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Report Title: Pre-European Settlement and Present Forest Composition in Kings County, New Brunswick

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Year of project: 1996

Principal contact information: University of Saskatchewan

File Name:
Biodiversity_1996_Lutz_Pre_European_Settlement_and_Present_Forest_Composition_in_Kings_County_New_Brunswick

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Pre-European Settlement and Present Forest Composition in the Fundy Model Forest

PRE-EUROPEAN SETTLEMENT AND PRESENT FOREST COMPOSITION IN KING'S COUNTY, NEW BRUNSWICK, CANADA

by

Serge Gregory Lutz

B.A. (Hist.), University of Saskatchewan, 1993

A REPORT SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS

FOR THE DEGREE OF

Master of Forestry

in the Faculty of Forestry

at the University of New Brunswick

This report is accepted.

....
Dean of Graduate Studies

THE UNIVERSITY OF NEW BRUNSWICK

June 1996

ABSTRACT

A total of 3881 witness trees were counted from land survey records (1785-1820) and 958 Forest Development Surveys (1986 and 1993) were analyzed in Kings County, New Brunswick. Forest composition was measured by percentage where original land survey data was available and was compared to present day composition.

Three ecoregions and twenty-five ecosites were delineated in southcentral New Brunswick based on the Ecological Land Classification System of New Brunswick. A relative frequency of genera of each ecoregion and species of each ecosite was calculated. The outstanding feature of the pre-settlement forest was the abundance of *Picea* spp. Spruce ranged from more than 45% of the species composition in the Fundy Plateau Ecoregion to 13% in the Continental Lowlands Ecoregion. Today, spruce is decreasing in the Fundy Plateau and Fundy Coastal Ecoregions and is increasing in the Continental Lowlands Ecoregion. In all ecoregions, the percentage of *Abies balsamea* and *Populus* spp. have increased since the pre-settlement era. The dominance of these late successional species suggest that disturbance has played a key role in altering the species composition in Kings County, New Brunswick.

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INTRODUCTION

The character of the pre-European settlement forests in Atlantic Canada is not well known due to the scarcity of forest remnants and lack of historical records. In New Brunswick, commercial logging for pine and spruce (*Pinus* spp. and *Picea* spp.) was underway by 1696 (Defebaugh 1906). By the late seventeenth and early eighteenth centuries all types tree species were considered merchantable timber. Most data on forests of New Brunswick are limited to accounts of seventeenth, eighteenth and nineteenth century travellers. Several of these early navigators' descriptions of pre-European-settlement New Brunswick describe vegetation. However, none dealt with any quantitative data and they are not comprehensive (Lescarbot 1609; Baird 1612; Denys 1672; Le Clercq 1691; Charlevoix 1761; Campbell 1793; Head 1829; Baillie 1832; Perley 1843; Springer 1851).

The best source of quantitative information of pre-European-settlement forest composition has been the records of land surveys. In the north-central, northeastern and southeastern United States, a considerable amount of information pertaining to the pre-European-settlement forest conditions has been extrapolated from records of early land surveyors and the General Land Office surveys of public lands begun in Ohio in 1786 (Sears 1925; Lutz 1930a and 1930b; Gordon 1940; Shanks 1953; McIntosh 1962; Ogden 1965; Lindsey et al 1965; Weunscher and Valinus 1967; Rankin and Davis 1971; Siccama 1971; Delcourt and Delcourt 1974 and 1977; Lorimer 1977; Janke et al 1979; Leitner and Jackson 1981; Russell 1981; Grimm 1984; Whitney and Davis 1986; Whitney 1986; Loeb 1987; Seischab 1990, 1992; Palik and Pregitzer 1992; Gardescu and Seischab 1992; Seishab and Orwig 1992; White and Mladenoff 1994). Most information sources include tree species, their diameter, their distance along a boundary line and ancedotal comments on the nature of the forest. In Canada only one study exists of pre-European-settlement forest composition making use of land survey records (Elliott and Sheils 1995).

Vegetation-site reconstructions have been extremely valuable where the majority of the original vegetation has been destroyed, making it difficult to envision the natural vegetation types or disturbance regimes. The present study does not claim to represent a virgin condition or undisturbed climax, it is only an adequate description of the forest in the late 1700's and early 1800's for a part of southeastern New Brunswick called Kings County where the clearing for agriculture and forestry in the 1800's was extensive. Such a reconstruction is one of the most efficient means available to provide study of present day forests in New Brunswick.

