, 1867; Gentilecore and Donkin 1973a, 1973b). This makes OLS data suitable for recreating forest conditions prior to widespread human use and settlement. Certain biases and errors associated with the land survey information have been suggested. The limitations in land surveys are primarily related to the coarse resolution of the data and the selection of witness trees, which tend to be long-lived trees, and the tendency to over-record the presence of commercially important tree species along transects.

The OLS contain spatial information as well as a description of the tree cover along the boundaries of each township, the location and extent of forest stands along these boundaries, and a list of the tree species and genera present within each stand. Stands were delineated based on the changes in composition (proportion accounted for by each taxon) or changes in the order in which tree species were listed.

Records of instructions given to Ontario land surveyors in the past suggest that tree species in a stand had to be listed in order of their abundance (Canada Department of Crown Lands 1862, 1867; Gentilecore and Donkin 1973a, 1973b).

An examination of the pre-settlement forest composition was reconstructed from Ontario Crown Land Survey Notes (OLS) by the Southern Science and Information Section at North Bay. Their study was conducted in the White River, Black River and Big Pic Forest Management Units in northeastern Ontario. In these areas only a few township boundaries have been surveyed by Ontario land surveyors; therefore these three forests were grouped and analyzed as one unit. The presettlement forest composition was reconstructed from Ontario Crown Land Survey Notes (OLS) for the three forests for the 1907-1955 period. The comparison between the current FRIs and the OLS was done along each township boundary using individual boundaries as the sampling unit. The OLS data is considered acceptable for determining the total forest composition of the respective Forests (Pinto et al. 2006). A summary of combined results from the three Forests are shown in the tables below.

In Table 40, the land survey data is displayed to show changes in first-listed species composition. Table 41 shows the increase or decrease in dominance and frequency of occurrence of tree species in the forest today. An increase in dominance is determined by an increase in FRI ranked abundance importance value compared to the OLS ranked abundance importance value. An increase in frequency of occurrence is suggested by an increase in the FRI equal abundance importance value over the same value in the OLS data. Table 42 compares the OLS and FRI data by importance value. In all tables, since not all birch, maple, pine and spruce were recorded by species in the land surveys, all entries were lumped at the Genus level (shaded rows). Each value is expressed as the percent length of each species and represents the mean for all township boundary lines.

Table 40. Comparison of first-listed species composition between land survey data (OLS) and current FRI.

Species / Species Groups	OLS (1907-1955)	FRI (2002-2003)	p-value	Change
BF	3.30	2.02	0.940	Not significant
BIR	5.79	n/a		
BW	3.09	11.62		
Birch spp.	8.89	11.62	0.105	Not significant
Cw	2.43	2.65	0.991	Not significant
La	0.63	0.40	0.730	Not significant
Pj	23.23	14.63	0.048 **	Decreased
Po	11.40	16.51	0.027 **	Increased
Pine spp.	0.12	Not present	0.180	Not significant
Spruce	45.42	n/a		
Sb	0.73	51.33		
Sw	0.66	0.84		
Spruce spp.	46.85	52.17	0.876	Not significant

** significance at 95% confidence interval between OLS and FRI township boundaries.

Table 41. Summary of the increase or decrease in dominance and frequency of occurrence of tree species.

Species or Species group	Change in Species Dominance	Change in Frequency of occurrence
Balsam	---	More frequent*
Total Birch	---	More frequent
Cedar	---	More frequent*
Larch	---	More frequent
Total Maple	Less dominant	---
Jack Pine	---	Less frequent
Poplar	---	More frequent*
Total White Pine and Red Pine	---	Less frequent
Total Spruce	---	More frequent

* Change is statistically significant at the 95% confidence interval
** Change is statistically significant at the 99% confidence interval

Table 42. Comparison of OLS data with current FRI by importance values.

	Township boundaries OLS (1907-1955)		Township boundaries FRI (2002-2003)	
Species or Species Group	Ranked abundance	Equal abundance	Ranked abundance	Equal abundance
BF	4.87	5.65	6.20*	8.24*
BIR[N]	7.20	7.25	n.a.	n.a.
BW[N]	3.93	4.18	11.88	11.94
Total birch	11.13	11.44	11.88	11.94
CE	2.94	3.19	4.41	5.05*
L	2.45	2.95	2.45	3.05
Total maple (M)	0.00	0.01	---	---
PJ	18.55	17.33	14.90	14.52
PO	13.81	14.76	16.77**	17.41*
Total White Pine and Red Pine	0.16	0.17	---	---
SP[N]	39.92	37.72	n.a.	n.a.
SB[N]	0.95	0.97	40.51	36.12
SW[N]	0.37	0.24	2.73	3.48
Total spruce	41.24	38.94	43.24	39.60
Other[N]	0.44	0.60	0.15	0.19

* significance at 95% confidence interval between OLS and FRI township boundaries.
** significance at 99% confidence interval between OLS and FRI township boundaries.
N species not analyzed.

In reviewing the tables above, it is apparent that while there have been some minor shifts in the relative abundance of the working groups, the current forest composition is very similar to the earlier condition along the township boundaries, as documented through the historic land survey notes.

The five largest working groups from the OLS (spruce, jack pine, poplar, white birch, and balsam fir) are still the five largest working groups today in the combined Forests. All working groups present in the historic condition are still present today. Poplar, white cedar and balsam fir levels appear to be slightly higher today than they were historically. Otherwise, changes in species abundances were not statistically significant.

It is difficult to assess the accuracy of the data for minor species given the limitations of the respective survey methods, for example, modern FRI often does not capture species occupying less than 10% of the basal area of any stand.

Generally, the composition of the modern forests appear to be similar to the composition of the historical forest, although some shifts in the relative importance of some species seem to have occurred, such as increases in poplar and white cedar. The trends in species composition described by these studies will provide useful information for consideration when setting targets and objectives related to forest composition in future forest management plans for the Pic River and Big Pic Forests.

11.1.1 Results of the Ontario Land Survey Analysis for Ecoregion 3E

Pinto et al. (2008) recently used the OLS information to characterize the pre-industrial forest on a regional basis. Stand data from the OLS records provide an invaluable source of information to help develop a template for the composition of the preindustrial forest (see Figure 25). The OLS records for the site regions provided a statistically adequate sample to describe the preindustrial abundance of all tree species except for cedar in Site Region 3E (Pinto et al. 2008). Note that a similar analysis is not possible for Site Region 3W since only a small number of townships in northwestern Ontario were surveyed by the OLS, thus data is not available.

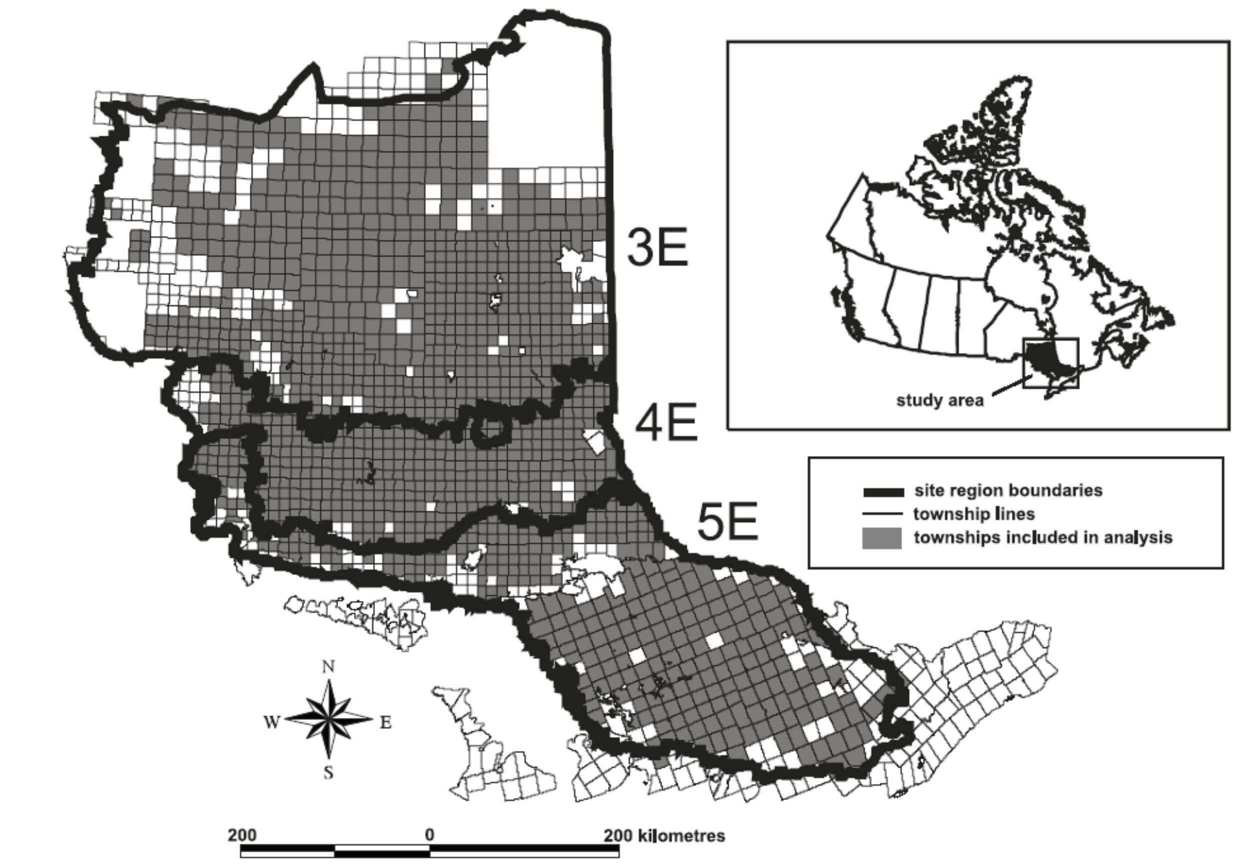


Figure 25. Outline of the township boundaries in the study area that includes the three site regions in central and northeastern Ontario, Canada.

Historical data from 1816 to 1955 for Site Region 3E suggest that today's forest composition is somewhat different from that in the past. Economically valuable species, such as white pine, red pine, and the spruces, as well as tree species with a shorter history of industrial use, such as cedar and larch, have decreased in abundance. The changes in cedar and balsam fir may be more a factor of differences between the OLS and the current FRI. The reduced abundance of larch was probably caused by the introduction of the European larch sawfly, an insect defoliator, in the 1880s. It is suggested that the changes in the abundance of economically valuable tree species have resulted from logging, fire suppression, and (or) inadequate regeneration effort. The reduction in the abundance of these valuable timber species and the concomitant increase in the abundance of intolerant hardwoods including poplar species and white birch and maples are changes that might not have occurred if only natural disturbance had been responsible for the current landscape.

Severe infestations by the eastern spruce budworm (Choristoneura fumiferana (Clem.)) in the 1980s or earlier is likely to have reduced the area and importance value of balsam fir within stands. These reductions were indeed found in Site Region 3E, suggesting that budworm defoliation may have played a role in the reduced dominance of balsam fir in addition to spruce.

Similarly, an outbreak of the European larch sawfly, an introduced insect defoliator, may have played a dominant role in decimating larch populations in northeastern Ontario in the late 1800s and early 1900s, particularly in upland sites (Howse 1983). In Minnesota, approximately 10^9 board feet (1000 board feet = 2.360 m^3) were lost as a result of this defoliator from 1910 to 1926 (Baker 1972). The first record of an outbreak in Canada was in the Quebec City area in the early 1880s (Girardin et al. 2005). The decrease in abundance and frequency of larch stands in Site Region 3E could be attributed to these defoliation events. Logging may also have been a factor in the reduction of larch abundance and frequency. In the early 1880s, the Canadian Pacific Railway (CPR) opened up into northern Ontario and with it arose the need for railway ties, in which primarily larch and cedar were used. Larch was preferred for railway ties because it holds nuts and bolts better than any other resinous species (Lutz 1997). In the 19th century, larch was also used extensively for shipbuilding purposes. Along with tanbark (hemlock), cedar posts, and telegraph poles, large volumes of larch for railway ties were harvested in throughout northern Ontario from 1893 to 1903 (Cameron 1902; Gunning 1998). Railways, such as the Temiskaming and Northern Ontario railway, are constructed to follow the height of land and, as such, would be cutting ties from upland forests, which contributed to reductions in larch; however, this would be minor compared with the impact of widespread insect defoliation.

