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EASTERN ONTARIO MODEL FOREST
ECOLOGICAL WOODLANDS RESTORATION PROJECT
PROJECT 2.1/93

A Forest History of Eastern Ontario

The following report was prepared by Cathy Keddy as part of the Ecological Woodlands Restoration project, funded as part of the Eastern Ontario Model Forest. This report is a preliminary investigation of the original forest cover of the eastern Ontario area, and is the first step in providing the foundation for any restoration activities.

The lands of the Eastern Ontario Model Forest have undergone dramatic transformation during the last few centuries. Disturbances from urban and agricultural developments, transportation and communications corridors, fires and logging have all impacted on the landscape.

The overall goal of the Ecological Woodlands Restoration project is to try to direct the current and future forests of eastern Ontario towards a more "natural" state. The project will deliver a historical overview of the forests in this area (this report). It will also help to examine various methods of forest restoration through a review of restoration programs in other jurisdictions. A method of determining the ecological integrity of forest stands will be developed, which will assist in establishing a network of sites requiring restoration measures.

Comments on this report, or on the overall project objectives, will be welcomed.

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FOREST HISTORY OF EASTERN ONTARIO

1.0 Introduction

In 1992, the Eastern Ontario Model Forest region was created as part of a model forest network under the Federal Government's Green Plan. It covers Ontario east of, and including, Lanark and Leeds counties. The Eastern Ontario Forest Group, composed of a variety of partners representing industry, development, and conservation, identified several projects that would enhance the sustainable development of forest resources in eastern Ontario. The purpose of one of these, the Ecological Woodlands Restoration Project, is to make recommendations on ways of adapting current management programs so that they will promote forest evolution toward historical, more natural associations of the species native to this area when the majority of the region was forested. In order to do this, it is first necessary to know what the forests were like at that time and have an understanding of the major forces that have modified this forest cover.

This report describes the historical forest cover of the region based on palynological data, published historical accounts and present day forest remnants. It does not address the traditional knowledge of the area as held by the indigenous people, as this will be addressed under a separate Model Forest initiative. The influences of natural forces (fire, wind) as well as changes brought about through human exploitation (settlement, logging and fire) are discussed. Finally, recommendations are made concerning the acquisition of additional information on historical forests and its application for forest restoration. I have deliberately adopted a non-technical style, such as the use of common names for plants, to ensure that this report can be used by a wide audience.

1.1 Forests and Their History

A few centuries ago eastern North America was covered by deciduous forests. Similar forests once covered western Europe and eastern Asia. These forests were remnants of the great Arcto-tertiary forests which, for millions of years, covered much of the Northern Hemisphere. These original forests are largely gone. Remnants persist in three forms: extensive areas of second growth recovering from past logging and agricultural practices, tiny fragments thought to represent fragments of virgin forest, and the occasional larger protected area. In the Eastern Ontario Model Forest (MF) region, we have no large protected areas (two of the larger being Carillon Provincial Park and Murphy's Point Provincial Park at approximately 1,400 ha), and no known remnants of virgin forest (although Shaw Woods is nearby in Renfrew County).

The early loggers and settlers were just too efficient. There are, however, some areas of maturing forest, and some of these may approximate the early forests in certain limited ways. Some of them may return to historical conditions if managed appropriately. The best remaining deciduous forest in North America, and quite possibly the best in the world, occurs in Great Smoky Mountains National Park in the United States. It is impossible to fully appreciate eastern Ontario forests without visiting the forests of the southern Appalachians. It is stunning to see mile after mile of hill sides covered in mature forests, with our familiar sugar maple and hemlock trees growing mixed with unfamiliar southern species such as tulip trees and species of magnolia.

Eastern Ontario lies near the northern edge of the deciduous forest region (Barnes 1991, Braun 1950; Fig. 1). Owing to the severity of the climate, we have only a few common tree species -- a fraction of the number which occur in the southern Appalachians. Typically, the commonest tree species in a mature stand of upland forest would be sugar maple, and beech followed by basswood, red maple, yellow birch, hemlock and white ash (Rowe 1972). Others found in lesser abundance would include red oak, bur oak, bitternut hickory, and butternut.

The type of forest which occurs on a site is strongly influenced by bedrock and the post glacial deposits which cover it. These are used as a template to reconstruct eastern Ontario forests. A brief overview of geology and physiography follows.

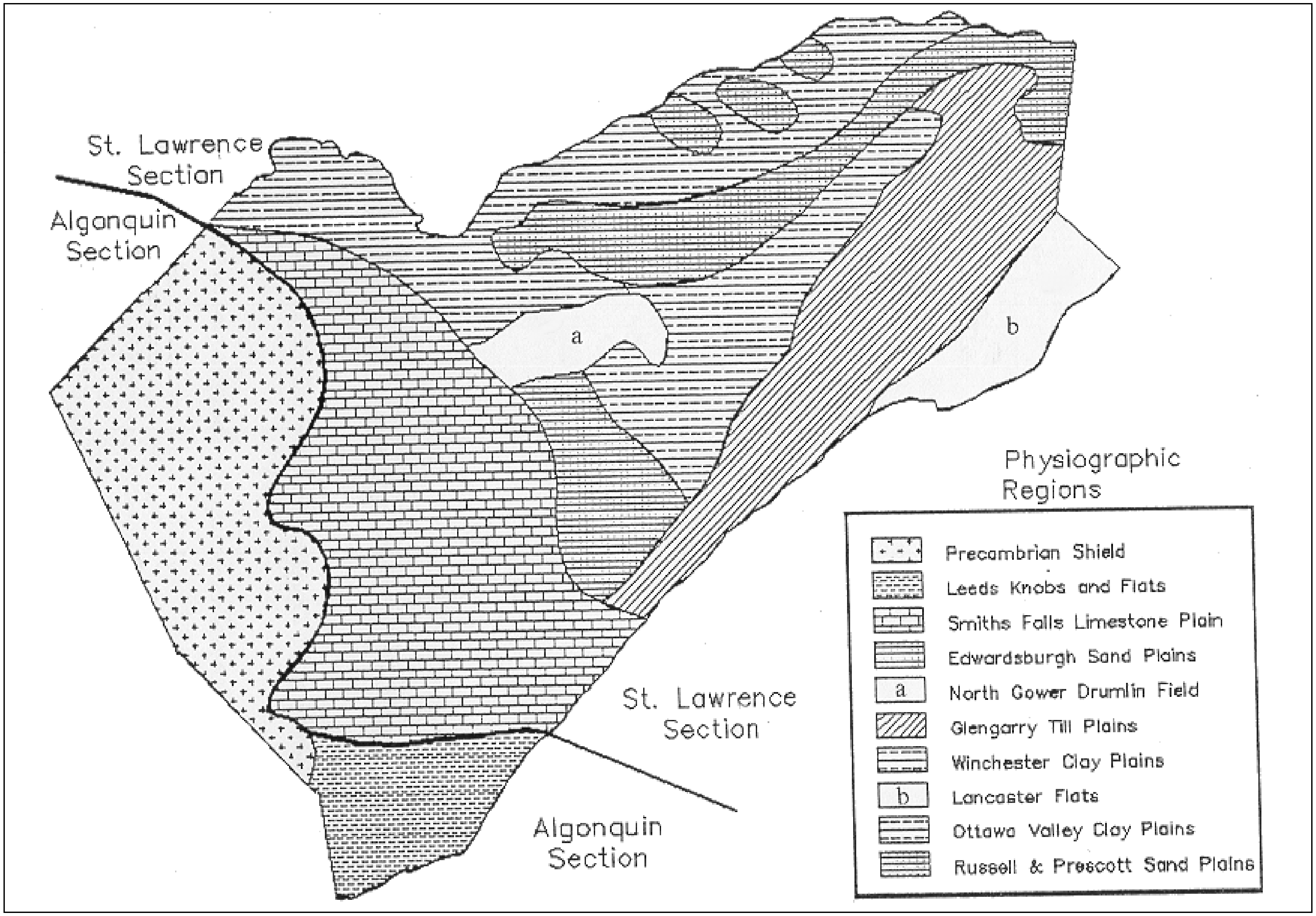
1.2 Geological Context

One of the most important factors affecting the natural and human history of eastern Ontario is bedrock. The western edge of the MF region is underlain by the Precambrian Shield (Fig. 2, Algonquin Section). The Shield is made up of some of the most ancient rocks on Earth-- some close to 4 billion years old. It occupies more than 4.5 million square kilometres of Canada. Granite and gneiss are the most common rocks here (Chapman and Putnam 1984); both are very hard and produce thin, acidic soils. The shield prevented the spread of agriculture and was an obstacle to the construction of roads and railroads.

The remainder of the region (Fig. 2, St. Lawrence Section) is underlain by palaeozoic rocks that are much softer and date from the Ordovician era (Chapman and Putnam 1984). They are a mere quarter of a billion years old. The fossils in them (crinoids, gastropods, cephalopods) indicate that they were formed in an era when shallow oceans covered eastern North America. They are composed of sandstones, limestones, shales and dolomite. Owing to the chemistry of the rock, the soils which form are also neutral or alkaline.

Figure 1 The eastern deciduous forest region of North America (X = location of MF region).

Figure 2 Physiographic regions of the MF region (from Eastern Ontario Forest Resources Stewardship Council 1992).



1.3 Physiographic Context

The nature of the landforms of an area (topography, soils, drainage) influence the forest cover present. The physiographic regions of eastern Ontario shown in Figure 2 will be used as the framework for reconstructing past forest cover (see section 2.2.2) and therefore need to be briefly introduced here. These regions represent precambrian shield (bedrock) overlain with shallow till, precambrian shield with clay deposits (Leeds Knobs and Flats), limestone plains, till plains, clay plains, till and clay plains (Lancaster Flats), sand plains, and clay and sand plains with drumlins (North Gower Drumlin Field). Each is briefly described below (Chapman and Putnam 1984).

The first two have precambrian bedrock.

Precambrian: Ridges of precambrian bedrock may be exposed or covered by deposits of shallow till.

Leeds Knobs and Flats: Channels between knobs of precambrian bedrock are filled with clay. The deep soils are good for agriculture.

The remainder have palaeozoic bedrock.

Smiths Falls Limestone Plain: This is the largest and most continuous tract of shallow soil over limestone in southern Ontario. Due to gentle gradients, drainage is poor and swamps are numerous. Remnants of old marine beaches often provide the only areas of deep soil for cultivation or for road construction materials.

Edwardsburg Sand Plain: The bedrock and most of the boulder clay are covered by sand. The sand surface is largely level with hummocks or ridges in some places. The soils are acid and deficient in nutrients.

Russell & Prescott Sand Plains: Old deltaic deposits have created sand plains. The sand texture varies from coarse in the north to fine in the south. It reaches a maximum depth of around 9 m. Soils are well-drained with the water issuing from river bluffs into clay valleys.