To date there have been no reports on pre-European-settlement species composition and distribution nor vegetation-site relationships of New Brunswick or any of the Maritime provinces. The ojectives of this study are to use the original land-survey records and early historical writings to interpret the nature of pre-European-settlement forests in New Brunswick and to compare species composition and distribution of the pre-settlement forests with the present-day forest in Kings County. The study was based on three primary sources: (a) the Crown Lands Office surveys of land grant lines in the County of Kings, N.B.; (b) private diaries and personal journals kept by many of the early timber barons, surveyors, naturalists and geographers; and (c) the Forest Development Surveys of New Brunswick. Witness trees recorded by surveyors on individual land grant lines and forest development surveys were not limited to Kings County; however, the task of collecting and analyzing these data for the rest of the province, on the scale used for Kings County would be monumental and beyond the scope of this study.

LITERATURE REVIEW

North American Land Survey Records

In the United States and Canada land survey records have yielded some general findings regarding species composition changes in species distribution in the pre-settlement era and today. Most studies in the Northeastern, Northcentral and Southeastern United States have indicated a substantial shift in species distribution away from the successional species of the study areas (Siccama 1971; Delcourt and Delcourt 1974 and 1977; Lorimer 1977; Janke et al 1979; Whitney and Davis 1986; Whitney 1990; Palik and Pregitzer 1992; and White and Mladenoff 1994). Other studies have not compared past to present forest conditions, but have examined the land survey records and presented vegetation maps of specific regions (Sears 1925; Lutz 1930a and 1930b; Gordon 1940; Shanks 1953; McIntosh 1962; Wuenscher and Valinus 1967; Grimm 1984; Loeb 1987; Seischab 1990; Gardescu and Seischab 1992; and Eliot and Shiels 1995). Although these studies do not contrast the forest conditions of yesterday and today, they are a very important tool for re-mapping past vegetation.

Northeastern United States Land Survey Records

In New England, Lorimer (1977) examined Maine land survey records between 1793 and 1827. He found spruce, beech, balsam fir, cedar and black birch which each comprised greater that 10% of the total composition of the Maine primeval forests. Much of the forest seemed to be in a climax state as indicated by the dominance of shade-tolerant species. In Vermont, Siccama (1971) found between 1763 and 1802 beech composed over 13% on the spruce-fir dominated highlands to over 60% of the total species found on the upland mid-elevations in northeastern Vermont. Today, beech comprises only 3-5% of the Vermont forest. In Concord, Massachuschetts, Whitney and Davis (1986) examined the forest history from 1652 to the twentieth century. They showed that the present white-pine northern red-oak forest resulted from succession following various types of disturbances.

In southern New England several scholars examined land survey records between the 1760's and 1840's. In southwestern New York, Gordon (1940) described the bottomland forests to be composed of sycamore, cottonwood, elm, black willow, and silver maple. He found the low elevation upland forests to be primarily composed of sugar maple and hemlock while on upper slopes oak and chestnut mixes prevailed. In the Catskill Mountain region, McIntosh (1962) discovered low and mid-elevations to have been birch, sugar maple, beech and hemlock. In central-western New York

Seischab (1990, 1992) compared the forest composition of the Alleghany Plateau to those of the Till Plains of the Central Lowlands. It was found that the forests of the Alleghany Plateau supported a section of hemlock, white pine and northern hardwoods forests, as well as oak, chestnut and hemlock communities. The upland forests of the Till Plains were composed of beech and maple, while the bottomlands mostly black ash, silver maple and elm swamp forests. Nearby in the central Finger Lake Region of New York, Gardescu and Seischab (1992) found that beech-maple-basswood was the predominant forest type in the region. In the wetlands, the most common species were black ash, while on the ridges in the upland region of the Alleghany Plateau hemlock, cherry and birch were the most prevalent. Loeb (1987) discovered that in southeastern New Jersey, maple, oak, pine and eastern white cedar to be dominant. Northeastern New Jersey and southeastern New York was dominated by black, red and white oak, chestnut and hickory. In Pennsylvania, Lutz (1930a and 1930b) and Whitney (1990) investigated land surveys from the Alleghany Plateau and detected beech and hemlock forests on mesic sites and oak forests on xerophilic sites. Today, due to a intensive human-mediated disturbance regime a black cherry and red maple forest is dominant.