Unlike in coniferous stands, outbreaks of defoliating insects, such as the forest tent caterpillar (*Malacosoma disstria* Hbn.) in deciduous forests do not seem to have reduced the abundance of white birch, poplars, or maples, rather, these species show a significant increase in abundance today, compared with estimates of pre-industrial conditions.

Other studies in similar forest regions in Ontario (Jackson et al. 2000; Leadbitter et al. 2002; Suffling et al. 2003) show no change or a statistically significant increase in poplar and maple as a dominant species in the forest today. These results match those that were found in the studies conducted by Pinto et al. (2008). Results from other research that use historic land surveyor data are consistent with Pinto's and show no change or a reduction in stands dominated by tamarack (Suffling et al. 2003), and red and white pine (Whitney 1987; Radeloff et al. 1999). Pinto's work also shows an increase in white birch and a decrease in yellow birch contrary to the results of Leadbitter et al. (2002).

Table 43. Comparison of dominant species composition in OLS and FRI for Site Region 3E.

Species or species group	OLS (1887-1955)	FRI	p (sigma = 0.05)	Trend
A	0.02	na		
AB	0.06	0.01	na	-
Ash species	0.08	0.01	0.000	decrease
BF	3.48	2.71	0.003	decrease
BW	1.91	10.33	-	-
BY	0.02	0.07	-	-
Birch spp.	6.39	10.40	0.000	increase
CE	1.99	2.22	0.154	
LA	2.80	1.21	0.000	decrease
M (unspecified)	0.03	na	-	-
MH	<0.01	0.05	-	-
MS	0.01	0.05	-	-
Maple species	0.04	0.10	0.023	increase
PJ	15.22	11.32	0.000	decrease
PO	9.64	19.92	0.000	increase
P	0.16	na	-	-
PR	0.14	0.02	-	-
PW	0.36	0.10	-	-
Pine species (PR + PW)	0.67	0.11	0.000	decrease
SPR	56.35	na	-	-
SB	0.42	50.62	-	-

Species or species group	OLS (1887-1955)	FRI	p (sigma = 0.05)	Trend
SW	0.06	1.33	-	-
Spruce species	57.10	51.95	0.000	decrease

Table 44. Increase or decrease in dominance and (or) frequency of occurrence of tree species in the forest in Site Region 3E today, based on ranked and equal abundance importance values.

Species or Species Group	Ranked	Sign.	Equal	Sign.	Interpretation
Hardwoods					
Ash species	decrease		decrease		Less dominance and frequency
Birch species	increase		decrease		More dominance and less frequency
Maple species	increase		increase		More dominance and frequency
Poplar	increase		increase		More dominance and frequency
All hardwood	increase		increase		More dominance and frequency
Conifers					
Balsam fir	decrease	ns	decrease		Less frequency
White cedar	increase	ns	increase	ns	More dominance and frequency
Larch	decrease		decrease		Less dominance and frequency
Jack Pine	decrease		decrease		Less dominance and frequency
Pine species (Pr, Pw)	decrease		decrease		Less dominance and frequency
Spruce species (Sb, Sw)	increase		increase		More dominance and frequency
All conifer	decrease		increase	ns	Less dominance

Sign. = *Significant Wilcoxon's signed ranks test except as indicated (ns = non-significant).

Key results are shown in Table 43 and Table 44 above. Results of the analysis of the OLS and FRI data for Northeast Region show that:

1. Conifer WG's, other than the jack pine WG in Ecoregion 5E, have become less common in all three Ecoregions studied.
2. Poplar and maple WG's have become more common in all three Ecoregions studied. Birch WG (primarily white birch) increased in Ecoregion 3E and 4E. Red and white pine WG's have been reduced significantly in all three Ecoregions studied. These species have also become less dominant within stands and also found in fewer stands today than in pre-settlement times in Ecoregion 3E.

Changes in individual species dominance and prevalence within stands in Ecoregion 3E:

- White birch, poplar, and maple are more dominant in stands today than in pre-settlement times.
- White birch, spruce and maple are found in more stands today than in presettlement times in Ecoregion 3E.
- In Ecoregion 3E spruce has become more dominant in stands today however there are fewer stands with spruce as the first listed species so the portion of the forest in Ecoregion 3E occupied by the spruce WG has decreased since pre-settlement times.
- Tamarack and cedar have become less dominant within stands and also found in fewer stands today than in pre-settlement times.
- Jack pine has become less dominant within stands and also found in fewer stands today than in pre-settlement times in Ecoregion 3E.

11.2 Age Class Distribution and Old Growth

The age class distribution of the historic forest condition was probably highly variable over time. Large widespread forest fires would have caused dramatic changes to the historic age class distribution. One of the modelling analyses that are required within the FMP is the examination of the forest without human intervention, also called the null run or the Benchmark run. In developing the null run, the historic natural forest condition is estimated through modelling the impact of natural disturbance events (i.e., fire and natural forest succession) on the current forest condition, using the Sustainable Forest Management Model (SFMM). This analysis is useful because it provides a theoretical benchmark for the age-class structure of the natural forest, which can be considered, along with other information, in setting goals and objectives for Forest Management Planning.

Table 45 summarizes the forecast age class distribution by forest unit as determined by the null SFMM analysis, for the Big Pic Forest, following 150 years of natural disturbance. In preparing this table, the age-of-onset for old growth conditions were based on the Old Growth Forest Definitions for Ontario (Uhlig et al. 2001). For illustrative purposes, age classes that satisfy the minimum age for old growth condition have been shaded on the table. For the Big Pic Forest, a negative exponential age-class distribution is readily apparent in most forest units. The irregular results (increased area in middle age classes) are due to succession rules in the SFMM model. Within the model, area is returning to these forest unit age-classes due to disturbance events in other forest units.

Table 45 shows that the percentage of old growth in the simulated natural forest (presumed to be analogous to the pre-industrial forest condition), as determined through current forest modelling, ranged from 6% to 48% for different forest units depending on their susceptibility to fire (flammability). For the forest as a whole, the benchmark simulation indicated a total value for old growth area equal to 23.5% of the productive forest landbase, or approximately 138,400 ha. This is a lower proportion than indicated by the current situation (derived from the 2007 FRI), which shows old growth area equal to 34.3% of the productive forest landbase, or 196,383 ha. It is, however, consistent with the estimated proportions of old growth indicated by historical inventories (e.g., 1960 and 1977).

Table 46 shows a similar analysis for the Pic River Forest which was conducted for 2013-2018 FMP. The total forecast areas of Crown productive old growth forest by forest unit are shown, for the natural benchmark and for the long-term management direction (LTMD) SFMM runs projected over three time periods: 10, 20 and 100 years. These analyses indicate that the amount of old growth forest area under the proposed management strategy (LTMD) will be equal to or greater than the forest unit old growth areas forecast by the natural benchmark simulation (i.e., forest succession as a result of natural disturbances and natural regeneration only, with no harvesting).

There are a number of limitations in using SFMM to provide an indication of the historic age class distribution: it is a deterministic model which provides no indication of the variation in age class distribution. Other simulation tools are able to better estimate historic condition, e.g., simulations completed with the BFOLDS Model and included in the Ontario Landscape Tool (OLT) package developed by OMNR. This model more accurately describes the natural variation in age classes and includes better consideration of site and terrain conditions in modelling fire behaviour.

Table 45. Forecast Age Class Distribution of All (Available + Reserved) Even-aged Forest Area by Forest Unit for the Big Pic Forest after 150 years (year 2157), based on SFMM analysis of the natural disturbance regime, compared with the current situation (2007 FRI).

	Forest Unit Area (ha) Projected to Year 2157											
Age Class	BOG	SB1	PJ1	LC1	PJ2	SP1	SF1	PO1	BW1	MW1	MW2	All FUs
Age 1- 10	321	13,526	10,177	932	947	2,211	0	25,749	6,049	2,023	0	61,935
Age 11- 20	318	12,396	8,798	864	847	1,986	0	22,834	5,442	1,802	0	55,288
Age 21- 30	359	11,362	7,559	802	767	1,814	0	20,213	4,913	1,607	0	49,396
Age 31- 40	449	10,413	6,480	744	688	1,681	941	17,855	4,451	1,448	0	45,150
Age 41- 50	534	9,541	5,519	697	620	2,208	4,086	15,758	4,235	1,317	2,897	47,412
Age 51- 60	475	9,391	4,693	643	559	1,921	3,615	13,897	3,794	1,191	3,107	43,288
Age 61- 70	316	8,560	3,979	656	508	1,801	4,056	12,260	3,420	1,082	2,636	39,275
Age 71- 80	208	7,976	3,381	655	469	1,596	4,353	10,784	3,032	972	1,913	35,340
Age 81- 90	166	7,241	2,869	775	437	1,434	3,962	9,460	2,756	877	1,877	31,854
Age 91-100	171	7,305	2,435	881	405	1,277	3,353	8,285	2,506	787	1,696	29,102
Age 101-110	160	7,184	2,085	995	374	1,127	2,665	7,251	2,307	708	1,684	26,540
Age 111-120	129	7,691	1,775	1,029	352	1,038	2,248	6,322	2,089	626	1,170	24,470
Age 121-130	117	7,788	1,131	968	434	1,445	2,251	5,508	1,872	554	1,446	23,516
Age 131-140	112	8,112	724	853	439	1,538	2,789	3,822	1,287	477	2,757	22,911
Age 141-150	103	6,848	0	800	0	1,250	3,620	1,324	715	294	2,163	17,118
Age 151-160	9	12,957	0	692	0	1,338	2,819	0	101	136	2,501	20,553
Age 161-170	11	7,477	0	327	0	347	1,667	0	0	0	88	9,916
Age 171-180	0	836	0	176	0	0	0	0	0	0	238	1,250
Age 181-190	0	1,224	0	284	0	0	0	0	0	0	217	1,725
Age 191-200	0	605	0	90	0	0	0	0	0	0	109	804
Age 201-210	0	168	0	52	0	0	0	0	0	0	147	368
Age 211-220	0	28	0	44	0	0	0	0	0	0	184	256
Age 221-230	0	0	0	15	0	0	0	0	0	0	196	211
Age 231-240	33	0	0	105	0	0	0	0	0	0	0	139
Age 241-250	1	0	0	18	0	0	0	0	0	0	0	19
Age 251+	0	0	0	0	0	0	0	0	0	0	0	0
All Age Classes, Year 2157	3,993	158,632	61,606	14,098	7,849	26,009	42,427	181,321	48,970	15,902	27,027	587,834
Total Old Growth, 2157	n/a	46,043	3,630	4,424	1,599	8,083	18,059	32,512	8,371	2,795	12,900	138,416
% Old Growth, 2157	n/a	29.0%	5.9%	31.4%	20.4%	31.1%	42.6%	17.9%	17.1%	17.6%	47.7%	23.5%
Forest Unit & Old Growth Area (ha), Current (Year 2007)												
All Age Classes, Year 2007	3,993	149,964	15,403	17,425	22,512	96,353	55,967	73,224	21,220	23,177	93,770	573,004
Total Old Growth, 2007	n/a	58,963	595	10,694	3,743	38,022	11,735	23,831	9,614	4,374	34,812	196,383
% Old Growth, 2007	n/a	39.3%	3.9%	61.4%	16.6%	39.5%	21.0%	32.5%	45.3%	18.9%	37.1%	34.3%

Table 46. Comparison of the total area of Crown productive old growth forest on the Pic River Forest for the natural benchmark and the long-term management direction (LTMD) SFMM simulations by forest unit after 10, 20 and 100 years. Source: 2013-2018 PRF FMP.