Ottawa Valley Clay Plain: The clay plain is interrupted by ridges of rock or sand. The proportion of acid soil is greater than in the Winchester Clay Plain.

Winchester Clay Plain: Although clay plains dominate, they are punctuated by other features such as till protrusions, low drumlins, bars and beaches. The soils are generally poorly drained.

Lancaster Flats: The till plain has been buried under water-laid deposits of clay and sand. It is flat and poorly drained.

North Gower Drumlin Field: Drumlins arise from a clay plain. While the drumlins have good drainage, the clay soils are poorly drained.

Glengarry Till Plain: The undulating to rolling surface consists of drumlins with clay flats. The loamy till is often less than 8 m deep, but does reach a depth of 30 m. Its stoniness is noticeable.

2.0 The Original Forests of Eastern Ontario

There are few scientific data available on the original forests of eastern North America, and the challenges in reconstructing them are summarized in Botkin (1990). Three sources of information were examined to prepare a description of presettlement forests in the region:

(1) literature on preserved pollen in lake sediments,

(2) historical references, and

(3) descriptions of existing remnants.

Details concerning historical forest cover provided by each of these sources are presented below.

2.1 Palynological Evidence of Past Forests

During the last ice age there were obviously no forests here. Trees survived in refugia far to the south, and, as the ice sheet receded, they began to spread northwards. In general, the historical evolution of the forests of the region is as follows (Davis 1976, Bennett 1986, Anderson 1985, 1989). Glacial activity and flooding by the Champlain Sea left bare rock and deposits of sand, gravel, and clay. Early plant cover was open tundra-like communities with willows, grasses and sedges intermingled with spruce trees. Willow, birch, alder and juniper were also common. In general herb tundra was replaced by shrub tundra which was replaced by a spruce and poplar woodlands. As the climate warmed and trees moved back from the south, pines and hemlock increased in abundance. In time, deciduous forest trees arrived and became the dominant trees in the landscape. The types of bedrock and soil then determined the local distribution of these tree species.

More specific to the MF region, palynological sequences have recently been studied by Hall (1993) in three lakes: Long Lake (North Burgess Twp.) and Flower Round Lake (Lavant Twp.), Singleton Lake (Leeds-Lansdowne Rear Twp.). All tell a similar story.

Around 11,000 years ago, the area was sparsely vegetated by herb-shrub tundra. This was followed by a dwarf-shrub tundra with spruce. After 9,500, a coniferous forest dominated by pine emerged. There was a shift to hemlock dominated forests with hardwoods (sugar maple, oak, beech, birch, elm) on the rise 7,500 years ago. A major event occurred in this mixed deciduous forest about 4,800 years ago when hemlock trees apparently died *en masse*. This die off occurred throughout eastern North America. It has been suggested that the cause was a rapidly spreading disease, like Dutch Elm Disease, which removed elm trees from our landscape in the early 1960's. With the decline in hemlock, hardwoods increased in abundance. About 3,500 years ago, hemlock recovered and oak began to decline.

It is in the last 150 years that the most dramatic changes have occurred in vegetation cover--forests were cleared, roads were constructed and weeds invaded. Ragweed, which causes so much human suffering each summer, invaded with the settlers. Its sudden increase in abundance in lake sediment is so dramatic that ragweed pollen is a good marker for determining which portions of sediment cores date from periods after European settlement.

One draw back of pollen data is that lakes accumulate pollen from a large geographic area. The record in any lake therefore combines information on forest cover from many site types, but is a good indicator of "regional vegetation" (for anemophilous species). To get information on forest composition at a finer scale, we must turn to other sources.

2.2 Historical References to Past Forests

Historical evidence ranges from anecdotal descriptions of the forests to more quantitative data from surveyors' notebooks.

2.2.1 Anecdotal Observations

Early newspapers (e.g. Mirickville (Canada West) Chronicle), and settlers' journals or letters provide some impressions of the nature of the forests the settlers found when they arrived in the region. These, and other sources, have been used to reconstruct the history of settlement in the MF region in recent publications such as Lockwood (1991) (Beckwith Twp.), Brown (1984), McGill (1968) (Lanark Co.), Lockwood (1980) (Montague Twp.), MacGillivray and Ross (1979) (Glengarry Co.), Burns *et al*. (1972) (March Twp.), and McKenzie (1967) (Leeds and Grenville Co.). Because the European settlers were far more interested in levelling the forest to open the land for agriculture than they were in noting its qualities and composition, most historical accounts are fragmentary at best, and negative and subjective at worst. Below is a sample of quotations from settlement times that will provide a picture of the forests as they were seen.

Early settlers in Beckwith Township describe their experience of the forest as follows (Lockwood 1991), *"There is something in the ponderous stillness of these forests-- something in their wild, torn, mossy darkness, their utter solitude and mournful silence which impresses the traveller with a new aspect each time he sees them ... In Upper Canada the endless hills of pine give way at last, or at most stand thinly intermingled with gigantic beeches, tall hemlocks and ash, with maples, birch and wild sycamore, the underwood of these great leafy hills. Mile after mile, and hour after hour of such a route was passed-- a dark black solitude, with here and there a vista opening up, showing the massive trunks, grey as cathedral ruins, which bore the rich canopy of leaves aloft."* (Sycamore is native to more southern parts of Ontario. A modern equivalent for "wild sycamore" was not found.)

Another immigrant described other aspects of the forests (Lockwood 1991), *"The greater part of the forest, the underwood or bramble, is not as thick as at home but a great deal of it is worse to go through than the worst of Crucatone Wood... [C]onceive Paisley Moors, for instance, all grown over with large trees, some fresh and green, others half rotten and a great many rotten from top to bottom, and almost as many lying in all directions as are standing, with not a living creature to be seen or heard except a bird or two, and the owl screaming in your ears at night."*

A Lanark County pioneer described a forest *"through which the sun never penetrated"* (McGill 1968).

Some information concerning the appearance of forests in Montague Township were provided by a settler faced with the task of forest clearing (Lockwood 1980), *"There is always a great quantity of timber lying on the ground, which has been blown down by the wind, and must be cut up."*

Additional descriptive material might be obtained in the numerous travel accounts catalogued by Craig (1963).

2.2.2 Surveyors' Notebooks

Information on the forests of southern Ontario was recorded by crown surveyors who began surveying in 1783 (Gentilcore 1969) as a prelude to European settlement. As the surveyors laid out the boundaries of counties, townships and lots within, they described the vegetation, hydrology, topography and soils of the land they traversed. There is considerable variability in the quantity and quality of the information recorded. Some surveyors listed up to five tree species when describing forest cover, while others would list only the most common or none. Typically, each time tree species composition changed along the concession boundary walked by the surveyor, he would note the distance in chains and links, and list the species present in order of abundance. No indication of forest structure was provided. Occasionally, "small pine" or "good timber" and evidence of fire would be noted.

2.2.2.1 Methods

Data collection

Information on forests in the region was obtained from surveyors' notebooks and used as follows. The objective was to reconstruct the forest cover for each of the larger physiographic types represented in the region. From a physiographic map (Chapman and Putnam 1984), I selected townships which represented the five major physiographic types (sand plains, clay plains, till and rock (precambrian), limestone plains, till plains). Given the preliminary nature of this investigation (to provide an overview of historical forest cover), data from physiographic regions representing the same physiographic type were combined. For example data for sand plains were obtained from townships on the Edwardsburg Sand Plain and from the Russell and Prescott Sand Plains. The proportion of the type data obtained from each physiographic region was directly related to the size of the region.

Using the list of surveyors notebooks by township provided by Gentilcore and Donkin (1973), notebooks covering townships representative of the five physiographic types were identified. Records for clay plains were taken from surveyors' notes for Alfred, Cambridge, Huntley, and Pakenham townships. Sand plain data were obtained from Cambridge and Edwardsburgh townships. Forest cover in the precambrian region was recorded for Pakenham, Beckwith and Darling townships. For limestone plains, records were taken from Bastard, Kitley and Drummond townships. From Lancaster and Osnabruck townships, forest cover for till plains was recorded. At the Survey and Mapping Branch of the Ministry of Natural Resources (Toronto), all the notebooks for a particular township were examined. For each township, notebooks covering concessions that occurred well within the physiographic type of interest were selected for further review. For each of these notebooks, the number of species frequently listed by the surveyor for each entry was determined (sometimes none, usually 3, rarely 5). Notebooks in which none or only one species was listed for each entry were put aside where there were other notebooks with better species lists for nearby areas.

Having thus selected notebooks with the greatest level of detail, concessions occurring well within the physiographic type within the township were identified. Lot selection on each concession was based on position as indicated on the physiographic map, prior to the detailed examination of surveyors' notebooks. Data were recorded for 4 to 24 (typically 10-18) lots on each concession sampled. The number of lots sampled on each concession depended upon the length of the concession within the physiographic type and the need to obtain a representative sample of the physiographic type by distributing lots among several concessions. The total number of lots selected in each township for each physiographic type reflected the size of the physiographic type in the township relative to the size of the physiographic type for the MF region.

For each physiographic type, data were recorded for a total of 80 lots (76 lots on clay plain and 33 lots on till plain, due to time constraints). For each lot, the tree species present in the first type of forest cover encountered by the surveyor were recorded. The order in which they were listed (relative abundance) was also noted (Appendix A). Data from lots noted by the surveyors as wet, swamp or lowland were used in the analysis of lowland forest. Those not so noted were used in the analysis of upland forest. The numbers of upland and lowland lots sampled are not standardized, but vary according to the terrain within the physiographic types over which the surveyors walked. The numbers of upland and lowland lots (indicated in brackets, respectively) examined in each physiographic type were as follows: till and rock (60,20), sand plain (75,5), clay plain (71,5), limestone plain (68,12), till plain- undrumlinized (23,10).

Some species names noted by the surveyors are not used today. Where known, the old names have been changed to current names (e.g. water elm = American elm; rock maple = red maple; Norway pine = red pine) through reference to older botanical manuals (A. Dugal, pers. comm.). For other names, where more than one modern name could be used (e.g. soft maple = silver maple/red maple; water ash = Manitoba maple- less likely/black ash- more likely), the original name is retained. In accounts where both white oak and oak are listed, oak could be either red or bur. References to white oak may include bur oak.

In surveyors' notebooks and in this report, maple, beech, hemlock, fir, pine and cedar refer to the following species, respectively: sugar maple, American beech, eastern hemlock, balsam fir, white pine, white cedar.

Data analysis and interpretation

The data from surveyors' notebooks were analyzed in two ways for physiographic types. First, the frequency of occurrence of individual tree species was examined. The percentage of the upland lots on which each species was recorded (regardless of position in the species list) was determined. Similarly, the frequency of occurrence of each species on lowland lots was calculated. In addition, for uplands, the percentage of the lots on which each species was listed as the first, second or third species in surveyors' lists was determined. There were insufficient data to do a similar analysis for lowlands.