Northcentral United States Land Survey Records

In the northcentral region of the United States there have been numerous studies completed comparing the findings of pre-settlement surveys with today's land records. Again, studies indicate a substantial shift in species distribution away from the late successional species. In Wisconsin, White and Mladenoff (1994) determined that over a hundred and twenty year period the forest cover changed form a landscape dominated by old-growth hemlock, sugar maple and yellow birch forests to largely second-growth hardwood and conifer forests. Nearby in the Isle Royal Park region of Michigan, Janke et al (1979) found in the upland boreal forests a decrease of balsam fir and an increase of white birch and poplar. In northern Michigan, Whitney (1986) discovered the region's red, jack and white pine pre-settlement forests on coarse textured soils were very susceptable to fire. Palik and Pregitzer (1992) found in pre-settlement times in fire sensitive areas hemlock and beech and in fire dependent areas red, jack and white pine were dominant while in both areas today bigtooth aspen, red maple and red oak dominate. In Indiana, Lindsey et al (1965) divided the pre-settlement forests into three main types: 1) oak and hickory; 2) beech and maple; and 3) beech, oak and maple. In the Shawnee Hills region of Illinois, Lietner and Jackson (1981) grouped witness trees into four main stands that dominated the pre-settlement forests: 1) mesic oak and hickory; 2) beech and white oak; 3) lowland depressions (elm, ash and oak); and 4) flood plain forests (poplar, oak and ash). In the river hills region of Missouri, Wuenscher and Valinus (1967) discovered that in pre-settlement forests white oak was dominant as sugar maple developed in the understory. In western Ohio Sears (1925) and later Shanks (1953) concluded 42% of the pre-settlement forests were composed of beech, nearly four times the abundance of its nearest competitor. In south-central Minnesota, Grimm (1984) reconstructed vegetation by use of land survey records and determined the pre-settlement forests to be dominated by elm and co-dominated by sugar maple.

Southeastern United States Land Survey Records

In the southeastern region of the United States several states have had investigators study General Land Office land survey records and on the Coastal Plain of Lousiana, Delcourt and Delcourt (1974) found that tupelogum and cypress occurred on alluvial plains; magnolia,holly and beech on upland sites; and magnolia, beech and holly on river lowlands. Today, the forest is made up of various less important hardwood species. In the Apalachicola region of northcental Florida, Delcourt and Delcourt (1977) a magnolia and beech forest dominated all areas, while on upland sites, a pine and oak or open pine flatwoods were dominant in pre-settlement times. Today, a mixed hardwood forest has replaced the magnolia/beech and pine/oak forests.

Canadian Land Survey Records

To date the only the study of pre-European-settlement species composition and distribution through land surveys of Canada exist for Darling Township, Lanark County, Ontario in the Eastern Ontario Model Forest. Elliott and Sheils (1995) used similar techniques to those of the American investigators and found that the forest cover circa 1822 were dominated by maple, pine and cedar. It is interesting that while some of the common species of the Canadian boreal forest such as maple, pine, cedar, hemlock and ash were found, spuce and birch were not. It could indicate that the survey completed in 1822 was subject to personal bias by the surveyor.

Forests in New Brunswick As Recorded in Historical Writings

Lescarbot (1609), Baird (1612), Denys (1672), LeClerqc (1691), Charlevoix (1761), Campbell (1791), Baillie (1832), Perley (1843) and Springer (1851) have written historical sketches about New Brunswick. Their writings emphasize descriptions of early navigation and settlement, but in most cases brief comments were included on the nature of the pre-European settlement forests of New Brunswick. As seventeenth century explorers travelled throughout what was once Acadia but now New Brunswick, Frenchman Marc Lescarbot remarked, "As for the trees, they are the fairest that may be seen...the most common be oaks, elms, ashes, birch, maples, pine-trees, fir-trees, willows..." (Lescarbot 1609). Another early navigator, Nicholas Denys in reference to the forests of New Brunswick exclaimed, "the trees are beautiful, and in great abundance, such as Oaks, Birches, Beeches, Ashes, Maples...also a great number of native Pines...many Firs...and Spruce..." (Denys 1672).