	2023			**2033**			**2113**		
Forest Unit	Natural Benchmark	FMP Management Strategy (LTMD)	%	Natural Benchmark	FMP Management Strategy (LTMD)	%	Natural Benchmark	FMP Management Strategy (LTMD)	%
SB1	14,688	16,175	110%	14,539	14,539	100%	13,015	13,015	100%
PJ1	550	550	100%	796	796	100%	1,438	1,438	100%
LC1	1,994	2,000	100%	1,889	1,889	100%	2,356	2,356	100%
PJ2	860	860	100%	1,974	1,974	100%	1,596	1,596	100%
SP1	18,038	19,222	107%	17,443	17,535	101%	12,413	12,413	100%
SF1	10,147	12,296	121%	10,247	12,707	124%	13,488	12,296	91%
PO1	12,421	14,129	114%	11,433	13,118	115%	3,807	4,951	130%
BW1	18,266	20,071	110%	15,516	15,516	100%	4,239	4,600	109%
MW1	902	1,079	120%	2,407	2,407	100%	1,790	1,877	105%
MW2	33,213	38,447	116%	29,771	32,826	110%	15,594	15,594	100%
Total	111,079	124,829	112%	106,015	113,307	107%	69,736	70,136	101%

12 Summary and Conclusions

Fire Cycle Information

- At present, information regarding fire cycles for use in Forest Management Planning is provided to planning teams by OMNR. This information is based on an analysis of fire data relevant to each Region and provides fire cycles for each forest unit based on their fire hazard characteristics. This information is summarized in the current Forest Management Plan (2007-2017) for the Big Pic Forest and in the current Forest Management Plan (2013-2023) for the Pic River Forest.
- A literature review was conducted to assemble descriptive material of the major disturbance factors affecting forest development in the boreal forest of northeastern Ontario (fire, insects and diseases, windthrow), which are summarized in this document.
- Additional historical information related to these elements of fire disturbance was collected and is summarized in this document – this will provide additional context and ancillary information which may assist in the development of future management plans for the Pic River and Big Pic Forests.
- A study conducted by Richard Fry (Fry 1997) provides excellent local information about fire history of the area and the likely nature of the pre-industrial forest. This study made extensive use of the American Can inventory datasets.

Species Composition

- The five largest working groups from the OLS (spruce, jack pine, poplar, white birch, and balsam fir) are still the five largest working groups today in the combined Forests. All working groups present in the historic condition are still present today.
- On the Big Pic Forest, poplar, white cedar and balsam fir levels appear to be slightly higher today than they were historically. Otherwise, changes in species abundances were not statistically significant. It is difficult to assess the accuracy of the data for minor species given the limitations of the respective survey methods, for example, modern FRI often does not capture species occupying less than 10% of the basal area of any stand.
- On the Pic River Forest, balsam fir and white spruce appear to be less common than they were historically, likely due to the extensive and prolonged spruce budworm infestations of the1970s and 1980s. Poplar, white birch and jack pine appear to be more abundant than they were historically, likely due to succession of budworm-killed balsam fir and spruce stands to these types. There may also be a slight shift from the conifer-dominated forest types into mixedwood types due to long-term trends resulting from harvest depletions in the absence of fire. All these changes in average species composition are relatively small in magnitude.
- Generally, the composition of the modern forests appears to be similar to the composition of the historical forest, although some shifts in the relative importance of some species seem to have occurred, such as increases in poplar and white cedar and decreases in balsam fir.
- The trends in species composition described by these studies will provide useful information for consideration when setting targets and objectives related to forest composition in future forest management plans for the Pic River and Big Pic Forests.

Key observations made by Fry from his 1997 study included:

- The tree species normally considered to be early successional species (spruce, jack pine and trembling aspen) are far-and-away the dominant species in the young forest.
- As stands age, aspen and pine become less prominent while spruce, balsam fir and white birch increase in prominence.
- White spruce is very seldom found in young age classes and, with the exception of the white birch working group, seldom accounts for more than 10 percent of the stand until after the stand reaches 100 years.

- Species composition of stands in older stages is often not at all the same as their composition in the early stages of their development.
- Observation of prolific levels of tamarack regeneration whenever a seed source is nearby could lead one to believe that this species could be more prominent in early stages of the next forest than in the past. However, given its susceptibility to the larch sawfly, it is doubtful that such levels could be maintained over an entire rotation.
- White cedar could also be expected to increase in the forest in the absence of fire.

Trends in changes in species composition, in the broader context of Ecoregion 3E, include:

- White birch, poplar, and maple are more dominant in stands today than in pre-settlement times.
- White birch, spruce and maple are found in more stands today than in pre-settlement times in Ecoregion 3E.
- In Ecoregion 3E spruce has become more dominant in stands today, however there are fewer stands with spruce as the first listed species, so the portion of the forest in Ecoregion 3E occupied by the spruce working group has decreased since pre-settlement times.
- Tamarack has become less dominant within stands and is also found in fewer stands today than in pre-settlement times.
- Jack pine has become less dominant within stands and is also found in fewer stands today than in pre-settlement times in Ecoregion 3E.

Uncommon Tree Species

- Uncommon species found in the Pic River and Big Pic Forests include black ash, red maple, sugar maple, red pine, and white pine. None of these can be shown to have significantly declined in abundance from a statistical perspective.
- The uncommon species of today were also uncommon in the preindustrial forest, as indicated by the OLS records and the earliest forest inventory records. There are no records indicating that these species were ever harvested in these Management Units.
- References to the locations of historical red pine and white pine occurrences within the Pic River and Big Pic Forests were provided in the expectation that forest managers may wish to use this information to identify historical and existing sites for these species as a guide to future management or restoration efforts.

Age Class Distribution & Old Growth

- Based on SFMM analysis for the Pic River and Big Pic Forests, a negative exponential age-class distribution is forecast for most forest units.
- The percentage of old growth within the natural, unmanaged forest condition (which presumably is similar to the pre-industrial forest condition), as estimated through forest modelling included in the FMP (i.e., SFMM), averaged 23.5% and ranged from 6% (for the PJ1 forest unit – pure jack pine) to 48% (for the MW2 forest unit – mixedwood) of the total forest area for the Big Pic Forest. Different levels of old growth are associated with the different forest units depending on their susceptibility to fire (flammability).
- The current forest has an average of 34.3% old growth for all forest units combined. The Big Pic may thus be described as an old forest. This increase in the proportion of old growth over time is consistent with trends illustrated by historical inventories for the Big Pic Forest over time.
- Estimates of old growth over time for the Pic River Forest are contained in Supplementary Documentation and the Analysis Package from the current FMP for the Pic River Forest (Cameron 2013).

Historical Records

- The use of historical inventory to generate estimates of the historical forest condition, for comparison with the current forest condition, has been problematic due to differences in inventory formats, scales, and attributes. Broader, regional or district level summary of forest inventory are also problematic to compare because of numerous boundary changes over time. Although logical trends can be discerned, there is usually not the ability to calculate statistical significance attributable to these observed changes.
- A series of historical inventories were acquired, collated and summarized with regard to species composition and age class distribution. This information provides a range of values for these parameters, which can be used for comparison with current inventory, and may be useful for validating the simulated ranges of natural variation used in forest management planning.

A data catalogue of the historical information collected during the preparation of this report has been prepared in order to facilitate data archiving and to help ensure the preservation of valuable data.

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Appendix 2. Dick Fry's study of the pre-industrial forest, extracted from the 1997 FMP for the Big Pic Forest (Appendix 3).

A FIELD STUDY OF THE COMPOSITION, STRUCTURE AND PATTERN OF ORIGINAL FORESTS IN THE MANITOUWADGE AREA.

INTRODUCTION

The allocation of stands for harvest on the Crown forest lands of Ontario has largely been based, historically speaking, on the need for industrial wood fibre. In the earliest stages of timber management, the allocation process was primarily influenced by demand, ease of access and quality of timber. As time went on, however, considerations of sustained yield and harvest regulation became more prominent. More recently, regard for other forest values and their protection has resulted in a "constraint management" approach whereby other values that may be impacted by proposed forest operations are identified and the operations are constrained through the application of various protective measures such as the prohibition or modification of operations. When applied to some particular species, this approach has been termed the "species approach" (Soulé, 1994) or, in the Ontario context, "featured species". Examples of this approach are the establishment of no-cut reserves around eagles nests and the limitation of clear-cuts to some maximum size to provide habitat for moose and other wildlife species.

As a result of recent policy developments, attention has been focused on what has been called "ecosystem management". Since it is highly presumptuous to ever believe that mankind can *manage* ecosystems, the approach could probably be better called "ecosystem-based management". Although the term is not well-defined nor well-understood, the implication of this latter terminology is that resource management will be based on an ecosystem approach. In Ontario, as a matter of policy this will take the form of timber management strategies that will "mimic" natural forest composition, structure and pattern. Once again, though, it would probably be better to use the word "emulate", a term that better recognizes that imitation is impossible and that trade-offs - within the bounds of sustainability and practicality - are necessary and desirable.

As a result, Forest Management Plans will be required to place a great deal of emphasis on the determination of a set of desired future forest conditions that will be based in part on the natural forest state i.e. the type of forest that would prevail in the absence of man's influence. Timber supply models and habitat supply models could then be used to test some of the key outputs of various mixes of forest conditions before settling on some target conditions. Management practices and strategies will then be designed to ensure that the forests under management will meet those desired conditions in some reasonable and planned time-frame. This will not mean an abandonment of the species approach but this latter strategy will be used primarily to deal with threatened or endangered species whose need for specific types of habitat and/or protection mandates this approach.

Heretofore, a problem with determining just what the desired future forest condition should be, however, has been a poor understanding of what the natural forest (i.e. one undisturbed by man's activities) would look like. In part, this is because what many people consider the natural forest is, in fact, a forest that has been modified to a great degree by human activities. The purpose of this study is to use the best existing local information and a review of pertinent scientific literature to attempt to synthesize an approximation of the composition, structure and pattern of the natural forest and to use that synthesis to develop management strategies and useful indicators of progress.

THE STUDY AREA

The Big Pic Forest and the Black River Forest are located in the Central Plateau (B8) and Superior (B9) Sections of the Boreal Forest Region (Rowe, 1972). The town of Manitouwadge, Ontario, is located near the centre of this study area. The tree species common to these forests include black spruce, jack pine, trembling aspen, white spruce, balsam fir, white birch and balsam poplar. Tamarack and eastern white cedar are scattered throughout the area. A small concentration of red pine occurs near One Shot Lake on the Big Pic Forest. Scattered white pine can be found in several places on the Black River Forest. Terrain conditions can generally be described as precipitous to rolling in areas near Lake Superior to flat to very gently rolling in the northeastern corner of the study area.

All of the area was glaciated and much of it is now covered by shallow to moderately-deep ablation tills left behind following the retreat of the ice sheet. The lower-lying portions of the river-valleys have extensive deep lacustrine deposits resulting from ponding during periods when a forerunner of Lake Superior extended up the main river valleys. Outwash deposits of coarse and medium sands are widespread but large concentrations are not extensive. Silt fractions in many of the soils seem to be higher than in areas to the west of Lake Nipigon.

Logging operations in the area probably started when the Canadian Pacific Railway was first constructed and the forests became a sporadic source of ties, building timbers and some lumber. Early commercial logging operations on the area commenced following the creation of the Pic River Pulp and Timber Limited licence in about 1916. The licence area covered part of the present-day study area and saw a number of different operators remove small volumes of timber from time-to-time from the lower stretches of the larger rivers. There are no known records of the harvesting levels of those operations but they were probably relatively small and sporadic. Following a reorganization of timber licences in 1937, logging operations on the Big Pic and the Black River commenced anew and have been continuous ever since.