The second way the data for uplands were analyzed was to determine the frequency of occurrence of species combinations. For each lot the combinations of first and second species recorded were listed. The percentage of the lots having each combination of first and second species was calculated. These species combinations do not correspond to cover types, but simply represent species that were found growing together. These data therefore do not allow the assignment of cover types to physiographic types. The original data for sand plains were not available for the preliminary combination and wetland species analyses. Their acquisition is recommended as a priority for future work (section 4.0).

There are some considerations and limitations concerning the use of data from surveyors' notebooks that should be noted. The level of detail (numbers of species listed for each forest cover) varies among surveyors. The level of detail and the accuracy of species and wetland/lowland identification may be related to the time of year the surveyor was in the field. In the winter, soil moisture may not be obvious. In the fall and winter species identification would be more difficult (foliage absence) and conditions would discourage lengthy note-taking. Even the most comprehensive notes on forest cover represent transects through townships, for the establishment of lot corners, not for the purpose of providing comprehensive forest cover data. The forest cover analysis and interpretation for any physiographic type is constrained to areas where adequate data are available.

2.2.2.2 Upland Forest

Tree species frequency

Table 1 shows the frequencies of tree species in upland forest (forest not noted as wetland or lowland in surveyors' notes) varied with physiography. Using this table, a map of historical forest cover was prepared (Figure 3). The species richness of these forests ranged from nine (till plain) to 19 species (clay plain). Seven species occurred in all five physiographic types (sugar maple, beech, elm, basswood, hemlock, cedar, ash). Sugar maple was most frequently recorded on limestone plains and till plains. Beech was found most often on till plains, followed by limestone plains. Elm was most common on limestone plains where it occurred on 60% of the lots. Basswood was most frequent on clay and till plains. Hemlock was found in close to half the lots examined in all regions except clay plains. Cedar and ash occurred in less than 15% of the lots in all physiographic types.

In the lots examined, white pine was not recorded from the limestone plain. Oak and white oak as well as red pine and red spruce were recorded infrequently and only on clay plains. Poplar and soft maple were noted only on sand and clay plains. Till and rock, sand plains and clay plains supported birch and balsam fir.

Table 2 shows that sugar maple was the dominant species on limestone plains and a co-primary species on sand plains (with hemlock) and clay plains (with white pine). Hemlock dominated till and rock. On till plains, beech (almost as frequently mentioned as sugar maple, Table 1), was more often listed first.

Table 3 shows the frequency of species occurring second in surveyors' species lists. Considering the three most frequent species for each physiographic type, sugar maple is again an important secondary component of forest cover. On all types except till and rock, elm frequently occurs as secondary species. Beech is the most common secondary species on sand plains and important on limestone and till plains. Spruce is a secondary component on sand and clay plains. White pine was observed as a major secondary component only on till and rock.

Table 1. Frequency of tree species on upland sites in the major physiographic types, based on data from surveyors' notebooks. Numbers are per cent of lots on which each species occurred. (See footnotes and text for discussions of species names.)

SPECIES **PHYSIOGRAPHIC TYPE**

	Till & Rock * (60)***	Sand Plain (75)	Clay Plain (71)	Limestone Plain (68)	Till Plain** (23)
Maple	50	41	48	87	83
Beech	8	33	1	54	78
Elm	7	28	38	60	26
Hemlock	58	47	10	40	43
Basswood	15	21	48	43	52
White Pine	50	37	34	-	4
Spruce	-	37	14	-	-
Birch	2	25	3	-	-
Balsam Fir	3	11	23	-	-
Tamarack	-	20	11	3	4
White Cedar	12	13	9	10	13
Ash	5	8	6	6	13
Ironwood	-	4	-	9	-
Poplar	-	9	4	-	-
Soft Maple	-	4	6	-	-
Red Spruce	-	-	10	-	-
White Oak	-	-	8	-	-
Oak	-	-	4	-	-
Red Pine	-	-	3	-	-
Water Ash	-	-	-	1	-
Red Maple	-	-	-	1	-
White Birch	-	-	1	-	-
n species	10	15	19	11	9

* = Precambrian region, ** = Glengarry Till Plain (undrumlinized portion), *** = number of upland lots examined in surveyors' notebooks; maple = sugar maple; birch = white/yellow birch; ash = red/green/white ash; soft maple = silver/red maple; oak = red/bur oak; water ash = likely black ash

Figure 3 Tree species in upland forests prior to European settlement. For each region the five species most frequently mentioned in surveyors' notebooks (Table 1) are listed in order of abundance.

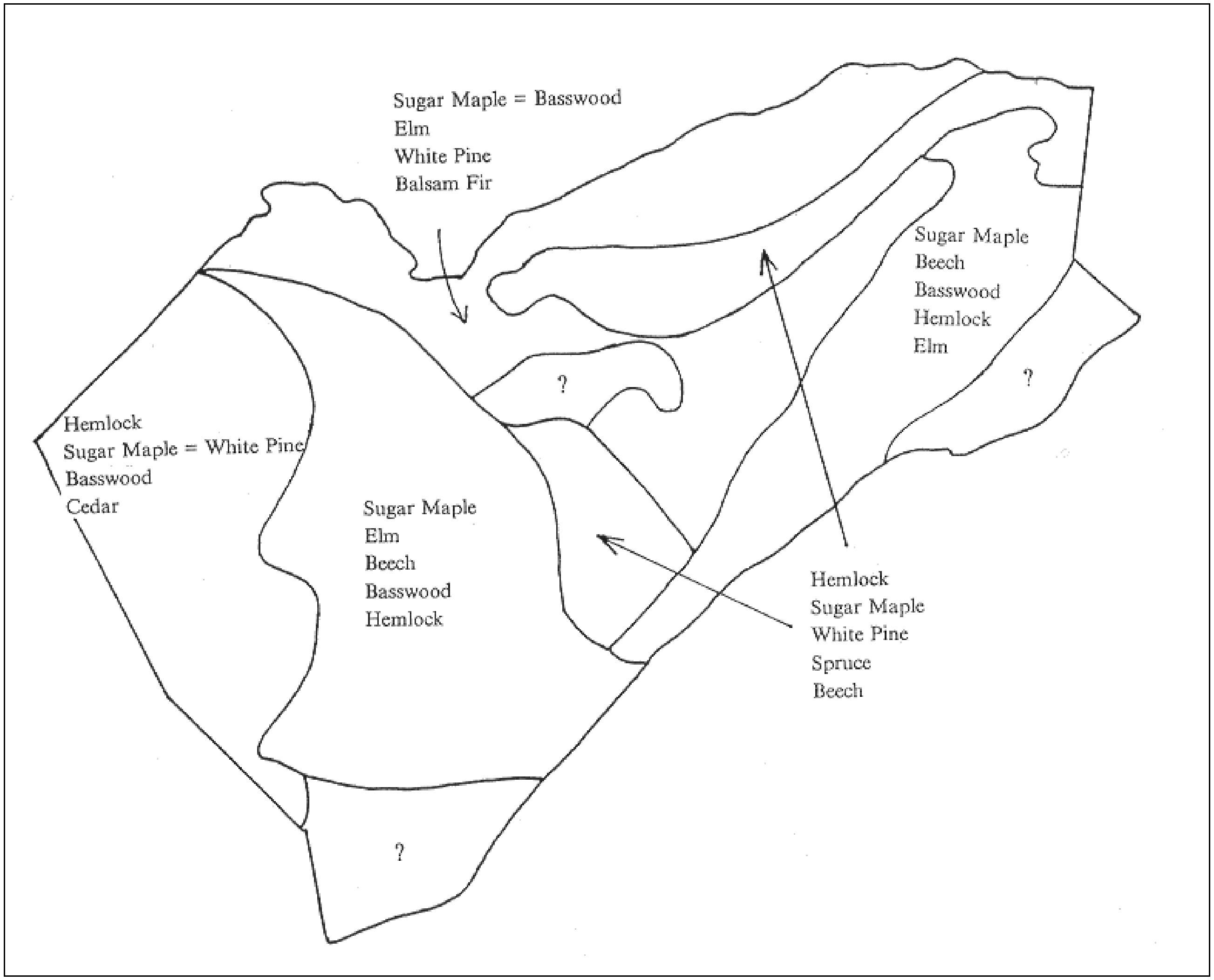


Table 2. Frequency of tree species considered most abundant on upland sites in the major physiographic types, based on data from surveyors' notebooks. Numbers are per cent of lots on which each species was listed first. (See footnotes and text for discussions of species names.)

SPECIES **PHYSIOGRAPHIC TYPE**

	Till & Rock* Plain (60)* **	**Sand Plain (75)**	**Clay Plain (71)**	**Limestone Plain (68)**	**Till Plain** (23)**
Hemlock	47	28	3	13	9
Maple	35	27	28	43	30
Beech	7	3	-	26	43
White Pine	-	9	25	-	-
Tamarack	-	13	8	-	-
Basswood	2	-	11	12	-
Spruce	-	13	-	-	-
Ash	5	-	1	-	9
White Cedar	5	3	1	6	9
Red Spruce	-	-	10	-	-
Poplar	-	3	1	-	-
Balsam Fir	-	-	4	-	-
Elm	-	3	-	-	-
Birch	-	3	-	-	-
White Oak	-	-	3	-	-
Red Pine	-	-	3	-	-
n species	6	10	12	5	5

* = Precambrian region, ** = Glengarry Till Plain (undrumlinized portion), *** = number of upland lots examined in surveyors' notebooks; maple = sugar maple; birch = white/yellow birch; ash = red/green/white ash; soft maple = silver/red maple; oak = red/bur oak

Table 3. Frequency of tree species recorded as second most abundant on upland sites in the major physiographic types, based on data from surveyors' notebooks. Numbers are per cent of lots on which each species was listed second. (See footnotes and text for discussions of species names.)

SPECIES **PHYSIOGRAPHIC TYPE**

	Till & Rock* (60)* **	**Sand Plain (75)**	**Clay Plain (71)**	**Limestone Plain (68)**	**Till Plain** (23)**
White Pine	48	12	3	-	-
Elm	7	13	35	13	22
Maple	13	5	17	41	52
Beech	-	23	-	20	13
Spruce	-	16	13	-	-
Hemlock	8	11	4	9	4
Basswood	5	1	3	7	-
White Cedar	7	5	4	1	4
Tamarack	-	5	1	3	-
Balsam Fir	-	4	3	-	-
Birch	2	1	3	-	-
Ash	-	-	-	1	4
Poplar	-	3	-	-	-
Water Ash	-	-	-	1	-
Red Maple	-	-	-	1	-
White Birch	-	-	1	-	-
n species	7	12	11	10	6

* = Precambrian region, ** = Glengarry Till Plain (undrumlinized portion), *** = number of upland lots examined in surveyors' notebooks; maple = sugar maple; birch = white/yellow birch; ash = red/green/white ash; water ash = likely black ash

The frequencies of tertiary species are shown in Table 4. Basswood was the most frequent tertiary species in four physiographic types. On limestone plains, elm was often the third species listed. Hemlock occurred in all types, most commonly on limestone and till plains. Balsam fir was listed as a significant tertiary species on clay plains while white pine and birch were important only on sand plains. On till and rock, no one species was often listed as a tertiary cover component.