Later eighteenth and nineteenth century travellers' journals and diaries were not much more elaborate in detail when referring to the forests of New Brunswick than their seventeenth century predecessors. Perley (1843) and Bailey (1876) however, provided descriptions and uses of the tree species found in New Brunswick, while Springer (1851) provided an interesting view into mid-nineteen century logging camps in Maine and New Brunswick, but none of the monographs contained any quantitative data about the nature of the forests of New Brunswick. These descriptive comments were extracted and used as aids in referring to the pre-settlement forest conditions in New Brunswick.

DESCRIPTION AND HISTORY OF STUDY AREA

Study Area Description

Kings County is in the humid-temperate climate zone. The climate of New Brunswick is affected by three main air systems: (1) arctic, cold high pressure systems originating in Canada's high arctic and subsequently descending southwards.; (2) warm air masses that originate in the tropics or the Gulf of Mexico that increase precipitation throughout the year; (3) a mixture of arctic, pacific and tropical systems that are referred to as "continental" (Power and Mason 1995). The mean average temperature in southeastern New Brunswick is -8.6 C in winter and 15.1 C in summer (Power and Mason 1995). Arctic air masses are most common in the winter when the prevailing winds are from the northwest and west, while in the summer it is less common as the winds are commonly from the southwest and west. Precipitation averages 1200 mm and is usually evenly distributed seasonally (Power and Mason 1995). The average number of frost free days ranges from 90-110 per year in the Kings County area (Power and Mason 1995).

The bedrocks of Kings County reveal a general correspondence between the physical and geological features. There is a relationship between the southern upland, the rolling to hilly upland and the undulating lowland to the geographical distribution of the Precambrian, the Mississipian and the Pennsylvanian geological formations, respectively. These geological formations include grey sandstone, quartz-pebble conglomorate, red sandstone, shale, red shale, limestone, gypsum, anhydrite, siltstone, sedimentary, igneous, volcanic and metamorphic rocks (Fahmy et al 1986; Fahmy and Colpitts 1995)

The surficial deposits of the entire area of Kings County are of pre-Wisconsinan and Wisconsinan morainial, colluvial and glacial outwash origin. As the glaciers melted, portions of the county have been scoured and subsequently covered with a layer of till deposits of different thickness. The average thickness of the till is between 0.5 and 1.5 m and varies from sandy to clayey and are rubbly to strong to boulders (Fahmy and Colpitts 1995). In Kings County, areas of outwash and subtill outwash are found in the valley train in the upper reaches of the Kennebacasis River and Smith Creek, respectively (Fahmy and Colpitts 1995). Patterns indicate that not only the Laurentide Ice Sheet reached the Saint John River Valley and the Chaleur Uplands, but another separate centre of ice over the southern part of New Brunswick could have created the Appalachian Glacier complex (Clayton et al 1977).

The soils of Kings County consist of Podzols. There is some variation in the degree of podzolization in the region, but typically they are distinctly acidic, have organic matter accumulating on the surface and not in the soil; under the organic matter it is grey, which in turn is underlain by reddish brown to yellow brown layers. Most of the county consists of soils developed from glacial till. Only a small percentage are derived from outwash gravels, sands, marine, alluvial and organic soils (Aalund and Wicklund 1950).The study area is Kings County and is located in southeastern New Brunswick. It is bounded on the west by Charlotte, Saint John and Queens Counties, on the east by Albert and Westmorland Counties, on the north by Queens County, on the south Saint John County and is approximately 849,920 acres in size. A general southwest to northeast direction of the physiographic features are common to Kings County. The trend is plainly seen by the drainage systems, valleys and hill ranges. The drainage system of Kings County has developed in a trellis-like pattern, which is characterized by long, parallel streams fed by short transverse tributaries. The largest of these are the Long Reach of the Saint John River and Belleisle Bay, the Kennebecasis River and Smith Creek, the North and Anagance rivers and the Hammond River.

Kings County includes a part of three ecoregions, Southern Uplands, Fundy Coastal and Continental Lowlands (Fig. 1). The Southern Uplands or Ecoregion 3, is located in northwest, central and southern New Brunswick.