THE FORESTS

Boreal forests have long been recognized as having an extensive fire history (Lutz, 1956; Rowe and Scotter, 1973; Heinselman, 1971b). Some of the evidence of this is anecdotal and historical resulting from eye-witness accounts of fires during this century that have been recorded by surveyors, area residents and in official Government reports. Other evidence is based on such things as the presence of occasional dead burned trees in an otherwise young stand of trees, the occurence of charcoal in the humus horizon of the soil in a forest, and the presence of charcoal and soot particles in lake sediment cores dating back thousands of years (Swain, 1973; Clark, 1988 and 1990). The expert opinion is overwhelmingly in favour of an extensive fire history in the Boreal forests in this part of Ontario that no doubt extends back many millennia.

Some of the tree species common to Boreal forests have evolved silvical characteristics that are well-adapted to an ecosystem in which wildfire is a regular, though not frequent, occurrence. Black spruce produces and stores its seed in persistent semi-serotinous cones that protect a large proportion of its seed during a wildfire (LeBarron, 1948). Jack pine does the same although its cones are completely serotinous (Roe, 1963). Following a wildfire in stands of black spruce and jack pine, hundreds of thousands of seed are released from cones in the tops of the dead, scorched trees in the weeks following a fire. Fire-killed trembling aspen and balsam poplar produce thousands of root suckers and white birch and balsam poplar produce many stump sprouts when the parent tree is killed by wildfire. For these groups of species, wildfire is a mechanism which triggers substantial levels of regeneration that will quickly come to occupy the site on which the previous stand of trees was killed.

Other tree species are poorly-adapted to wildfire. White spruce, balsam fir, tamarack and eastern white cedar release most, if not all, of their seed immediately upon seed maturation (Sims *et al.*, 1990). Once released, the seed is very susceptible to destruction during intense wildfire - particularly if it has already germinated into a young seedling by the time of the fire. For these tree species, their continued existence in the Boreal landscape depended on a physical location which, because of site conditions (excessive soil moisture), position in the landscape (along a large river or lake) or simply chance, resulted in their escape from destruction in the fire. These refugia become locations from which, over time, they slowly spread-out through seeding into adjacent areas. For these species, wildfire can be seen as a mechanism that limits their numbers and distribution while providing a means whereby they are not entirely eliminated from the landscape.

A common perception by the public of the manner in which forests, in general, exist is that of the "steady state ecosystem". In ecological theory, this assumes that forest vegetation recovers from initial disturbance by the colonization of the site by "pioneer" species that are gradually replaced, over time, by "climax" species. The climax species then continue to exist in associations, stand structures and patterns that are self-perpetuating and change little, if at all, with the passage of time. In steady state theory, this condition was considered to be the most stable state of the forest and the one which optimized biodiversity. Natural disturbances, if they occur at all, are infrequent and of the scale of small gaps in the forest stand resulting from the death of individual or, rarely, small groups of trees.

More recently, an alternative to steady state theory is that of the "constant change ecosystem" (Oliver, 1994). In this model of forest development, there is no stable climax stand condition. Rather, the forest is seen as being comprised of a matrix of stages of recovery from the many small-scale and the fewer large-scale disturbances common to many forest ecosystems. This matrix is comprised of stands of composition, structure and distribution that gradually change over time. Inevitably, the gradual development of the stand is interupted by disturbance of catastrophic proportion that re-starts the cycle. Within-stand diversity is often narrow and more complex levels of biodiversity can only be seen at the landscape level. While stand conditions popularly referred-to as "old growth" may occur, in the constant change forest it is a transitory stand condition that is not particularly stable and, if not interupted by major catastrophe, may lead down a successional pathway that, as described by Heinselman (1971a), is unpredictable, unnatural and one "largely unknown to science".

The tolerant hardwood forests of the Great Lakes-St. Lawrence Forest Region and the Coastal Forests of British Columbia (Rowe, 1972) are probably the best Canadian examples of steady state forest ecosystems. The Boreal Forest Region is arguably the best example of the constant change ecosystem.

The study described below, while not of a scientific nature, will hopefully shed some light on the applicability of the two models to the real forest and provide a little more practical insight to the direction that one should travel along the "ecosystem-based management" approach to timber management.

THE STUDY

The primary objective of this study is to establish some sort of snapshot of the species composition at the stand and landscape level, the age class and stand structure of the forests and of the disturbance patterns in the study area prior to the arrival of white culture. To do this, several sources of information were used. Firstly, a literature search was undertaken to obtain relevant scientific publications on the subject-matter. Secondly, old inventory information dating back to the 1940's and 1950's was assembled for analysis. And, finally, old aerial photos taken in the 1940's were assembled for specific study areas on the two forests.

An important information source for the study was forest inventory data that was collected by the former American Can Canada Inc. (ACCI) and its corporate predecessors, Marathon Paper Mills and the Marathon Corporation, over the course of four decades starting in the early 1940's. The inventory system was abandoned in 1986 and replaced by the more universal Forest Resource Inventory (FRI) promoted by the Provincial government.

The ACCI inventory program was described in detail in a document - "Forest Management Program for Canadian Woodlands (1971)" - and summarized in another document "A Management Plan for the Pic Area, 1977". Fortunately, a large part of the data was saved following its abandonment.

There are several essential features of the ACCI inventory that have proven to be valuable to this study.

Firstly, the inventory was mapped at a scale of 1:7,920 (10 chains per inch) which facilitated a finer resolution of stands than the 1:15,840 or the more current 1:20,000 scales would permit. This resulted in a finer level of detail in stand mapping that recognized more differences in stand composition and age than was normally practiced in the FRI system.

Secondly, a great deal of the data relavent to stand age came from sets of aerial photography taken in 1943 and 1947. These photos provided very clear delineation and interpretation of most wildfires dating back to the turn of the century that, together with the historical data of the day, permitted a very precise determination of the date of stand origin. For areas burned prior to 1900, it is reasonable to believe that age data, combined with a substantial amount of reconaissance and operational cruising conducted since 1940, would be more precise than the 1974 FRI (the first FRI that was completed for the study area) simply by reason of the shorter interval between the date of stand origin and the date of photography.

And thirdly, the ACCI inventory provided for the collection and retrieval of a substantial data bank of volumetric information that generated a series of empirical yield tables based on cover type and decade of stand origin. While there are some limitations with respect to the accuracy of yield forecasts in the tables, they still provide some indication of changes in species composition and stand structure within stands of similar attributes over time.

While there are few aerial photographs remaining from the 1947 set for the Big Pic Forest, about one-half of the 1943 photographs are still available. Data summaries for land and timber inventory information are readily available.

Another data source that was used although it was much less extensive, was the inventory developed by the Ontario Paper Company, the former licensee for the Black River Forest. This data was largely in the form of forest stand maps that helped to identify cover types and broad age classes, presumably from 1947 aerial photography. Unfortunately, there is little in the way of a description of the system and no data base remaining. However, almost the entire set of 1947 aerial photography for the Black River remains.

To try to determine the characteristics of historic wildfires in the area, a total of five wildfires dating from the period between 1920 and 1936 were selected. They were chosen to represent several very large fires of greater than 20,000 hectares (the Foch River fire and the Pinegrove fire), one moderately sized fire (Hillsport fire) of about 7,000 hecatares and two of small fires of less than 1,000 hectares (Bullmoose Lake and Twin Falls fires). A large part of the largest fire (the Foch River fire) extended off the study area. While an analysis of the whole area covered by this fire was not possible at this time, we plan on completing the analysis as soon as time permits. The earliest aerial photography available for these areas, usually 1943 or 1947 but sometimes 1962, was used to delineate the boundaries of the fire and any unburned patches within the perimeter of the main body of the fire. The information was transferred from the photographs to maps at the scale of 1:15,840 for the calculation of such things as total area burned/unburned, size of unburned patches, edge/burn ratio, et cetera.

To try to get some sort of sense of the scope and pattern of wildfires at the landscape level, an age-class map of the Big Pic Forest at the scale of 1:126,720 (2 miles per inch) was prepared. To develop this map, stands that fell into 20-year age classes were transferred, by freehand, from the ACCI mapsheets. While not precisely a fire-history map, the delineation into the twenty-year age classes does give some idea of fire patterns in the past. To obtain a more precise map from the existing data-set would be possible but would probably require that the data-set be digitized for ease of operation.

THE RESULTS

A number of stand- and landscape-level attributes were examined in the course of the study. Each of these will be discussed separately.

Species Composition. Of all the stand-level and forest-level attributes by which forests can be described, tree species composition is the most readily-understood and the easiest to inventory. While there are many other plant species present in the forest, this discussion will be limited entirely to *tree* species.

As noted earlier, all of the tree species that are characteristic of the eastern Boreal Forest can be found on the Big Pic and Black River Forests. In attempting to determine some sort of benchmark for species composition, the dynamics of Boreal Forests is a confounding factor. At the stand level, it is entirely unlikely that the relative species composition of a thirty-year-old stand will be the same as the same stand at 130 years: shorter-lived tree species will die-out more rapidly than their longer-lived associates, and gaps created in the canopy may be filled by later-regenerating species that are reasonably tolerant of heavy shade. At the forest level, a forest with a preponderance of young age-classes will similarly have a different relative abundance of tree species than a forest in which wildfire has not been particularly active for a number of decades.

The ACCI inventory developed a set of empirical growth and yield tables using 15,260 single- examination cruise plots established over the course of twenty-four years of operational cruising. While most of the plots were concentrated in the mature and over-mature age classes, there were, nevertheless, about 360 plots in immature age classes. Where gaps in the sample existed, they were filled by using data from a set of Permanent Sample Plots established on the Forest, and by additional cruise plots located for the specific purpose of filling the remaining gaps. A set of smoothed tables was developed for the bS, M, H and MS cover types. The more limited numbers of sample plots for the S and jP cover types made it impossible to develop smoothed tables for these two cover types.

Figure 1 is a graphical presentation of the changes that occur over time in the relative abundance of tree species. Separate graphs portray these changes by the cover type associations in the ACCI inventory. It is important to note that the S cover type is *not* always considered to be fire-originated: it is often a late-successional phase of the M covertype that results from the death, due to over-maturity, of the pioneer species. For this reason, care must be taken in interpreting the eratic changes in composition in this cover type. While the sudden changes in species composition in the S cover type may be nothing more than a sampling artifact (and the result of the tables not being smoothed - see discussion in the above paragraph), it does lend some credence to Heinselman's warning noted earlier relative to the prognosis for stands as they slip into over-maturity.

It is easy to see that tree species normally considered to be early successional species (spruce, jack pine and trembling aspen) are far-and-away the dominant species in the young forest. As stands age, aspen and pine become less prominent while spruce, balsam fir and white birch increase in prominence. The increase in spruce is due, in part, to its generally longer expected life-span than that of jack pine and aspen. It may also be due to a recruitment of white spruce in later stages of stand development - a development that is masked by its combination in the inventory under the heading of "Spruce".

The increase in the proportion of white birch as the stand ages is puzzling considering that it is regarded as a short-lived species that is very intolerant of shade (Sims *et al*., 1990). It may be that this could be attributed to the fact that white birch is a prolific seed producer whose germinants on rotten logs and stumps or on mineral soil exposed by windthrown trees can quickly take advantage of gaps created in the stand as the original stand breaks-up. Heinselman (1973) reported an earlier study in which the authors believed that white birch could maintain its position in overmature stand conditions because of its sprouting ability. Whatever the reasons, these findings might explain the substantial increase in the white birch working group from the 1974 FRI to the 1990 FRI on the Black River Forest as overmature stands dominated by balsam fir and white spruce converted to white birch after the spruce budworm killed most of the conifer.

One noteworthy short-coming with respect to the yield tables is the combining of white and black spruce as "Spruce". Since white spruce is often considered to be a species that comes into the stand slowly after a severe fire (Kelsall *et al*., *1979)*, the separation of these two species within the yield tables would have been a valuable piece of information in analyzing species development over time. An off-shoot of the ACCI inventory, however, was a set of "Limit Average Stand and Stock Tables". These tables combined data from *all age classes past the rotation age* for each cover type but separated the two spruce species.