For some lots a fourth and fifth species were listed. Because this was uncommon, cover comparisons among regions at this level were not made as they would be unreliable.

Species Combinations

Table 5 shows the frequency of occurrence of species combinations for four physiographic types. Based on this table, a map of historical forest cover was prepared (Figure 4). On till and rock, hemlock-pine was the most common combination, followed by maple-pine, beech-maple, hemlock, maple-basswood, maple-elm, maple-hemlock and maple. Typically, surveyors did not record a third species with these combinations. An additional 11 combinations were recorded on 2% or fewer of the lots.

Twenty-four combinations were found on clay plains. A maple-elm combination occurred on 25% of the lots, followed in abundance by red spruce, pine-maple, basswood-maple and pine-spruce. No tertiary species were listed with red spruce or pine-maple combinations. Red spruce was recorded only from Alfred Township. With pine-maple combinations, basswood and white oak occurred as tertiary species. With pine-spruce combinations, balsam fir was also recorded.

On limestone plains the most abundant combinations were maple-beech, beech-maple, maple-elm, basswood-maple and hemlock-maple. Combinations with beech are more abundant on this physiographic type than on the others surveyed. Basswood and elm were the tertiary components in maple-beech forests. In beech-maple forests, hemlock and elm were also found. Elm occurred as a tertiary species in basswood-maple forests while basswood and hemlock occurred as additional components in maple-elm forests. In hemlock-maple forests, beech, elm and basswood were also found.

On till, the main combinations are beech-maple, maple-beech, maple-elm and hemlock-maple. Basswood and hemlock are the most common tertiary species in beech-maple forests. Hemlock was also found in maple-beech areas. In maple-elm forests, beech was a tertiary component.

The accuracy of the frequencies reported could be increased by the incorporation of more data from surveyors' notebooks.

2.2.2.3 Lowland Forest

From 6% to 30% of the lots sampled for each physiographic type were classified as lowlands or wetlands by the surveyors. The frequency of tree species occurring on these lots is shown in Table 6. In three types, cedar was the most frequent species listed while elm occurred on 60% of the lowland clay plain lots. Other lowland species included alder, ash, tamarack, spruce, willow, white oak and water ash. Further detailed analysis by position in the species list is not warranted given the small number of lots sampled.

Table 4. Frequency of tree species recorded as third most abundant on upland sites in the major physiographic types, based on data from surveyors' notebooks. Numbers are per cent of lots on which each species was listed third. (See footnotes and text for discussions of species names.)

SPECIES **PHYSIOGRAPHIC TYPE**

	Till & Rock* (60)* **	**Sand Plain (75)**	**Clay Plain (71)**	**Limestone Plain (68)**	**Till Plain** (23)**
Elm	-	3	4	40	-
Basswood	8	15	34	21	30
Beech	2	7	1	7	22
Hemlock	3	5	1	18	22
Balsam Fir	3	7	13	-	-
White Pine	2	13	3	-	-
Birch	-	12	-	-	-
Ash	-	9	4	-	-
Maple	2	7	-	3	-
White Oak	-	-	4	-	-
White Cedar	2	4	1	-	-
Tamarack	-	-	1	-	4
Ironwood	-	4	-	-	-
Poplar	-	1	3	-	-
Soft Maple	-	1	3	-	-
Oak	-	-	3	-	-
Spruce	-	1	-	-	-
n species	7	14	13	5	4

* = Precambrian region, ** = Glengarry Till Plain (undrumlinized portion), *** = number of upland lots examined in surveyors' notebooks; maple = sugar maple; birch = white/yellow birch; ash = red/green/white ash; soft maple = silver/red maple; oak = red/bur oak

Table 5. Frequency of first and second tree species combinations listed by surveyors for four major physiographic types. Numbers are per cent of upland lots with each combination for combinations with ≥ 3%. (See text for discussions of species names.)

Till & Rock* Combinations (60)***		**Clay Plain Combinations (71)**		**Limestone Plain Combinations (68)**		**Till Plain** Combinations (23)**	
36	Hemlock - Pine	25	Maple - Elm	21	Maple - Beech	43	Beech - Maple
12	Maple - Pine	10	Red Spruce	18	Beech - Maple	13	Maple - Beech
7	Beech - Maple	8	Pine - Maple	13	Maple - Elm	13	Maple - Elm
5	Hemlock	7	Basswood - Maple	12	Basswood - Maple	9	Hemlock - Maple
5	Maple - Basswood	6	Pine - Spruce	12	Hemlock - Maple	4	Cedar - Ash
5	Maple - Elm	4	Fir - Spruce	7	Beech - Hemlock	4	Cedar - Elm
5	Maple - Hemlock	4	Pine - Hemlock	7	Maple - Basswood	4	Ash - Cedar
5	Maple	4	Basswood - Elm	3	Cedar - Tamarack	4	Maple - Hemlock
3	Beech - Basswood	3	Maple - Basswood			4	Ash - Elm
3	Hemlock - Maple	3	Pine - Fir				
		3	White Oak - Maple				
		3	Tamarack				
		3	Tamarack - Cedar				
		3	Hemlock - Birch				

* = Precambrian region, ** = Glengarry Till Plain (undrumlinized portion), *** = number of upland lots examined in surveyors' notebooks

Figure 4 Co-occurring tree species in upland forests prior to European settlement. For each region, species combinations (first and second species listed) mentioned with a frequency of ≥ 5% in surveyors' notebooks (Table 5) are listed in order of abundance.

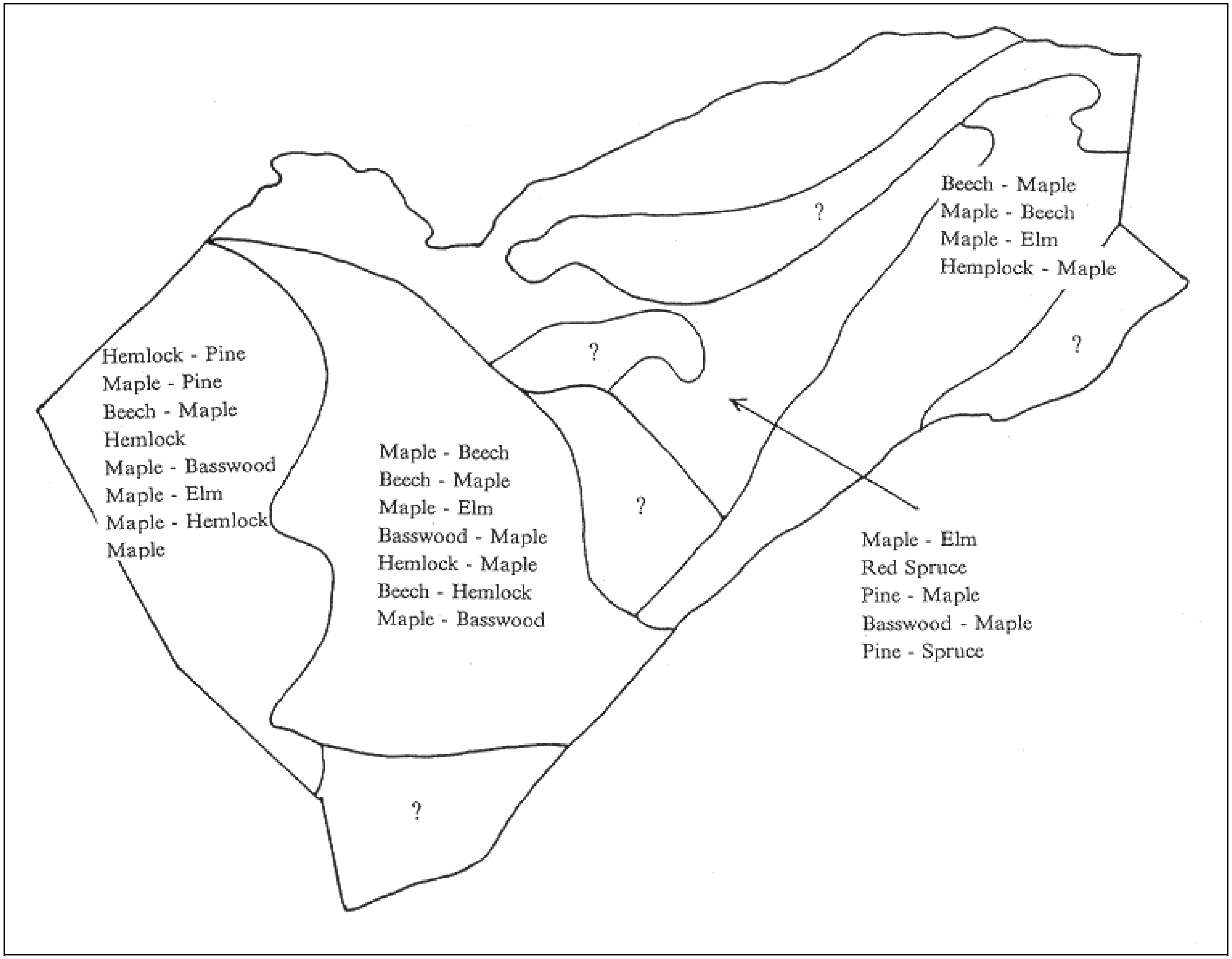


Table 6. Frequency of tree species on lowland/wetland sites in four major physiographic types, based on data from surveyors' notes. Numbers are per cent of lots on which each species occurred. (See footnotes and text for discussions of species names.)

SPECIES PHYSIOGRAPHIC TYPE

	Till & Rock* (20)* **	**Clay Plain (5)**	**Limestone Plain (12)**	**Till Plain** (10)**
White Cedar	30	40	75	90
Tamarack	20	-	42	10
Ash	15	40	1	30
Alder	30	-	17	10
Spruce	10	20	-	-
Elm	-	60	-	20
White Oak	-	40	-	-
Willow	-	-	8	-
Water Ash	-	-	8	-

* = Precambrian region, ** = Glengarry Till Plain (undrumlinized portion), *** = number of lowland lots examined in surveyors' notebooks; water ash = likely black ash

2.3 Forest Remnants

As a last source of evidence, we can examine our older tracts of forest, and assume that those old tracts with relatively less human disturbance provide a reasonable example (or at least the best we have) of past forests. Eastern Ontario has been so thoroughly disturbed that there is little such evidence to draw upon. There is only one known site (Shaw Woods, Dugal 1980) that has been considered virgin forest. It occurs north of the MF region and represents upland mixed forest dominated by beech, sugar maple, hemlock and basswood (White 1990). The largest trees in this woods range from 90 to 60 cm in diameter. Moderate to large snags (standing dead) and logs are common. Small openings comprise 10% of the canopy and are the result of the loss of a single tree or a small group of trees. The forest floor is a combination of pits and mounds.