The southern part of the Ecoregion is characterized by the Fundy plateau. The plateau area is cooler than the surrounding lowlands as elevations exist up to 500m and is influenced by the cold waters of the Bay of Fundy. There is local development of the association of sugar maple, beech and yellow birch on ridges or higher elevations. Balsam fir and spruce species are common, however they are mostly found in valleys and lower slopes (Ecological Land Classification Group 1996). Fundy Coastal (Ecoregion 4) is a strip of coastal cliffs and hills bordering the Bay of Fundy. Most of the Ecoregion lies below 100m (ASL). It is characterized by a milder climate than the continental climate much of New Brunswick with cooler summers, milder winters and higher precipitation levels. Ecoregion 4 is dominated by red spruce and balsam fir in response to the cooler climate. Shade tolerant hardwood stands composed of beech, yellow birch and sugar maple are rare. Yellow birch is found with red spruce, but white birch and red maple are the most dominant hardwood species (Ecological Land Classification Group 1996). The Continental Lowlands (Ecoregion 5) surround the Upper Saint John River Valley, the Grand Lake Basin and encompass most of Kings County. It is a broad, rolling territory with an elevation range of 100m to 300m (ASL). It is located in a typical continental climate regime with warm summers and cold winters. Localized patterns of climate and soil fertiliity determine vegetation factors. The ridge/valley topography are favourable for shade tolerant hardwood forests, however, all tree species indigenous to New Brunswick are found in this Ecoregion. Hardwoods tend to be located on ridges, hilltop or upper slopes, while the coniferous species are found in the moist, lower slopes and valley bottoms. (Ecological Land Classification Working Group 1996).