Table 1, below, gives some indication of the amount of white spruce in those age classes for each cover type. The proportion of white spruce shown for the S cover type is no surprise given earlier comments relative to the origin of this cover type. It is impossible to determine from this data when white spruce starts to increase its presence in the various cover types, but it seems reasonable to assume that it would probably be at about the same time as the balsam fir component starts to increase. Additionally, a set of weighted average stocking and species composition tables prepared for the Black

Table 1: White spruce as a percentage of "Spruce" by cover type - all ages past Rotation Age.

bS	H	S	MS	jP	M
2.1	45.2	53.9	1.9	3.0	35.3

River Forest in 1989 and based on the original 1974 FRI gives some credence to this model: in those tables, white spruce is very seldom found in young age classes and, with the exception of the white birch working group, seldom accounts for more than 10 percent of the stand until after the stand reaches 100 years. Overall, white spruce accounted for less than 5 percent of the species composition of the Forest in 1974.

These graphs reveal a point of some importance when considering the choice of species for the next crop: regenerating stands similar to those harvested is not a universally valid approach. The species composition of stands at the time of harvesting are often not at all the same as their composition in the early stages of their development. Indeed, silvicultural prescriptions for forests in the Manitouwadge area should generally concentrate on establishing species in the same general proportions as they appear in the youngest of the age classes shown on the graphs in Figure 1.

These graphs can be used in the development of the Silvicultural Ground Rules to provide some insight as to the desired species composition for various forest units and the silvicultural prescriptions that would be required to regenerate and tend harvested stands. Amongst conifer species, silvicultural prescriptions to meet these targets will have to stress the regeneration of jack pine and black spruce in the appropriate forest units since experience throughout much of Boreal Ontario has shown that these species do not regenerate well following harvest without some some active intervention (Hearndon *et al*, 1992). Since trembling aspen and white birch are important components of mixedwood stands, stand management techniques will have to be developed and utilized that will ensure the continued presence of these two species in future stands of this type while maintaining the black spruce and jack pine component. Unlike jack pine and black spruce, regeneration of these hardwood species is not normally a problem: rather a problem may arise when management techniques such as aerial spraying that are designed to promote conifer survival lead to the demise of most or all of the aspen and birch stand component.

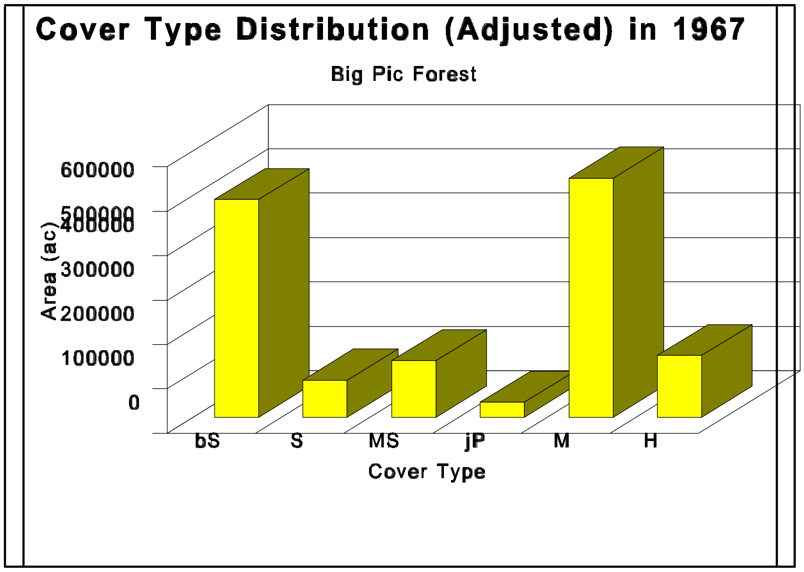
It seems reasonable to believe that white spruce behaves similarly to balsam fir and does not enter the stand in any significant quantity until late in a stand's life. Silvicultural prescriptions should then be designed, if possible, to limit these two species in the initial stages of the next crop. The allocation of areas for harvest should be designed to provide for scattered refugia that will, over time, become the seed source for a gradual re-entry into adjacent stands. Harvesting operations should, at least theoretically, try to leave as little unmerchantable live balsam fir and white spruce as possible standing in the cutover and site preparation techniques should aim at effective ways of eliminating young and advance growth of these two species.

Little has been said so far relative to the "Other Conifer" species - tamarack and cedar. As noted earlier, their presence in the forest is very limited. Because they are not well-adapted to fire, they likely react to disturbances similarly to balsam fir and white spruce only at a much more limited level. They are seldom, if ever, harvested in the course of logging operations and are probably going to have ample seed sources in the cutover forest to regenerate to adequate levels. In fact, casual observation of prolific levels of tamarack regeneration whenever a seed source is nearby could lead one to believe that this species could be more prominent in early stages of the next forest than in the past one. However, given its susceptibility to the larch sawfly (*Pristiphora erichsonii* Hartig), it is doubtful that such levels could be maintained over an entire rotation. Heinselman (1973), based on his observations in the Boundary Waters Canoe Area, suggests that cedar could be expected to increase in the forest in the absence of fire. So, as with balsam fir and white spruce, silviculture techniques should probably be designed to limit regeneration of these two species in the next forest.

While these graphs give some guidance to the species composition of stands falling in different forest units, it does not provide much insight as to the relative abundance of each forest unit in the original undisturbed forest. A feature of the ACCI inventory that allows its use for trying to reconstruct the compositional structure of the original forest lies in the fact that, when stands were harvested, they retained their original cover type classification in the inventory following cutting. It was not until a new cover type condition could be interpreted by aerial photography that the cover type classification would be changed and, in fact, such reinterpretation had seldom been done (because of the young age of most of the cutover).

However, offsetting this feature, was another one in which areas were reinterpreted following operational cruising. While most of the change resulting from the reinterpretation was simply a refinement of stand boundaries that reflected the level of detail available from the cruise data, there was no doubt some change resulting from stand dynamics and the passage of time from the initial interpretation in the late 40's and early 50's. There is no easy way of assessing the impact of this. Presumably it was not a lot simply because only twenty years had passed

Information extracted from a combination of sources (see below for the method of deriving the data) indicates a relative abundance of each cover type as shown in the graph to the right.



The data used came initially from a revision to a landbase summary prepared in August, 1967. This was a revision of data initially included in the 1960 Forest Management Plan that was necessary as a result of an exchange of licence area with Kimberly-Clark that added area notheast of Hillsport to the Big Pic licence. The area remains part of the current Big Pic Forest today. Additional data was added to account for the Hillsport "B" working circle which was comprised of Flanders, Frances and Downer townships. This data (for Flanders, Frances and Downer townships) came from the 1977 Forest Management Plan since no earlier data, in the format required, could be found.

The stand interpretation for the ACCI inventory was largely done in the late 1940's and early 1950's. At that time, the forests resulting from the fires from the first third of this century were so young that an accurate interpretation of cover type conditions based on aerial photography was next to impossible. As a result, the interpreters were instructed, when in doubt, to classify the area into the Mixedwood (M) covertype. It was expected that new aerial photography taken several decades later would permit a more accurate delineation at that time. However, the data described above did not incorporate any reinterpretation of the fires from the 1910's, 1920's or 1930's. Consequently, the cover type distribution would be artificially skewed to the M (Mixedwood) cover type. To try to adjust for this, the *combined* covertype distribution for those three decades were adjusted by applying the same cover type distribution as for all other age classes combined. While not entirely accurate, this data provided the best mechanism for establishing a target forest structure, by forest unit, for the Big Pic area.

Using the available data and a whole lot of judgement, Table 2 presents a suggested long-term target forest unit distribution for the Forest and compares it to the current FRI and 1976 ACCI inventory.

Table 2: Historical (1967), current (1996) and target forest unit distribution on the Big Pic Forest, in percent.

	bS	S	MS	jP	M	H
1967	34	7	9	2	38	10

	BS1	BS3	S	JP	JPM	MA	MB	PO	BW
Current	26	4	14	7	3	20	11	13	2

Target	26	4	10	11	4	22	11	10	2

The above table tries to draw some parallels between the cover type classification used in the ACCI inventory and the forest unit classification used in this Plan. At the risk of greatly over-simplifying things, *generally speaking*, it can be assumed that the bS cover type is comparable to the BS1 and BS3 forest units; that the S cover type is comparable to the S forest unit; that the MS and jP cover types are comparable to the JP forest unit; that the M cover type is comparable to the MA, MB and JPM forest units; and that the H cover type is comparable to the PO and BW forest units.

In establishing targets for the BS1 and BS3 forest units, it is hard to visualize the "Current" proportions changing: these types of stand conditions are largely controlled by site conditions and conversion of these sites to some other forest unit is not likely to happen. The difference between the proportion of the bS cover type in the ACCI inventory (34%) and the BS1 And BS3 forest units in the FRI (30%) is probably due to a fundamental difference in the descriptions between the three. In the course of working with the FRI, it has been noted that there are a noticeable number of cases where stands that the ACCI considered to be bS cover type have sorted into the S forest unit. There is no data at this point, however, to indicate the degree to which this contributes to the difference. Given the foregoing, the direction of operations should be to maintain the existing proportion.

The JP forest unit is comparable to the MS and jP cover types in the ACCI inventory system. Therefore, the target that was used for this forest unit was the sum of the MS and jP cover types. It may be that this target is too low in view of the extremely old state of the forest. Certainly, there were areas harvested in previous Plans in the vicinity of Airplane Lake and elsewhere where there was ample evidence of sites previously occupied by jack pine that had disappeared from the stand through old age. However, the ACCI inventory did a pretty reasonable job of identifying jack pine areas so the target seems reasonable for now. Given this target, there should be a significant effort made to increase the amount of jack pine renewal work. This target will definitely need to be reviewed, though, once the substantial area of barren and scattered is treated and/or surveyed for Free-to-Grow to see if there is any change in the "Current" level.

The proportion of H cover type stands in the old ACCI inventory is probably too low relative to historic levels. As a result of stand senescence, many stands that were previously pure hardwood stands likely converted to poorly-stocked mixedwood (M) cover type stands. Consequently, the target has been set at a level a little higher than in the ACCI inventory in order to reflect this. This target is still lower than the "Current" figure, though, probably a reflection of the amount of cutover area that has regenerated to trembling aspen over the years. The strategy, then, is to generally direct renewal more into the mixedwood forest units as opposed to the hardwood forest units.

The Mixedwood (M) cover type in the old ACCI inventory accounted for the largest single cover type but, as indicated earlier, is probably over-represented in that inventory relative to historic levels. The "Current" level (including Jack Pine Mixedwood) is at 34 percent. The target for the MA, MB and JPM forest units combined has been set at 37 percent with the distribution close to current levels. This will mean that forest renewal efforts will also have to be directed more into mixedwood silviculture as a general rule.

The Softwood (S) cover type in the ACCI inventory was around 7 percent. However, as noted earlier, this may be a little low for what is now defined as the S forest unit. The target of 10 percent is little more than a best guess given its relationship the the other targets and their analysis. It would mean less of an emphasis on the renewal of upland spruce stands in order to try to get actuals back in line with targets, over time.

Overall, the targets for the conifer forest units (BS1, BS3, S and JP) *combined* are quite consistent with the actuals from the ACCI inventory (51% vs. 52%, respectively) and the targets for the mixedwood and hardwood forest units are also quite close.

A caution relative to the management of mixedwood and hardwood stands is appropriate here. Because Boreal hardwoods primarily regenerate vegetatively, their harvest is a necessary first step in their regeneration. Markets for hardwood are, then, a key element in their utilization and subsequent management. The lack of a market for a significant part of the hardwood (nothing is in sight for white birch other than for the small proportion of birch suitable for veneer and the very limited market for firewood) will make progress towards meeting the above targets very difficult.