As a result of a preliminary inventory of twelve additional candidate old growth areas in the vicinity of the MF region, White (1990) found one area (Collins Lake, 15 km north of Kingston) of upland mixed forest that probably could be considered old growth. It is dominated by hemlock, sugar maple and beech and occurs in sandy soil over limestone. Further evaluation is required for confirmation. Sites within the MF region may yet exist, and work is needed to explore thoroughly for them.

There are other tracts of virgin forest in nearby areas of the Untied States from which we can obtain additional information. Stand tables for old growth hardwood-hemlock forest in states bordering on the Great Lakes have been made (Eyre and Zillgitt 1953, in Bourdo 1983) but were unavailable for preparing this report. Bourdo (1956) has, however, made tables for stands in the Upper Peninsula of Michigan. He found that sugar maple did not often exceed 75 cm in diameter, although some occasionally approached 1 m. The diameter of most dominants ranged from 45 to 55 cm. Yellow birch was larger than sugar maple on average, with some trees more than 1 m in diameter. The largest hemlocks exceeded 1.25 m, but most were the size of the maples. Elm and basswood were minor components, but did reach sizes comparable to the largest hemlocks. Large basswood frequently was hollow and ringed with root-collar sprouts. Some white pine attained diameters of more than 1.25 m when growing singly among hardwoods. In pine forests, most good sized trees ranged from 50 to 75 cm in diameter. On poorer soil (as would be the case in the Precambrian region of eastern Ontario), trees under 50 cm predominated.

Bourdo also notes that the cull percentage (defect factor), as interpreted by foresters, sometimes exceeded 40% and typically averaged 25%.

Studies in eastern North America (Muller and Liu 1991, Onega and Eickmeier 1991, Harmon *et al*. 1986, Bormann and Likens 1979) indicate that coarse woody debris (logs, snags, branches) typically is found at more than 20 Mg/ha in old growth forests. As well, undisturbed forest will have large, heavily decayed logs (MacMillan 1981).

2.4 Presettlement Disturbance Regimes

Prior to human settlement, the different forest types in eastern Ontario were attributable largely to the interaction between tree species and site type, the latter being primarily a description of moisture availability. Natural disturbance would have been superimposed upon this variation caused by different site types.

Coniferous forests are well-known for being heavily dependent upon disturbance by fire. Tolerant hardwoods are very different. Fire appears to play a lesser role, and wind-created gaps may be the main disturbance force.

2.4.1 Wind in the Forest

Wind can create small gaps in the forest by blowing over one or a few trees. At the other extreme, hurricanes can knock down entire stands of forest. There is an inverse relationship between size of disturbance and frequency of occurrence. That is, deciduous forests in general have large numbers of small disturbances (consisting of few trees) and relatively fewer large disturbances. This means that most species are adapted to regenerating in small gaps.

Even early settlers commented upon windfalls. Catherine Parr Traill (quoted in Kelly 1974, p. 66) says, *"There is no appearance of venerable antiquity in the Canadian woods... They are uprooted by storm, and sink in their first maturity, to give place to a new generation that is ready to fill their places."* Also see the quote from Lockwood (1980) in 2.2.1. While such anecdotal evidence needs to be interpreted with caution, it is consistent with more recent scientific data.

There is a large scientific literature on the regeneration of species in forest gaps (e.g. Moore and Vankat 1986, Collins *et al.* 1985, Runkle 1981, 1985, Thompson 1980) and it cannot be thoroughly reviewed here, except to draw attention to a remarkable table in Loucks (1983) that uses surveyors' records to establish the number of gaps of different sizes (> 0.5 ha) in historical hemlock-hardwood forests. The total of 776 disturbance patches ranged from 0.65 to 3,785 ha, with a mean size of 161 ha and a median size of 32 ha. Although these data are from Wisconsin, it is not unreasonable to extrapolate from these forest types to ours since the species, soils and climate are not that different.

2.4.2 Fire in the Forest

Fire has a natural role to play in many kinds of forests. Some tree species such as yellow birch and hemlock actually often require light ground fires to create the conditions for their seedlings to establish (Howe 1915, p. 222-223). Other species such as white pine and white birch establish after more severe burns. Ahlgren and Ahlgren (1983) indicate that the natural lifetime of white pine forest, a species which establishes well after fire, is 250 to 300 years. Good cone crops at three to ten year intervals supplied abundant seed to regenerate new white pine forests following fire.

During the review of surveyors' notebooks, reference to fire was made for three of the 349 lots examined. Descriptions for lots in adjacent concessions were examined to determine the extent of these fires, but no further evidence of fire was noted. This suggests that the burns were less than the distance between concessions in width. A surveyor noted for one lot on clay plains that it was formerly pine that had grown up to poplar and willow.

While there is a large body of literature on the effects of fire on forests in areas such as Algonquin Provincial Park and the Adirondacks, there appears to be little information on the role of natural fires in the forests of eastern Ontario. We can guess that fire had a role from what we know of the fire requirements of species that occurred here, and from studies on similar vegetation types (e.g. Botkin 1990, Chapter 10). As a first approximation, it is likely that drier areas of shallow soil over rock burned in the order of once a century. Studies of charcoal in lake sediments, the distributions of fire-adapted species, and a detailed analysis of relevant fire literature are necessary to say much more.

2.4.3 Tree Diseases/Insect Epidemics

It is likely that disease and insect attack influenced the forests in presettlement times, but evidence is sparse. It has been suggested that the decline in hemlock, about 4,800 years ago, was the result of disease (Hall 1993).

2.5 Summary of Historical Forests

Species composition data from surveyors' notebooks provide the best source of historical information on species composition of the forests of eastern Ontario, prior to European settlement. An analysis by physiographic types showed that hemlock-pine combinations were most common in till and rock regions, sugar maple-elm combinations often occurred on clay plains, limestone plains frequently had sugar maple-beech and beech-sugar maple combinations, and beech-sugar maple combinations were most frequently recorded for till plains. On sand plains, hemlock was the most frequent tree species, followed by sugar maple, white pine and spruce. Wetland and lowland forests were largely composed of cedar in three regions, with ash, tamarack, alder, and spruce as secondary species.

In addition to healthy trees, historical forests contained a large portion of cull trees and noticeable amount of coarse woody debris (typically > 20 Mg/ha). Dominant tree species probably reached 50 cm in diameter with the largest attaining 1.25 m.

Gaps in forest cover existed due to flooding by beaver ponds and disturbance by fire and wind. Evidence from anecdotal historical references and examination of old growth forests indicates that small gaps due to windthrow of individual or few trees were common. For larger gaps, a median size of 32 ha was recorded by early surveyors in Wisconsin. There is a paucity of data on the frequency and effects of fire in the MF region. It is suggested that drier areas of shallow soil over rock may have burned in the order of once a century.

While disease and insect epidemics likely affected forest cover, there is little evidence to provide details. The marked decline in hemlock about 4,800 years ago may have been due to disease.

The majority of the information available on historical forest cover of the MF region provides details on tree species composition. This, however, addresses only one aspect of forest reconstruction. Because forests are ecosystems, not just standing trees, many other information on numerous other aspects should be reviewed and used in setting targets for restoration. How much biomass was present? What was the bird species diversity? What large mammals were present? How much coarse woody debris was on the forest floor? Answering such questions would require comparing data from virgin forest stands representative of this part of the world. Dr. Paul Keddy, at the University of Ottawa, has been collecting such data on virgin forest stands throughout eastern North America.

3.0 Human Exploitation

3.1 Overview

Humans have had many effects upon the forests of eastern Ontario, ranging from the effects of early Algonquian and Iroquoian hunters on forest animals, through the effects of settlers in clearing land for agriculture, up to modern day effects of acid rain and urban sprawl. For simplicity, let us concentrate on four main factors (1) settlement, (2) logging, (3) changes in the fire regime, and (4) introduced tree diseases. Often these are difficult to separate; we know that forest area was lost, but we may not always be able to separate the causes.

3.2 Pre-European Settlement

At one time North America had a remarkable group of large mammals that rivalled those of Africa. This megafauna, as it is called, included mammoths, camels, elephants, giant beavers and ground sloths (Hibbard *et al*. 1965). Some paleontologists have suggested that early hunters were responsible for the extinction of this entire fauna (see Martin and Wright 1967). Other biologists then pointed out that such large mammals may have had important impacts on forests, ranging from grazing to seed dispersal. Would we have had more kinds of trees in eastern Ontario if there had been Giant Ground Sloths to carry their seeds back north after the Ice Age? Is this an effect of early human hunters? While this is only speculation, we may postulate that human impact on our forests can be traced back far before Europeans arrived.

Archaeological and historical data on indigenous people are limited and do not reflect the traditional knowledge as it is becoming understood today; the treatment here is based largely upon McGill (1968), Day and Trigger (1978), Jamieson (1990) and J. Pendergast (pers. comm.). In historic times the Algonquins and St. Lawrence Iroquoians were the main groups who lived in eastern Ontario. The Matouweskarini, an Algonquin band, was settled along the Madawaska River in the early 17th century; further to the east the Onontchataronon were settled along the South Nation River (Fig. 5a). We can say with some confidence that there was little clearance of land for agriculture by the Algonquin Indians, although there is some evidence that in the 17th century Algonquins did create small fields which were planted with corn, beans and squash. In general it appears that the economy was based upon hunting and gathering, with trapping and trading becoming more important as the European demand for furs resulted in the fur trade.

Iroquoian settlements were located all along the St. Lawrence (Fig. 5b). By 1350, the St. Lawrence Iroquois had developed agriculturally-oriented economies and cleared land around their settlements. With large population increases in the middle of the 15th century, these small villages gave rise to clusters of village sites in part of the St. Lawrence valley not previously occupied by the Iroquois. These clusters were composed of small, seasonally occupied special purpose camps and major villages. As the soil and forest resources around these villages became exhausted, the villages were moved to new locations.

3.3 European Settlement and Land Clearance for Agriculture

The first Europeans explored Ontario in the 1600's, and were followed by fur traders. Small numbers of primarily French and British settlers came during the 1600's and 1700's. During the mid 1700's, French and English armies, fought for control of North America (Parkman 1884).

During the American War of Independence in the 1770's, 10,000 United Empire Loyalists fled the United States with the aid of the Iroquoian people. Areas were set aside by the Mohawk people for the use of United Empire Loyalists in 1763. In 1763, crown land surveys were begun to describe lots for settlers. The pattern of settlement of eastern Ontario is shown in (Figure 6) based on dates when survey systems were initiated (Gentilcore and Donkin 1973). The majority of the region was surveyed beginning in 1783. Surveying of the remainder of the region began in 1815 and was completed by 1829.

In some ways loggers were loath to see forests cut and simply burned when they could produce timber to feed sawmills. But on the other hand, small farms produced food to support the logging camps. Land near the rivers was settled first. By 1800, the Rideau River still formed the northwestern boundary of settled lands (McGill 1968). The Rideau Canal was built between 1826 and 1832 to link Bytown (Ottawa) with Kingston. Settlement then moved northwest.

Figure 5 The distribution of (a) Algonquin Indian bands (from Day and Trigger 1978) and b) Iroquois villages (from Jamieson 1990) in the MF region.

Figure 5a)

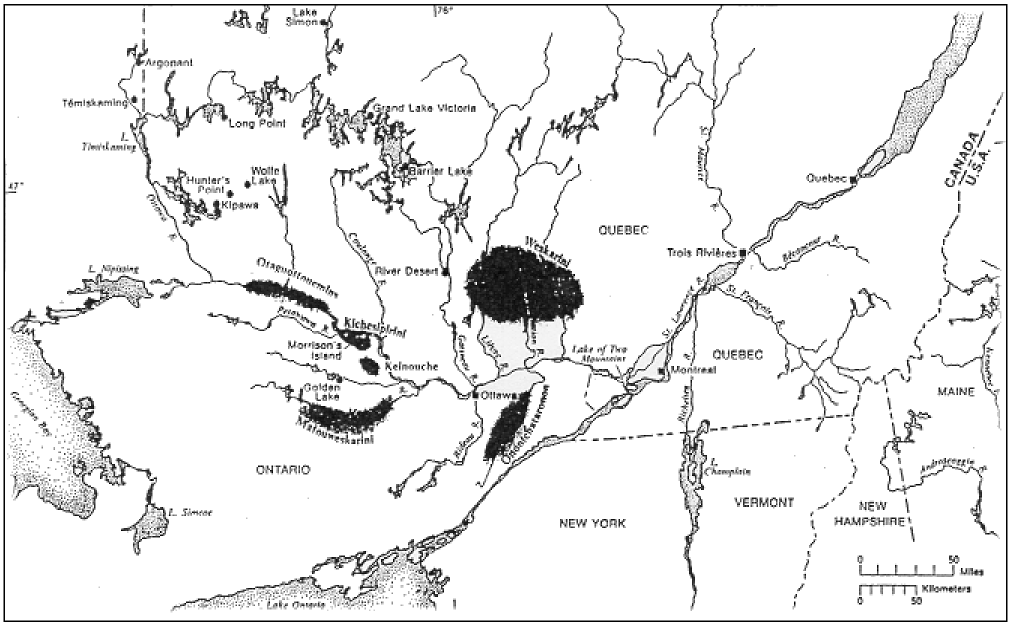


Figure 5b)

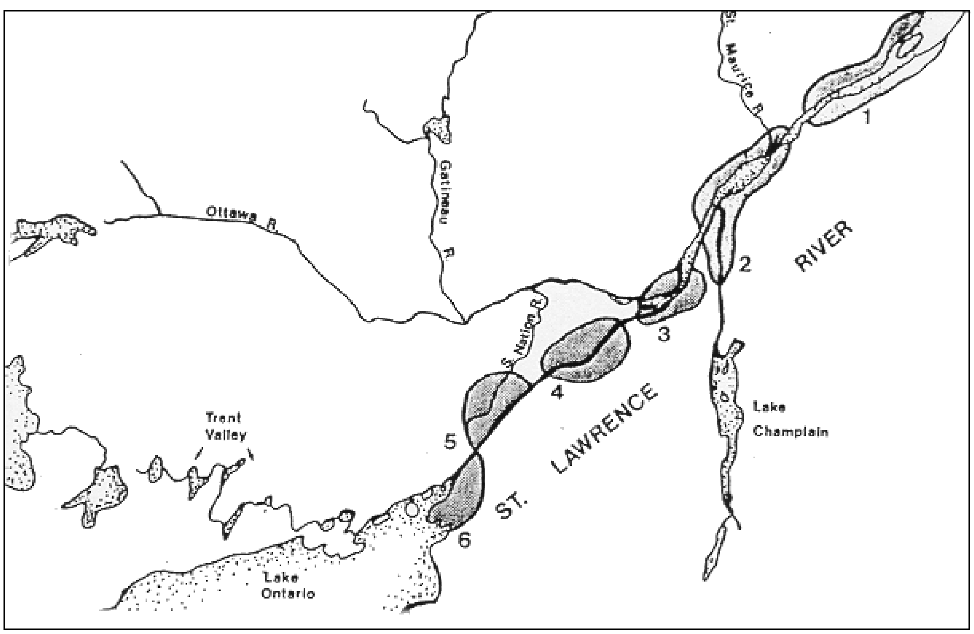
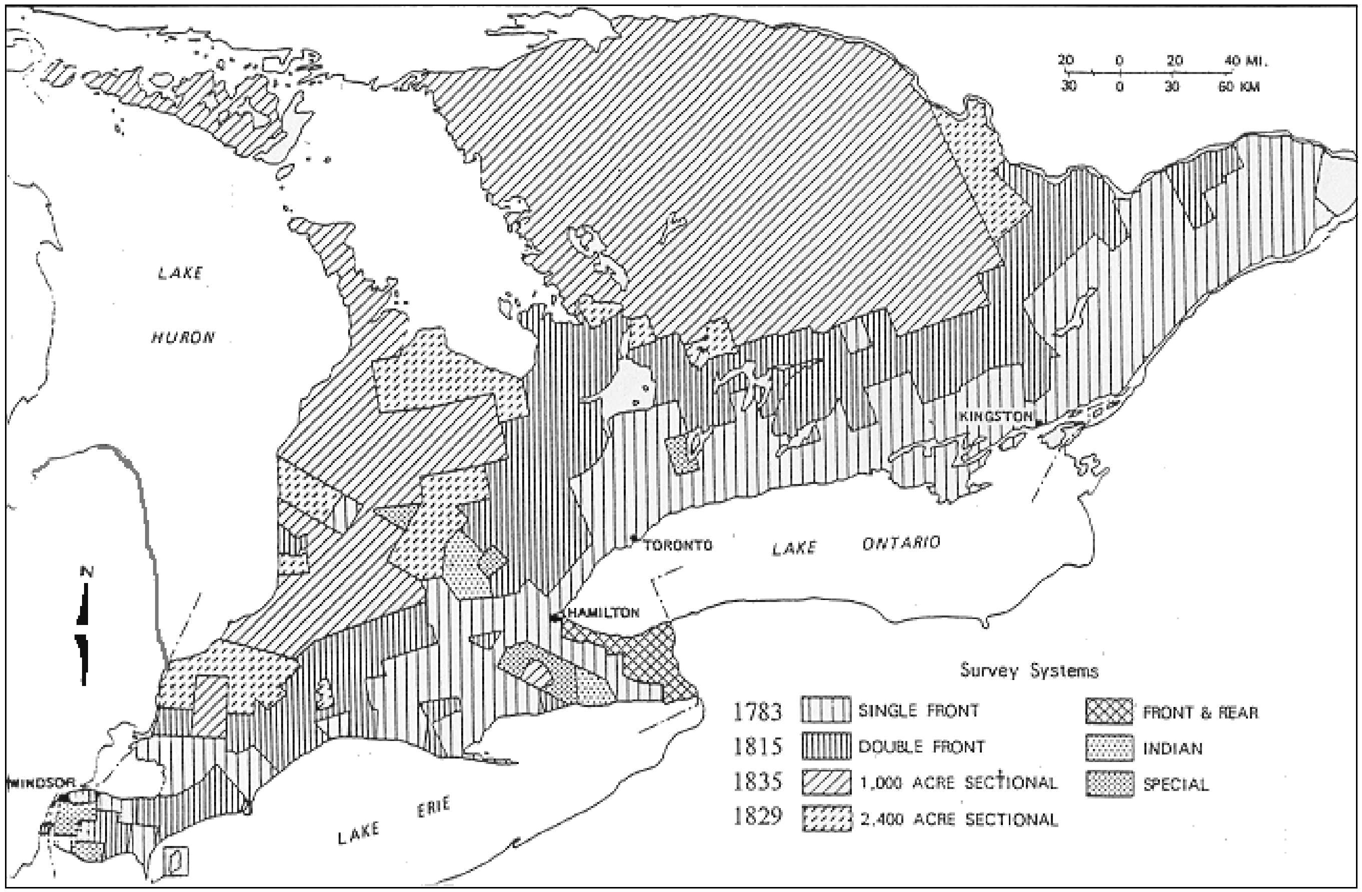


Figure 6 Settlement pattern of southern Ontario based on dates when survey systems were introduced (from Gentilcore and Donkin 1973).



Once the best land for agriculture had been settled, settlement roads were extended in a network along the edge of the Precambrian Shield (Parson 1987). In 1856 the Hastings road was opened northwards into Precambrian shield country of south central Ontario, and the Mississippi Road extended east into the north western corner of Lanark County.

It was obvious to some that the rocky shield soils could not support agriculture. The limitations of the shield had already been described by surveyors beginning in the 1820's, leading J. W. Bridgeland (cited by Gentilcore and Head 1983, p. 79) to conclude, *"The general quality of the land is extremely rocky and broken, so much so indeed, that, in a district of about five hundred square miles, not a portion, sufficient for a small township, could be contained in any one locality, of a generally cultivable nature."*