A final reminder needs to be made relative to these targets: they are based on an interpretation of the best information available and they must be considered preliminary in nature. Because we will probably never be able to entirely determine the overall forest unit composition of the undisturbed forest, the best guide will probably continue to be selecting species for renewal treatments that are best adapted to site conditions. Where site conditions provide for a range of species and some choice is possible, prescriptions should aim at working towards these targets while periodically reviewing their relevance. There should also be a recognition of the transitory nature of stands in the Boreal Forest, that they change with time and that the frequency, nature and distribution of the wildfires which created the natural forest no doubt resulted in a great variation in such things as species composition at the forest level at any particular point in time. So, the above targets need not be precisely met in order to have a reasonable level of tree species diversity: they simply provide some guidance for timber management activities to ensure that there is not an excessive level of inappropriate types of stand conversion over time.

Age Class Distribution. Another readily-apparent stand attribute that is easily measured is stand age. But first, it is necessary to consider just what is meant by the term "stand age".

The FRI chooses a "representative" tree of the working group species at three intervals along the point sample line and determines the age for each tree. The average of the three ages is then taken as the stand age. If the regeneration period following the fire that gave rise to the stand is relatively short, the stand age should be within five to ten years or so of the date of the fire. This would normally be expected with such fast-regenerating species such as jack pine and trembling aspen. It is a system that is also good for stands that have regenerated over a period of years as the previous stand gradually fell apart due to stand decadence (i.e. where there was no *major* disturbance). For black spruce, however, which often regenerates over a fairly long period (Kantola, 1960), the stand age as determined using this method can postdate the fire by ten to twenty years or more. A number of cruise plots established during the course of a re-inventory of the Black River Forest in 1993 that were located in a fire of known date (1923) illustrated this phenomenon quite well.

A second method of determining stand age is to try to establish the actual year of the fire. This can be accomplished using historical records, by dating fire scars on scattered remnant trees that were not killed by the original fire, or by carefully selecting trees that were probably amongst the first that regenerated following the fire. This method probably results in a more accurate estimation of the date of the fire. The stand age determined in this way may not, however, be as useful as a basis for such things as growth and yield determination, et cetera.

In both instances, though, the photo interpreter is obliged to work with the survey data that he/she is provided with. For this reason, much care must be taken in establishing the date and geographic distribution of fires using the FRI age. The ACCI inventory, on the other hand, used the second method and, rather than dating the stand, established the date of the fire disturbance and then slotted it into the decade of stand origin. Because there was a reasonably complete set of maps and data summaries for the ACCI inventory on the Big Pic, it was decided to use this data base for investigations into the age class structure of forests in the Manitouwadge area.

Previous studies (Alexander and Euler, 1981; Ward and Tithecott, 1993) have suggested an age class distribution in fire-driven ecosystems that approximates a negative exponential curve (i.e. reverse J-shaped). This notion is based on a model developed by Van Wagner (1978). More recent research has questioned the validity of that model (Suffling, 1991; Reed, 1994). In developing his model, Van Wagner assumed a forest of uniform site conditions, stands of equal size and flammability, a constant fire climate over time, random ignition and each fire ignition burning one stand only. When one considers these key assumptions, the validity of the model in the real world becomes problematic.

Most forests of any size have a variety of site conditions ranging from wet to dry, from poorly-drained to excessively-drained that impact on the chance of a fire-start developing into a wildfire. Stands are not of equal size. Nor are they likely of equal flammability: it seems reasonable that conifer stands are more flammable than hardwood stands and Rowe *et al.* (1975) presents evidence that suggests that older stands are more susceptible to fire. Armstrong and Vines (1973) have developed apparent periodicities in weather patterns sufficient to generate periods of extreme fire weather. Clark (1988) has developed a model for a forest area in Itasca State Forest in northwestern Minnesota that predicts significant variations in fire probability over time based on well-documented climatic cycles and fuel accumulation. Alexander (1987) studied weather records from White River that were taken between 1886 and 1975 and developed a graphical analysis of monthly and annual variations from long-term average rainfalls that clearly point to drought conditions extending over a period of several decades starting in 1910. This period coincides with a number of large fires that occured on the Black and Big Pic areas during that period. And Van Wagner's model, as Reed points out, ignores the "contagion" effect that results when a fire in one stand immediately increases the probability of fire starting in adjacent stands. In short, there seems to be reason to question the applicability of the negative exponential curve in describing the age- class distribution of the natural forest.

Figure 2 presents a graphical summary of the age class distribution of the various cover types on the Big Pic Forest. To try to get a picture of the undisturbed forest (one subject to natural fire regimes), the 1976 ACCI inventory was used but all stands dating from the decades 1950, 1960 and 1970 were removed. Most of these stands resulted from harvesting activities during that time. The area in age class 5 *does* contain some cutover stands but there is no way, in the time frame currently available to us, to accurately remove them from the inventory at this time. The year 1950 was chosen as the approximate mid-point between the major fire years of the 1910's, 1920's and 1930's and what could have been significant fire years (if fire suppression had not been so effective) of the 1970's and 1980's. It should be noted that the cutover that was removed from the 1976 inventory was *not* re-entered back into its original age class prior to harvest: this data necessary to do this was not available although future work will attempt its collection. If it had been available, it would probably have added to those age classes that were in excess of 85 years.

Rather than a negative exponential curve, the picture that emerges from this data relative to the age- class distribution of an undisturbed forest in this area is one of a series of peaks and valleys. This fits well with the model described by Suffling (1991) who postulates that wildfire occurence in northwestern Ontario tends to vary widely over both the short-term and the long-term. It also appears to be consistent with data reported by Heinselman (1973) who found that 83 percent the Boundary Waters Canoe Area that burned in the pre-suppression period was accounted-for by vigorous fire activity in nine major fire periods between 1681 and 1894. It must be noted, though, that Heinselman's data does not indicate the impact of this periodicity on the age class distribution of the resulting forest. Clark (1988 and 1990), although also not reporting age class distributions, presented graphs showing fire ocurrences over a 750-year period for an area of northwestern Minnesota that clearly showed cyclical variations in fire activity that would, like Heinselman's observations, help to explain the observed distribution for the Big Pic.

An ecologically-based age class distribution for the Manitouwadge area could, then, be one which is quite variable: age classes - singly or in groups - in which there is much area and others where there is little area. To obtain this type of distribution over the long term in the managed forest, however, means that there would have to be periods extending up to several decades in which there would be little, if any, harvesting activity and others where harvesting activity would be far in excess of annualized sustained yield levels. If the reduction in harvest in the Manitouwadge area could not be replaced by timber volumes harvested elsewhere, then mill closures would ensue. And, even if they could be replaced, the stability of the local communities and workforces would certainly be at risk.

To promote the sustainability of local communities, it is desireable, then, that harvesting operations be conducted annually with minimum fluctuations from year-to-year. Over time, this will result, in theory, in an age class distribution that approximates "normal" forests with more-or-less equal amounts of area in each age class. It would not resemble the peak and valley type of curve that the forests of the area currently exhibit nor would it resemble the negative exponential curve described by Van Wagner.

Would this type of age class distribution create a problem from an ecological perspective? This is likely an unanswerable question but, with periods where the natural forest is well-represented in four or more consecutive ten-year age classes, it is difficult to visualize what adverse impact there might be. Since each forest unit in a more "normal" forest would be well-represented (but not overly-so) in each age class, certain types of habitat would be reduced at the forest level during certain periods in comparison to the "natural" forest while others would be increased. It could be postulated that a "normal" age class distribution, by eliminating the feast-or-famine nature of the natural forest, might provide for a more balanced habitat structure to the forest and a greater diversity at the forest/landscape level.

It has been suggested that the retention of forests in overmature age classes is an important priority (Wildman *in* Anon., 1994) and that timber management plans should include a strategy to do so. The purpose of the strategy would be to retain what has been described by the Ontario Old Growth Forests

Policy Advisory Committee as "old growth forest ecosystems [which] are characterized by the presence of old trees and their associated plants, animals and ecological processes" (Anon., 1994). While old growth Boreal forest stands have been described by some as not particularly stable and species- impoverished (Wright and Heinselman, 1973; Alexander and Euler, 1981), at the forest/landscape level such stands may, nevertheless, be important in maintaining overall diversity levels.

To try to establish how much old forest one could expect to find in the natural forest, an analysis of the ACCI inventory for the Big Pic was undertaken. In this analysis, overmature forest was considered to be stands that are up to twenty years past their rotation age (at which point net growth rates approach 0) and decadent forest was up to forty years past rotation (at which point they are *generally* unmerchantable due to low yields and high defect rates). Previous Plans for the Big Pic set the rotations at 70 years for the H and jP cover types, 80 years for the MS cover type, 90 years for the M cover type and 100 years for the bS and S cover types. These rotations were based on an analysis of the empirical yield tables for the Big Pic and are comparable to those used on the Black River and other adjacent forests (to the extent that they can be compared).

Table 3 presents the results of the analysis. As discussed earlier, the figure for the S cover type has little real meaning because most of this cover type, irrespective of its age, is the result of successional dynamics. For the remaining covertypes, it would appear as if fewer conifer stands make it into overmature conditions while mixedwood and

Table 3: Percent of area, by cover type, in overmature (R - R+20) and decadent (R+21 and up) in 1950 on the Big Pic Forest.

	bS	S	MS	jP	M	H
% Overmature	6.5	10.7	3.8	8.3	13.1	20.2
% Decadent	6.2	37.0	3.4	1.5	8.5	10.9

hardwood stands are more likely to do so. The same relationship holds true for those stands entering the decadent category. Using findings from Table 3, then, it is possible to develop targets for the managed forest. Table 4 does this by adapting the information above to the forest unit classification for use in this Plan. The Inoperable forest units - IS and IH - are not included because they will not generally be harvested nor will they be managed. To some degree, they can, however, contribute to old growth targets since they are comprised of stands of composition and structure that are very similar to the operable stands.

Table 4: Overmature and decadent forest targets for the Big Pic Forest.

	BS1	BS3	S	JP	MA,MB	PO,BW
Rotation (yrs)	100	120	90	70	80	70
% Overmature	6	6	12	5	12	20
% Decadent	6	6	12	3	8	10

There is a reason for separating the two categories of old growth. While a significant amount of area in the natural forest does make it to the overmature category, the area is greatly reduced (probably due to fire) between overmaturity and stand decadence. In a practical sense, it is improbable that many stands that reach the latest stages of decadent age classes will be harvested for timber production purposes. It is even more unlikely that they will be destroyed by wildfire in managed forests as would have eventually happened in the natural forest. Old forest in the managed forest, then, is fundamentally different from old forest in the natural forest. In the latter, fire eventually returns old stands to the earliest stage of forest succession while, in the former, it is mainly successional forces that control stand composition and structure. With time, the application of targets such as those shown in Table 4 will probably result in an on-going build-up of a large area of old forest area that will have to rely, to a great degree, on a largely unknown successional process to work back into the production forest land base.

To minimize these kinds of long term losses from the production forest land base, the targets in Table 4 will be used thusly: the age class distribution by forest unit should attempt to have the target amount of area in **each** of the overmature and decadent categories. For example, in the **BS1** forest unit, there should be six percent of the forest unit area in the 101-120 age range, and six percent in the 121-140 age range. Forest area that contributes to either target becomes eligible for harvest allocation once they reach the far end of each of the two categories. In practical terms, this means that all stands in a forest unit can be harvested at a point 40 years past rotation (a questionable supposition since combinations of such factors as low yields, stem rot, isolation from other harvest areas, et cetera, would preclude the harvest of an unknown proportion of these stands). And, likewise, all stands reaching the point 20 years past rotation become eligible for harvest: the only thing to prevent the harvest of these stands would be the necessity of ensuring that the target for the decadent category will be met.

Where stands cannot be harvested due to stand decadence, isolation from cut blocks or due to by-pass, they may continue to contribute to the "Decadent" target until such time as they are classified into something else, whether that be young forest or barren and scattered lands.