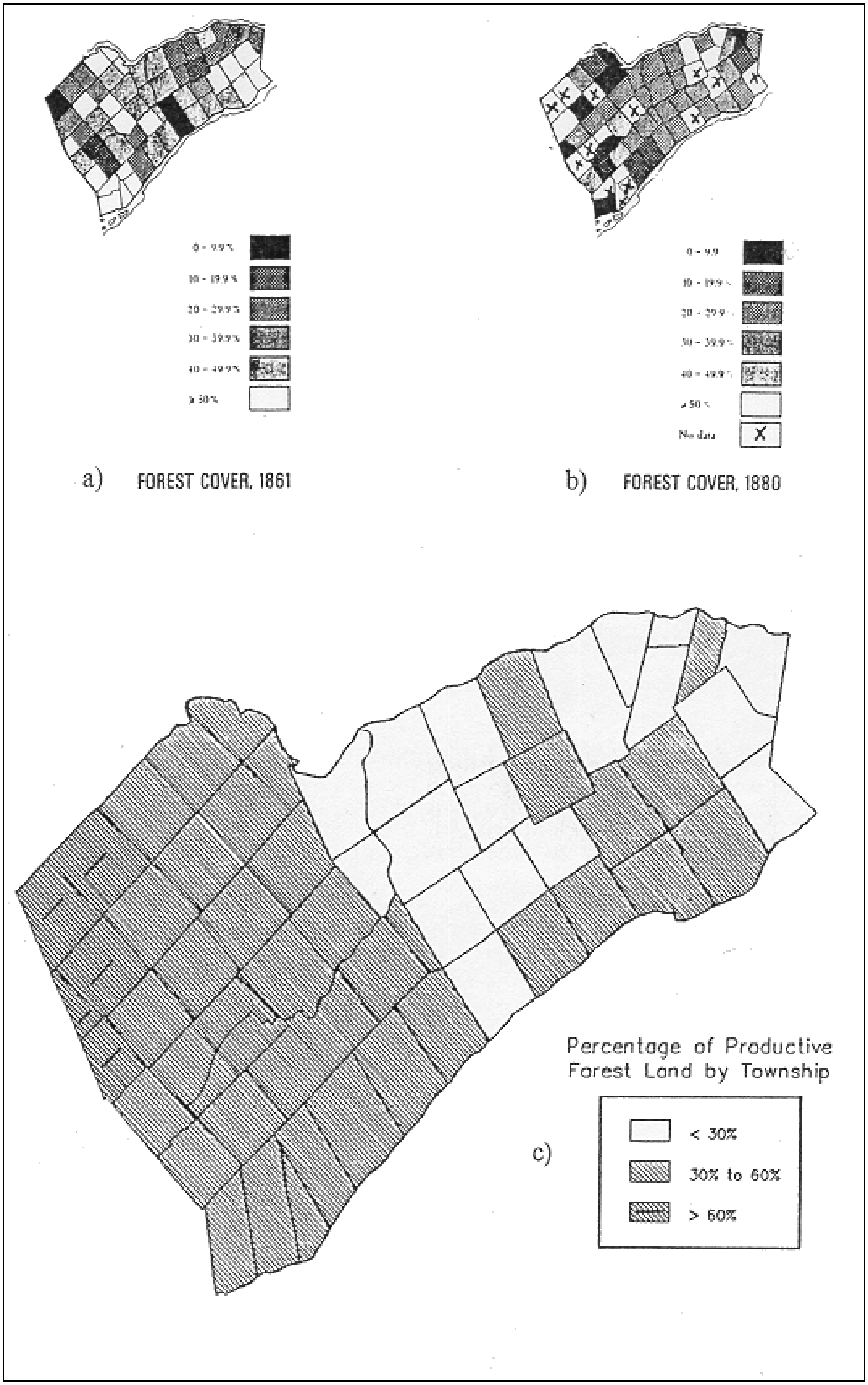
The primary objective of the settlers was to remove forest and replace it with fields to produce agricultural products. Trees were merely an obstacle to development. They were often just felled and burned to make way for crops, although in other cases the trees were burned to generate ash as a raw material for making potash (McGill 1968, Lockwood 1980). One Perth area firm handled 450 barrels of potash per year in the 1840's (McCalla 1987). In some cases squatters only occupied the land long enough to turn the trees into potash (McGill 1968). This represented not only a considerable volume of forest lost, but an actual export of soil fertility.

By 1861, 17 townships in the MF region had already reached levels of forest cover of less than 30%, with three, including Lavant Township, having less than 10% (Fig. 7a). Forest cover continued to decline over the following twenty years, and by 1880 there were 32 townships with less than 30% cover and eight townships with less than 10% cover (Fig. 7b). These figures do not include 13 townships for which no 1880 data were available. In 1992, only 17 townships had less than 30% forest cover (Fig. 7c). This is an increase in cover since 1880. The majority of these townships had 20-30% cover in 1880.

There were many negative consequences of this loss of forest. They included (1) shortages of fuel wood, (2) declines in wheat production owing to the lack of standing timber for shelter, (3) snow drifts blocking roads, (4) severe spring floods and reduced summer stream flow and (5) even reduction in the distribution and amount of rainfall (Kelly 1974). Although Kelly discounts the latter, he does not give his reasons; given the effects of trees increasing evapotranspiration, this effect should not be discounted. Decreased wheat production was more likely due to loss of soil fertility.

Confederation occurred in 1867. By 1889 maps show a network of railways and canals crossing eastern Ontario and linking it with other centres such as Parry Sound, Toronto and Montreal. A century later the Ottawa-Hull metropolitan area has become the fourth largest in Canada with a population size approaching a million people. The transition from forest, to farm to suburbs has occurred in just a few human generations, or about the life span of a sugar maple tree!

Figure 7: Percent forest coverage by township in a) 1861 b)1880 (from Kelly 1974) and c) 1992 (from Eastern Ontario Forest Resources Stewardship Council 1992).



3.4 Logging

The history of logging in the Ottawa valley is well-known (McGill 1968, McCalla 1987, Head 1975, 1980) and will be summarized here. Logging companies were already at work in the Ottawa Valley in the late 1700's, and the pace of cutting quickened during the early 1800's when the Napoleonic Wars blocked access to traditional British timber sources in the Baltic area. White pine was most in demand. The attitude towards hardwoods by the pine operators is illustrated by the following quotation in Kennedy (1947, p. 5) from a Bytown (Ottawa) resident, *"Surrounding this pine territory and contiguous to the great lumber fields is the large area to which we have alluded, possessing a fertile soil and timbered with hardwood. This timber has not the value of pine, and its destruction is not a national loss."*

Trees were felled, squared, floated downstream, assembled into large rafts and eventually floated to Montreal for export to Europe. In 1845 the upper Ottawa River watershed was the source of more than 12 million cu ft of squared pine timber; eastern Ontario was the source of several additional million (Rideau District and Lower Ottawa District) (Head 1975). From Ontario as a whole, oak, elm and tamarack were also cut as square timber, but the proportion produced in the MF region is not known (Head 1975). In the mid 1800's, there may have been up to 7000 raftsmen employed along the Ottawa River (McCalla 1987).

Waves of loggers then removed the smaller timber for sawmilling. In 1871, 490,000 standard pine logs were harvested from the MF region (Head 1975). No additional data have been published that would allow early trends in the volume of forest products to be assessed.

Logging decreased the reproductive potential of red and white pine in several ways. Once the vast supplies of historical stands were largely eliminated by logging, the probability that widely spaced good seed years would coincide with desirable post-disturbance seedbeds was dramatically reduced. Those seedlings that did develop had to be free from disturbance for about 25 years before they themselves contributed substantially to the seed supply. The pine portion of the forest cover was thus rapidly reduced and not restored. Fire incidence increased as a result of logging (see 3.5.1, 3.5.2) which also reduced reproduction.

In a little over a century the great forests were largely gone. Although we may romanticize the history of life in the lumber camps, the historian Grant Head, who has studied forest exploitation in 19th century Ontario, was led by his studies to observe *"... the clearing that resulted from 19th century sawlogging must have shocked even 19th century minds, and can today be described only as a desecration".*

3.5 Fire Associated with Human Activities

3.5.1 Occurrences and Causes

There is much evidence that indigenous people throughout eastern North America regularly used fire to modify forest composition (Day 1953), but we do not know how much these observations apply to eastern Ontario.

Fires were deliberately set by settlers as a means of clearing land. Settlers tended to regard trees as enemies to be removed from the land and replaced by fields. So endemic was this attitude that by the late 1800's it was realized that many farms were actually unable to meet their own demands for fuel and construction wood (Kelly 1974). Although loggers were dependent on the settlers for food, they were in competition with them for the forests. In Renfrew County (just north of the MF region), it was reported in 1875 that, *"hundreds of square miles of pineries had been cleared or destroyed by the fires set by careless farmers"* (Lower 1929 in Cross 1978).

Logging may have initially left more trees than the settlers, but it was often accompanied by wild fires which not only killed the remaining trees and tree seedlings, but removed the rest of the ground cover and allowed soil to erode from the site (e.g. Howe 1915). Such hot fires virtually sterilized the sites (Bourdo 1983).

Railroads were also built to both take advantage of and promote settlement, logging and mining. From the beginning of railway legislation in Canada, sparks and coals from the operation of coal-burning engines was a source of fire danger to adjacent lands (Leavitt 1913). Railways were noted as the most frequent cause of fire in any timber areas through which they passed.

All entries under `fire' in the indices of recent written accounts of settlement (see 2.2.1) were reviewed. In some accounts the term did not appear. In the remainder, it was often damage to individual buildings or personal property that was described, not the extent of any forest fire. In the northern portion of the region, major fires occurred in 1870, around 1900 and early in the 1900's (D. Lemkay pers. comm.). The fire of 1870 affected Darling, Pakenham, Lanark, Ramsay and Montague townships and spread east into Carleton County (Lockwood 1980). No maps of the coverage of these fires have been prepared. It would be necessary to piece together anecdotal information from many sources.

Based on recent forest fire records maintained by The Ontario Ministry of Natural Resources, Donnelly and Harrington (1978) prepared a map of reported forest fires from 1917 to 1976 that were larger than 200 ha. Within the MF region, two fires occurred in Mountain Township in lowland forest between 1970 and 1976. Three upland fires are indicated close to, but outside, the Lanark County boundary between 1920 and 1929-- on the west shore of White Lake, northwest of Flower Station, and west of Elphin. The causes of the fires were not mentioned.

More recent information for smaller forest fires for the portion of the forest fire region (6 townships in Lanark Co.) that occurs in the MF region (R. Frech pers. comm.) indicates that between 1981 and 1991 there was an average of 21 fires/yr, the majority of which (78%) were less than 1 ha. These fires were suppressed.

3.5.2 Effects of Fires and Fire Suppression

Kelly's data describe the loss of forest area, but the changes in species composition are more difficult to reconstruct. There is little information on fires in the MF region, but a fine example exists in a neighbouring area with similar soils and bedrock. In 1913 a special commission was set up to report on the state of forests in the Trent watershed in Peterborough County. Howe (1915, p. 172) reported that logging and repeated burning had led to massive soil erosion, *"One frequently finds stumps of trees from one to two feet in diameter on bare rock in such a position that the roots could not have penetrated crevices. The trees could not have germinated and lived* *for many years on bare rock."* Wildfire was frequent *"...there are no places in the former pineries, outside of the swamps, that have not been burned at least once since lumbering. Thirty thousand acres (50%) of the region examined have been burned over many times".* One of his main conclusions was that *"... the principal effort should be to devise a proper forest policy for the area".*

Howe (1915) examined the repeated effects of severe forest fires, since lumbering, on the regeneration of commercial tree species in a portion (69,333 upland acres) of Burleigh and Methuen townships at the eastern edge of Peterborough County. The area is a mixture of two physiographic types: shallow till and rock ridges (Precambrian and Leeds Knobs and Flats of MF region) and bare rock ridges and shallow till (Chapman and Putnam 1984). All areas had been burned at least once since lumbering. Table 7 (compiled from Howe 1915) shows that the number of species and density of trees decreases with the number of burns. The percentage of trembling aspen, large-toothed aspen (up to three burns), red pine, jack pine, white birch (up to three burns), white oak and red oak increases with the number of fires.