With the exception of the S forest unit, the targets are all consistent with the figures resulting from the analysis summarized in Table 4, above. The targets for the S forest unit have been reduced considerably because, in the ACCI inventory, the S cover type was an overmature stand condition to begin with, whereas the criteria for the S forest unit has been set to capture those stands that are primarily upland spruce stands of varying ages.

To determine where the Big Pic Forest sits now with respect to these targets, an analysis of the updated 1989 FRI was undertaken by applying the overmature and decadent criteria to the age class summary in Table 4.13.1 of this Plan. In addition, data for individual stands in the two inoperable forest units were worked into the analysis. The results are as shown in Table 5.

Table 5: Percent of area, by forest unit, in overmature and decadent age classes in 1993 on the Big Pic Forest.

	BS11	BS3	S	JP	JPM	MA	MB	PO	BW
% Overmature	26	48	12	29	35	10	15	16	14
% Decadent	53	14	42	44	31	50	38	51	61

In all cases except the Overmature categories for the MA, PO and BW forest units, the targets have been exceeded, in many cases by a substantial amount. This is the result of a forest that is dominated by old forest conditions. While there is no problem in meeting the old forest targets from Table 4 now, there may well be problems in meeting them many decades hence when the limited amount of forest currently in the age classes under rotation age move into the overmature and decadent categories.

In fact, with this kind of forest condition, it is almost a foregone conclusion that there will be times in the future when the target amount of old forest conditions cannot be achieved while still having reasonable harvest levels. However, in an ecological sense, this should not be a problem. As discussed earlier, the natural forest no doubt went through cycles when there would be large amounts of old forest and other times when there would be very little. Within the managed forest, it would seem to be quite acceptable to have the same kind of cycling of old forest conditions, albeit over probably a more limited range.
Unharvested by-pass can be used to account for some of the old forest targets. Table 6 summarizes by- pass on the Big Pic by cover type during the period from 1979 to 1987.

Table 6: Unharvested by-pass as a percent of total depletions, by cover type, for the period 1979-80 to 1986-87 on the Big Pic Forest.

Type of Depletion	bS	S	MS	jP	M	H
Reserve	5.9	8.8	5.7	5.6	5.8	1.3
Terrain	3.0	10.3	6.2	2.9	5.4	2.0
Size	14.7	3.7	4.3	1.7	2.9	0.6
Species	0.7	0.4	0.5	-	1.0	0.9
Other	0.7	2.0	0.3	-	1.7	1.2
Total	25.0	25.2	17.0	10.2	16.8	6.0

Such by-pass tends to be somewhat linear (i.e. along the edges of lakes and streams due to the establishment of reserves in those areas) and of relatively limited size but it can emulate burn patterns that leave behind unburned areas of similar shape (see next section).

Operational constraints that give rise to by-pass will continue to accumulate as an old forest condition in the inventory until such time as they cycle, through stand dynamics, into something else. At the same time, though, it does afford the opportunity to incorporate such areas into a semi-designed pattern of old forest areas.

As alluded-to earlier, the inoperable forest units can also help to contribute to the old forest targets. Table 7 presents the results of a study that took stands in the Inoperable forest units (IH and IS), separated them into the forest units using the same criteria as was applied to Operable stands and summarized them by age class. Table 7 displays the degree to which stands in these forest units contribute to the present inventory of over-mature and decadent forest condition. While generally not a major contributor to overall old forest targets, they do contribute to some degree. More significantly, because they will, by definition, never be harvested, they will continue to help meet old forest targets over the long term until stand dynamics converts them to some other forest con-

Table 7: Contribution of Inoperable stands to old forest targets in 1989 FRI.

	BS1	BS3	S	jP	JPM	MA	MB	PO	BW
% Overmature	0.0	1.2	0.4	0.0	0.2	0.1	3.8	1.3	3.2

% Decadent	0.1	1.4	1.7	0.2	0.3	2.1	14.2	0.8	71.5

dition. Consequently, they can be used to reduce, to some extent, the amount of Operable stands that need to be left to meet the Overmature and Decadent stand targets thereby reducing losses to the production forest landbase.

Spatial distribution. As important as the statistical distribution of stands of various age classes may be, the spatial distribution is at least equally important. The spatial distribution of stands of differing species composition in the managed forest will largely be controlled by site characteristics, as it is in the natural forest. The initial establishment of the species best adapted to the individual site will promote a reasonably natural spatial distribution of tree species at the stand level. At the forest level, the use of the forest unit targets established in Table 2 will promote their distribution across the landscape. But what about the distribution of stands or groups of stands of different ages?

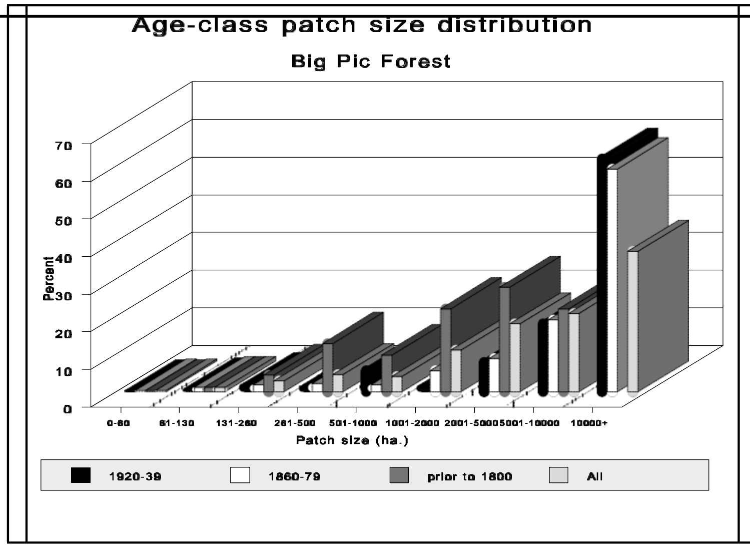
To gain some insight into this, two separate comparative studies were undertaken. The first was designed to assess and quantify spatial distribution of stand aggregations of different age classes at the forest level. It used the 1:126,720 age class map of the Big Pic Forest to display age class patterns. Because of the small scale of the map, the delineation of age classes obviously was limited to patch sizes at the bottom end whose area could be measured on a map of that scale (generally 20 to 25 hectares). Because of the limited amount of area in the 1800-1819 age class, where it occured it was combined with the 1820-1839 age class. Patch sizes were determined by electronic planimeter and recorded by age class. Table 8 summarizes the results of this part of the study.

The establishment of a "patch" boundary was very subjective and represents a limitation in this study in that it sometimes combined two ten-year age classes that may have been the result of two fires that could have been ten to fifteen years apart. This could skew the results in Table 8 towards "patches" of larger size than they really were. On the other hand, the table is designed to establish a quantitative value to discreet "patches" of similar age that, because of the irregularities of burn boundaries and because of residual patches of unburned are not the equivalent of individual fires. That is, one very large fire could well be, using the protocol for this study, a mosaic of a number of smaller "patches".

In any event, it is still quite clear that the fires which gave rise to most of today's forests were generally very large. There was little evidence at this scale of small fires (less than 100 hectares) although there can be no doubt that there were many small fires that seldom grew to more than a few hectares. However, cursory examination of the 1943 aerial photography for the Big Pic did not reveal much evidence of wildfire of less than 100 hectares. While a more careful examination is needed to confirm this, it may be that weather conditions at the time of a natural fire start were either unfavourable and the fire quickly was extinguished and burned out, or they were very favourable and the fire quickly grew to something in the range of several hundred hectares or more. From this

Table 8: Distribution of fire-origin forests of various age classes by patch size class, Big Pic Forest.

	Size				Class (ha)				
Year Class	0-60 ha (%) [no.]	61-130 ha (%) [no.]	131-260 ha (%) [no.]	261-500 ha (%) [no.]	501-1000 ha (%) [no.]	1001-2500 ha (%) [no.]	2501-5000 ha (%) [no.]	5001-10000 ha (%) [no.]	10000+ ha (%) [no.]



1940-59	0	0	0	321 (10.3) [1]	0	0	2788 (89.7) [1]	0	0
1920-39	208 (0.3) [5]	486 (0.8) [6]	1290 (2.1) [6]	1043 (1.7) [3]	3370 (5.6) [4]	1108 (1.8) [1]	4705 (7.8) [1]	10893 (18.1) [2]	36918 (61.8) [3]
1900-19	112 (0.5) [3]	248 (1.0) [3]	1206 (5.4) [6]	0	664 (3.0) [1]	1434 (6.4) [1]	2661 (11.9) [1]	5727 (25.6) [1]	10352 (46.2) [1]
1880-99	96 (0.6) [2]	408 (2.7) [4]	182 (1.2) [1]	345 (2.2) [1]	0	0	7248 (47.2) [2]	7077 (46.1) [1]	0
1860-79	556 (0.4) [19]	1619 (1.2) [19]	2343 (1.8) [13]	2824 (2.2) [8]	2408 (1.9) [3]	7247 (5.5) [4]	11525 (8.8) [3]	24926 (19.1) [3]	77252 (59.1) [5]
1840-59	352 (0.4) [11]	1232 (1.3) [14]	3133 (3.2) [15]	6938 (7.2) [17]	3833 (4.0) [5]	12544 (13.0) [7]	31406 (32.6) [8]	12300 (12.7) [2]	24698 (25.6) [2]
1800-39	96 (0.2) [2]	544 (1.4) [5]	1872 (4.4) [10]	2708 (6.3) [7]	3387 (7.9) [5]	14951 (35.0) [10]	3565 (8.3) [1]	15609 (36.5) [2]	0
Prior to 1800	96 (0.3) [2]	368 (1.2) [4]	1337 (4.4) [8]	3869 (12.8) [9]	2891 (9.6) [5]	6648 (22.0) [4]	8355 (27.7) [2]	6616 (22.0) [1]	0
TOTAL	1516 (0.4) [44]	4905 (1.2) [55]	11363 (2.8) [59]	18048 (4.5) [46]	16553 (4.1) [23]	43932 (11.0) [27]	72253 (18.0) [19]	83148 (20.8) [12]	149220 (37.2) [11]

study, it appeared that the vast majority of the small patches of a specific age class that did occur were primarily the result of small patches of unburned area within a much larger burn, a finding consistent with those reported by Rowe and Scotter (1973). Nonetheless, additional work to ascertain the size, frequency and distribution of the very small fires (i.e. less than 50 hectares) should be pursued in any future extension of this study.

Certain parts of Table 8 are presented in graphical format to the right. Of particular interest is the finding that, on average, over one-third of the forest area occurs in patches of 10,000 hectares or larger, and that less than five percent of the forest area occurs in patches of 260 hectares or less. Also of interest, is the general consistency of this pattern over the time frame covered, particularly at the small end of the range in patch size. In the older age classes, the pattern appears to be different. However, it must be kept in mind that the older age classes are somewhat more broken-up by more recent fires. Based on observations made during the course of preparing the map, there is no reason to believe that these oldest age classes did not originally exhibit any different distribution than the more recent ones.

Also worth noting (although not at all unexpected) is the frequency of occurrence of patches within the different size classes. Patches in the three classes up to 260 hectares accounted for about 53 percent of the total number of patches delineated in the study but only accounted for about 4.4 percent of the total area. At the other end of the scale, in the 10,000 hectare and up class, patches of that size accounted for about 3.7 percent of the total number, but 37.2 percent of the total area.

Based on the information summarized in Table 8, an attempt has been made to try to establish some sort of broad targets for disturbance patch sizes. They are presented in Table 9. The targets are primarily a rounding-off of the "Total" line in Table 8.

Table 9: Disturbance Patch size targets for the Big Pic Forest.