Table 7. Tree species composition by per cent and number of stems/acre for forests in Peterborough County that were burned repeatedly (compiled from Howe 1915).

Number of Burns	**1**		**2**		**3**		**Many Times**	
Species	**%**	**Stems/Acre**	**%**	**Stems/Acre**	**%**	**Stems/Acre**	**%**	**Stems/Acre**
Trembling Aspen	26.3	164.8	27.6	144.5	35.2	96.9	38.9	8.7
Large-toothed Aspen	14.8	92.8	21.6	113.0	26.1	71.8	6.0	1.3
White Pine	10.4	64.8	1.6	8.4	1.1	3.0	3.2	0.7
Red Pine	7.1	44.6	1.1	5.7	1.5	4.2	10.7	2.4
Jack Pine	0.2	1.3	-	-	-	-	20.7	4.6
White Birch	17.0	106.9	22.4	117.3	24.0	65.8	10.0	2.2
White Oak	0.4	2.5	3.1	16.3	0.5	1.3	2.3	0.5
Red Oak	2.4	15.0	13.7	71.4	3.9	10.7	4.3	1.0
Red Maple	6.0	37.7	6.3	33.0	5.3	14.7	3.9	0.9
Sugar Maple	1.7	10.2	0.5	2.6	0.5	1.4	-	-
Balsam Fir	2.5	15.6	0.5	2.8	0.8	2.0	-	-
White Spruce	1.4	8.8	0.3	1.5	0.7	2.0	-	-
Cedar	5.2	32.7	0.4	2.1	0.4	1.1	-	-
Hemlock	1.9	11.7	-	-	-	-	-	-
Ironwood	0.7	4.0	-	-	-	-	-	-
Yellow Birch	0.2	1.3	-	-	-	-	-	-
Basswood	0.8	4.7	0.6	2.8	-	-	-	-
White Ash	0.2	1.2	0.3	1.5	-	-	-	-
Beech	0.4	2.6	-	-	-	-	-	-
Tamarack	0.4	2.6	-	-	-	-	-	-
TOTAL		625.8		522.9		274.9		22.3

As a result of such reports, the Department of Lands and Forests (now the Ontario Ministry of Natural Resources) spent a great deal of effort in fire suppression. But putting out all fires is also a mistake because fire was probably a natural occurrence, particularly in sandy and rocky soils. In a sense we went from one extreme to the other. First, during early settlement, there was a surge of fire that was undoubtedly much higher than normal; then a reduction in fires, due to suppression, to a level that is probably much below normal. The first would have led to a surge in the establishment of pine, birch, poplar and oak; the latter probably reduced the establishment of the same species along with yellow birch and hemlock.

For pine forests in Algonquin, Quetico Park and the Boundary Water Canoe Area of Minnesota (within the Great Lakes-St. Lawrence Forests Region, but outside the MF region), the natural fire interval return time ranges from 65 to 78 years. Through the current fire suppression regime, the estimated return interval is 580 years (R. Frech pers. comm.).

3.6 Introduced Disease

Two diseases introduced to the forests of eastern Ontario since the beginning of settlement are noteworthy. The spread of Dutch Elm Disease occurred rapidly through eastern Ontario in the early 1960's. American elm, formerly a common species as indicated by surveyors (2.2.2), was severely reduced in abundance. As the elms died, they created large gaps which admitted sunlight and allowed other species to grow. Most wet forests are still recovering from the death of the elms and mature trees are rare.

White pine nursery stock infected with a blister rust was imported to North America from Europe. The abundance of the rust's alternate host, gooseberries, favoured its spread. This disease reduces white pine reproduction and can be fatal (Ahlgren and Ahlgren 1983).

3.7 Summary of Human Impacts

Prior to the arrival of Europeans in the MF region the impact of Hunter-gatherer economies on the forests were probably fairly small. The effects on forest cover of the Iroquois people, dependent upon an agriculturally-based existence, would have been more intense, but over a smaller portion of the region.

Between 1783 and 1829, lots were surveyed for settlers who felled and burned the trees so that they could begin agriculture and, in some cases, generate ash as a raw material for making potash. By 1861 and 1880, 17 and 32 (50%) townships, respectively, had forest cover of less than 30%. Settlement activities resulted in the loss of a considerable volume of forest, the export of soil fertility, increases in the severity of spring floods, reduced summer stream flows and even reduction in the distribution and amount of rainfall.

Logging began in the Ottawa valley in the 1700's and had a strong impact on forests of the region. In 1845 the MF region was the source of several million cu ft of squared pine timber. Some oak, elm and tamarack were also likely cut as square timber. Following the removal of the large trees for timber, loggers then sought smaller timber for sawmilling. In 1871, 490,000 standard pine logs were harvested from the MF region. Logging largely reduced the seed supply of historical pine stands and reduced the frequency of occurrence of desirable seed bed conditions.

Occupancy of the region by humans resulted in an increase in fire frequency and average fire size. We do not know the extent to which the indigenous people modified forest composition in the region by fire. Fires were deliberately set by settlers as a means of clearing land. Lumbering was often accompanied by wild fires which killed the remaining trees and tree seedlings, removed the rest of the ground cover, virtually sterilized the soil and enhanced soil erosion. Sparks and coals from the operation of coal-burning railway engines were noted as the most frequent cause of fire in any timber areas through which they passed. The largest of three major early fires in the region, which occurred in 1870, affected Darling, Pakenham, Lanark, Ramsay and Montague townships and spread east into Carleton County. From 1917 to 1976, two fires >200 ha were reported in lowland forest.

The number of species, density of trees and the percentage of tolerant hardwoods decreases with the number of burns after logging. The percentage of trembling aspen, large-toothed aspen (up to three burns), red pine, jack pine, white birch (up to three burns), white oak and red oak increases with the number of fires. Initially, humans were responsible for an increase in fires, but with fire suppression policies, fire return intervals have been reduced much below natural levels. The first would have led to a surge in the establishment of pine, birch, poplar and oak; the latter probably reduced the establishment of the same species along with yellow birch and hemlock.

As a result of the introduction and spread of disease, the frequency and size of elm trees, once a major component in forests of the region, have dramatically decreased over the last three decades. The introduction of a blister rust may have affected the distribution and abundance of white pine in the region.

Finally, we can note some obvious differences between present day and historical forests. First, tolerant hardwoods, particularly sugar maple, are less common, and have been replaced in many areas by intolerant species such as white birch and aspen. Within those areas which are still tolerant hardwood, beech and hemlock are generally less common today than in the past.

4.0 Recommendations for Future Work

In order to direct forest management activities towards restoration, additional work is recommended in four areas-- forest reconstruction, fire history, public education and policy. Tasks to be used as a basis for extending this current preliminary investigation are outlined below for each area.

4.1 Original Forest Characteristics

1. Based on surveyors' data, determine species frequencies for lowlands and species combinations for uplands in the sand plain physiographic type of the MF region, conduct species frequency and combination analyses for the minor physiographic regions, and examine species frequencies and combinations for component physiographic regions within physiographic types.

2. Prepare a detailed map of reconstructed forest types using the complete set of surveyors' records for the entire region or townships of particular interest (e.g. the two IRM Planning Pilot Areas within the region). Forest types should be related to site conditions in terms of aspect and soil types. For the entire region, this is probably best done in concert with an ecological land classification (recommendation 7).

3. Prepare a map showing the oldest forests in eastern Ontario. A preliminary criterion would be the oldest 25% (that is to say, the upper quartile) and within this, the oldest 10%. This would guide future field work on restoration. These regions could be designated for special management to protect their character and used as nuclei for expanding forest area.

4. Review the scientific literature to provide a more complete description of forest characteristics (e.g. bird diversity, coarse woody debris mass, tree size, frequency of windfalls). Use this information to set targets for forest restoration and management. Confirm that the Integrated Management Group intends to do this work and, if not, see that it is done.

5. Conduct field work and assemble existing inventory work to document stand composition and structure in those forests judged to be closest to old growth conditions. The fact that no virgin forest apparently remains within the region does not prevent us from learning a great deal from inspection of the oldest remaining stands. Such stands could also be considered for ANSI or ecological reserve status.

6. Locate all the information available on Shaw Woods. Determine gaps in knowledge. Decide which knowledge is needed for forest reconstruction. Gather it and publish it. (There is far more published information on old growth forests in the USA than there is here.)

7. Prepare an ecological land classification for eastern Ontario. Combine this with the forest map (1) to reconstruct all vegetation types at a finer scale. That is, the map should show both forest types and other vegetation types such as wetlands that have been drained.

8. Review all existing protected areas to determine the degree of representation in the protected areas system. Are some areas redundant? Where are the gaps?

9. Compare historical records and present day forest composition records. Document changes in forest composition. Set targets for restoration.

10. Compile a set of descriptions of the forest taken from notes and journals of early settlers. These can be updated as more records come to light.

11. Incorporate traditional knowledge of the forest by indigenous people into a better understanding of our forest history.

4.2 Fire History

12. Complete a map showing the outline of all major fires in the period 1800 to 1929. It could be updated as additional historical records are located.

13. Determine prehistoric fire frequency by examining charcoal in lake sediments. At a minimum, someone needs to do a thorough search for unpublished data which may already exist. If none can be found, a palynological lab should be hired to examine several cores representative of eastern Ontario.

14. Review the literature on the effects of fire on forest ecosystems that is directly relevant to forest restoration in the MF region.

15. Prepare a list of fire-dependent species and map their historical distributions. Compare this to existing knowledge on fire history. Provide guidelines for the management of fire dependent species.

16. Given the information on fire dependence, is there evidence that fire should be introduced as a management tool? Are there candidate areas where this would be possible?

4.3 Public Education

While carrying out this work, I as impressed by how little information is available, and how few historians have addressed forest related work. This led to the following recommendations.

17. Prepare a book for the public on the original forests of eastern Ontario. This could be based upon this report, updated and improved by adding in the information obtained by carrying out these recommendations.

18. Use this document to stimulate biology, history and geography departments at local universities to pursue related work on forest reconstruction and restoration.

19. Produce a brochure on forest restoration targets and techniques to guide landowners.

4.4 Policy

20. Evaluate and review Ministry of Natural Resources policies and activities which affect forest restoration. Suggest 5 to 10 priority actions to begin forest restoration.

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APPENDIX A DATA FROM SURVEYORS' NOTEBOOKS

1. For each lot, the number for each species shows the order in which the species was listed by the surveyor.

2. * = lot used in lowland species analysis.

3. Surveyor's name and year are indicated in brackets for each township.

4. Occasional comments by surveyors are indicated beside lot numbers.