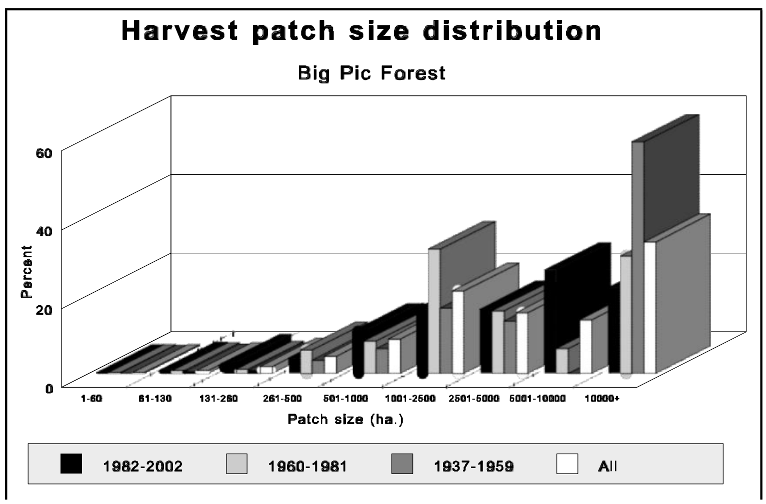
% of area by size class (ha)								
1-60	61-130	131-260	261-500	501-1000	1001-2500	2501-5000	5001-10000	10000+
1	1	3	5	5	10	15	15	45

But how does this pattern compare with what harvesting operations over the past four decades have created? At the outset it is necessary to say that it is very difficult to make a direct comparison because of certain inherent differences between wildfire and harvesting. A large wildfire most of the time will cover the area that it covers in a matter of weeks or, at the most, months. Consequently, it is possible to establish a distinct boundary to the disturbance and, within that boundary, the forests that subsequently develop will all be at a relatively similar stage of development. In contrast, the harvesting of an area of similar size (assuming that rules relative to maximum allowable depletion rates are followed) could take many years or, perhaps, decades as one cutover is added to adjacent cutovers. The forests that come to occupy the resulting mosaic of adjacent cutovers might well cover a wide range of early developmental stages. So, drawing the boundary between one cutover patch and another is problematic. In this analysis, to maintain some consistency in protocol with the previous study, a boundary in disturbance patch size could be strictly temporal (i.e. the boundary between a cutover from one twenty-year class and an adjacent cutover from the next twenty-year age class).

Table 10 is the result of an analysis of harvest depletion patterns on the Big Pic Forest

Table 10: Distribution of harvest-origin forests of various age classes by size class, Big Pic Forest.

Year Class	Size Class (ha) 1-60 ha (%)	61-130 ha (%)	131-260 ha (%)	261-500 ha (%)	501-1000 ha (%)	1001-2500 ha (%)	2501-5000 ha (%)	5001-10000 ha (%)	10000+ ha (%)
1982-2002	571 (0.4)	1376 (1.0)	3928 (2.9)	5416 (4.0)	14580 (10.8)	22222 (16.5)	22025 (16.3)	35331 (26.2)	29404 (21.8)
1960-81	336 (0.4)	673 (0.8)	1110 (1.2)	5300 (6.0)	7385 (8.3)	28018 (31.5)	14124 (15.9)	5652 (6.3)	26464 (29.7)
1937-59	176 (0.2)	339 (0.5)	627 (0.8)	2598 (3.5)	4706 (6.3)	12509 (16.7)	10021 (13.4)	0	43918 (58.6)
TOTAL	1083 (0.4)	2388 (0.8)	5665 (1.9)	13314 (4.5)	26671 (8.9)	62749 (21.0)	46170 (15.5)	40983 (13.7)	99786 (33.4)



that used essentially the same protocol as for the natural fire- caused depletions. The table summarizes results of *actual* harvest patterns for the two periods from 1937-59 and 1960-81. The data for the 1982-2002 period includes data for both actual harvests to 1996 and probable harvest allocations to 2002. An analysis of this table indicates that harvest allocation practices over the sixty year period have generally created the same kind of patch size patterns as suggested by Table 8. However, there has been a continuous decline in the proportion of area in the largest of patch sizes, consistent generally with the focus of the Moose Habitat Guidelines in use for the past several Plans. Nonetheless, current patterns appear to be reasonably close to the long term targets.

The figure to the right is a graphical presentation of Table 10.

This analysis would suggest, then, that the emulation of historic disturbance patch sizes at the forest level could best be achieved by a strategy that would add area to the smaller and larger patch sizes while decreasing area in the intermediate patch sizes.

To investigate spatial disturbance patterns at the stand level, for the five fires that were the subject of the previously described study on the Black River Forest and the Big Pic Forest, a number of other attributes were examined. Table 11 summarizes a number of these characteristics.

Table 11: Summary of wildfire burn characteristics for selected areas of the Black River Forest and the Big Pic Unit.

Name of Fire	Year of	Fire Size	Area Unburned	Long Axis Length and Az.	Short Axis	Total Edge	Edge/Area Ratio
	Fire	ha	ha (%)	km (°)	km	km	m/ha
Twin Falls	1931	644	69 (10.6)	5.4 (51°)	2.7	41.1	64:1
Bullmoose	1920	648	103 (15.8)	5.6 (59°)	1.9	31.2	45:1
Hillsport	1923	7071	836 (11.8)	18.5 (70°)	9.3	137.5	19:1
Pinegrove	1936	20191	938 (4.6)	N/A	N/A	315.9	15:1
Foch*	1923	50568	3005 (5.9)	N/A	N/A	N/A	N/A

*Black River Forest portion only. Additional area was also burned on the adjacent Big Pic, White River and Nagagami Forests.

By way of explanation, the year of each fire is based on the best information that is available. However, it should be noted that, since human habitation in the area prior to 1945 was sparse and the accuracy of records is unknown, the fire date could be out by a few years. The size of the fire is based on the total area (burned and unburned) contained within the outer perimeter of the fire. The unburned patches consisted of any standing green timber within the outer perimeter of the fire around which a line could be drawn on the aerial photograph (i.e. patches of less than about several tenths of a hectare could not be delineated). The long axis of the fire was the longest straight line that could be drawn from one end of the fire to the other (the length of the fire) and the azimuth is the presumed general direction taken by the fire based on the orientation of the long axis. The short axis was the longest straight line perpendicular to the long axis that could be drawn across the fire (the breadth of the fire). The edge of standing green timber is the total of the outer perimeter of the fire. The edge/area ratio is based on total edge distance divided by the burned area.

While it is difficult to generalize, based on these five fires it appears as if the larger the final overall size of the burn, the more complete the burn within its outer perimeter. The relatively small fires (less than several thousand hectares) appear to have something in the range of 11 to 15 percent of the total area left unburned within the perimeter. For the medium-sized fires (from two to ten or twelve thousand hectares), the unburned area is in the ten percent range. And for the larger fires (greater than twelve thousand hectares), the figure drops to the five percent range. (Analysis of one or two additional fires in the five to ten thousand hectare range would provide a greater degree of confidence for the medium- sized fires).

These results are consistent with what one would logically expect: larger fires *are* larger because of better burning and fuel conditions probably over a longer period of time. Not only would these conditions contribute to the growth of the fire, but it would also contribute to more complete burning within the fire's perimeter.

The matter of how it will be possible to maintain some semblance of this natural forest distribution pattern is problematic. Beyond the political issues relative to the public's perception of large clearcut areas, there is the problem of the already fragmented forest pattern present today. It has been created, in part, by economic factors relative to merchantablity of timber and operational constraints and, in part, by institutional guidelines (such as the Guidelines for the Provision of Moose Habitat) that have promoted forest fragmentation over most of the last decade. While some of these may be overcome eventually, there will still be the constraints that are imposed by the very different rotations that apply to stands that are a more-or-less homogeneous mixture over the forest landscape. In this latter case, an approach to maintaining large disturbed areas would mean either cutting some stands at ages substantially under their rotation, or cutting other stands at ages well past their rotation. In both cases, the price that is paid is in the level of the long term sustained yield.

A final parameter that was considered in the fire study described above was the nature of patches of unburned forest that were left behind within the burn perimeter. Table 12 summarizes some of these characteristics by presenting, by size class of the unburned patches, the total area covered by patches in each size-class, the percent of the total burn

Table 12. Selected characteristics of unburned patches within wildfires of varying sizes on the Black River Forest and Big Pic Unit.

		Size Class (ha)							
Fire Name	Fire Size (ha)	0-1.9 ha (%) [no.]	2-4.9 ha (%) [no.]	5-9.9 ha (%) [no.]	10-19.9 ha (%) [no.]	20-39.9 ha (%) [no.]	40-79.9 ha (%) [no.]	80+ ha (%) [no.]	All ha (%) [no.]
Twin Falls	644	20 (29.0) [39]	16 (23.1) [5]	20 (29.0) [3]	13 (18.8) [1]	0	0	0	69 (10.6) [48]
Bullmoose	648	13 (12.6) [19]	20 (19.4) [6]	19 (18.4) [3]	51 (49.6) [4]	0	0	0	103 (15.8) [32]
Hillsport	7071	100 (12.0) [146]	116 (13.9) [38]	137 (16.4) [19]	97 (11.6) [7]	106 (12.7) [4]	114 (13.6) [2]	166 (19.9) [1]	836 (11.8) [217]
Pinegrove	20191	223 (23.8) [370]	233 (24.8) [67]	198 (21.1) [28]	194 (20.7) [17]	90 (9.6) [4]	0	0	938 (4.6) [486]
Foch*	50568	307 (10.2) [426]	340 (11.3) [102]	365 (12.2) [51]	412 (13.7) [29]	550 (18.3) [19]	469 (15.6) [9]	563 (18.7) [4]	3006 (5.9) [640]

*Black River Forest portion only. Additional area was also burned on the adjacent Big Pic, White River and Nagagami Forests.

area that they represent, and the total number of patches in each size class. Future work might want to try to classify these patches with respect to the type of forest and/or site conditions that they occupied to see if there was some sort of relationship between the stand/site type and the frequency, patch size and/or amount of unburned areas. This summary indicates the wide variation that can occur. For example, for the two smaller fires, approximately one-half of the unburned area in the Bullmoose fire was in the 10 to 20 hectare range whereas, in the Twin Falls fire, less than one-fifth was in that range. For the larger fires, the Foch and Hillsport fires had about two-thirds of the unburned area in patches of 10 hectares or larger, while, for the Pinegrove fire, the relationship was completely reversed. It was speculated that the forest burned by the Pinegrove fire was comprised of more-flammable conifer stands whereas the other two fires were generally less-flammable hardwood and mixedwood stands. If so, this would suggest that harvest areas that are comprised largely of conifer stands might have more patches of smaller sizes designed into the harvest pattern whereas the reverse would be true of hardwood/mixedwood areas.

Moreover, it has to be recognized that, in nature, wildfire always has the final solution: areas that escape one fire through chance, will probably not do so the next time. As a result, regardless of how old the forest stand might be, the successional process will almost always be re-started by major disturbance. In the case of managed forests, however, where the major disturbance is logging, areas do not get harvested unless they have merchantable timber growing in them and if they are in locations that permit economical harvest. While succession will continue in those areas left behind to maintain old forest conditions for a time, if harvesting of the stands is not eventually possible, natural succession might give rise to new stands with characteristics quite unlike those created by periodic major disturbance. Therefore, in designing harvest allocation strategies that deliberately leave behind patches of forest, consideration needs to be given to the ultimate fate of those patches.

In this connection, future studies should look at old forest conditions in the Boreal context to try to determine the nature of forest succession in the long-term absence of wildfire or other major disturbance. The long-term fate of undisturbed forest stands needs to be a key element in decisions relative to deliberately leaving unharvested areas behind in the design of harvest allocations.

The foregoing will hopefully provide some information that can be used for the development of Forest Management Plans that have a more ecological-based rationale. It is by no means a complete document and should be revised from time-to-time as new information becomes available. Several areas for further study have been noted in the text. Additional to this would be study and review of snag trees in burned areas and in cutover areas as well as dead-and-down woody material on or near the forest floor.

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