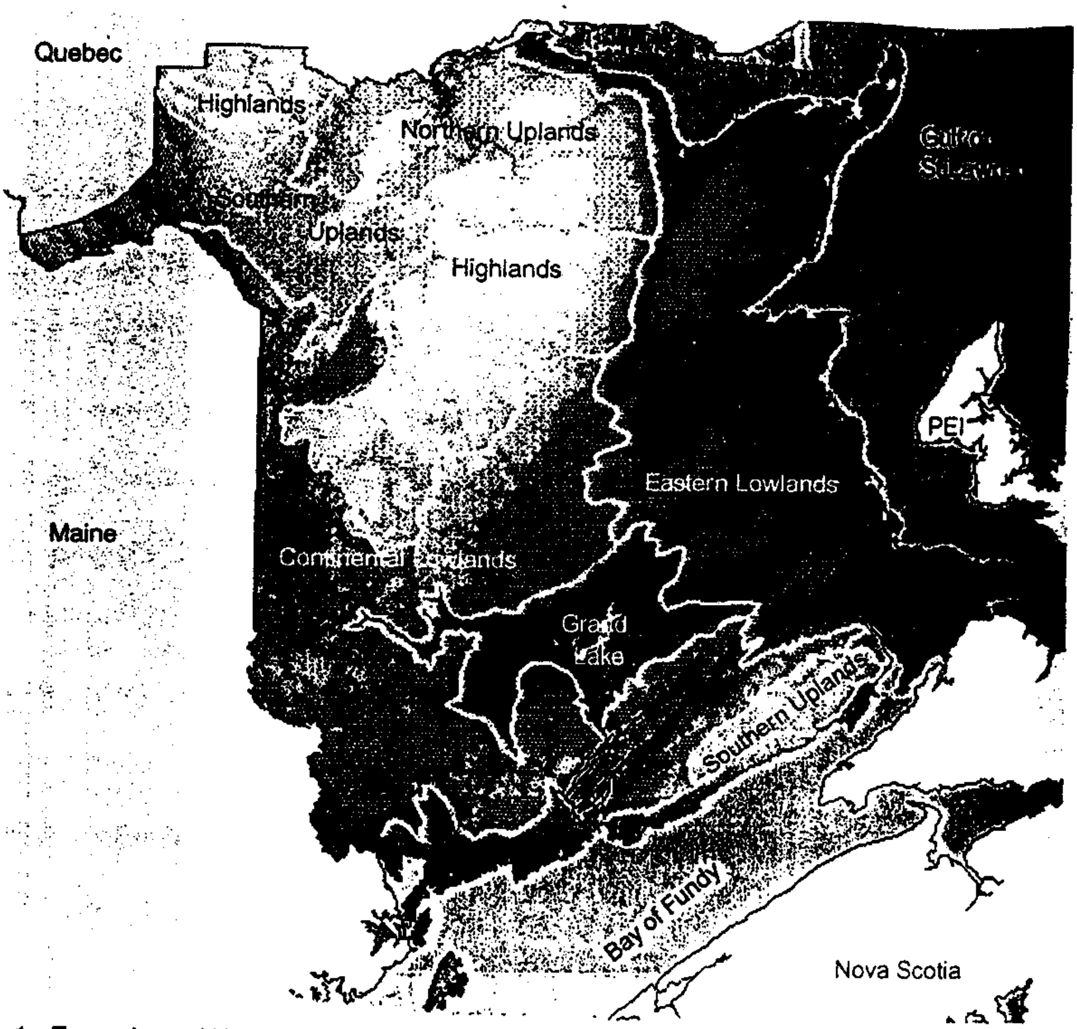

Figure 1. **Ecoregions of New Brunswick (from Ecological Land Classification Working Group 1996).**

Study Area History

The forests of New Brunswick were influenced by human activities before settlement by Europeans. The Paleo-Indians entered the Maritime region from the south and southwest approximately 11,000 years ago (Davis 1991). The degree of disturbance to the vegetation caused by inhabitants is indeterminate, but Davis (1991) suggests that the three most common tools found in the heavily forested Maritimes around the late Pre-Ceramic period were axes, adzes and gauges which were used to make canoes, wigwams, and hunting tools. As difficult as it is to trace the ecological impact thousands of years ago by the Native peoples, it was reported by early European missionaries and explorers that the greatest single disturbance was fire in the woodlands that were seasonally dry and readily susceptible to burning (Baird 1612; Denys 1672; Le Clercq 1691).

The first European settlement in New Brunswick was established by Sieur De Monts in 1604 on Saint Croix Island in Charlotte County, just east of Kings County (Hannay 1909). Several years later a small fort or encampment on an island in the Long Reach of the Saint John River called "Emenenic" by the French Captain Merveille was the first settlement in Kings County (Aiton 1967). No permanent settlements in New Brunswick of consequence were begun until 1765, two years after the Treaty of Paris was signed guaranteeing the British "Acadia". During that same year over 1,000,000 acres of land were granted to pre-Loyalists. From 1766-1782 over 140 land grants were registered with thousands more acres of new land being distributed. The Loyalist insurgence into what is now New Brunswick, but which at that time was still a part of Nova Scotia in the spring, summer and autumn of 1783 created an instant population seeking refuge. Because these new settlers were openly resentful at having to deal with Nova Scotia administration, political separation became a goal. Thus, in June of 1784 political independence was proclaimed and New Brunswick was established (Hannay 1909; MacNutt 1962). By the end of 1784 the choicest land along the Saint John and Kennebecasis River valleys were largely occupied. Throughout these early years there was some clearing on the intervale land along the said rivers. For every fifty acres of land received three had to be improved, "drain the same amount if the land was swampy, sustain three neat cattle if the land was wilderness, or dig a stone quarry if the land was rocky" (Fellows 1971). As the nineteenth century approached the promise of free land in exchange for security and survival was one that the new settler could not refuse. From 1784 to 1800 the population of New Brunswick had increased by approximately 20,000 people. In the early part of the nineteenth century population growth had surpassed most of the New England states for the same time period and was forecasted to continue (Journal of Legislative Assembly 1825).

Forest Harvesting In New Brunswick Before 1800

In New Brunswick, by mid-nineteenth century as settlement increased so did forest harvesting. Wynne (1981) examined early shipping records and suggested that in 1785 approximately one thousand tons of timber and over two million board feet of lumber left Bay of Fundy ports. Further, by 1800 exports of lumber and timber doubled. However, the reliability of these shipping records are questionable. Most of the early New Brunswick shipping records do not stipulate where the timber was cut, how is was brought to port or who the lumberman was. In turn, only speculation of the quantity of exported timber can be drawn from examination of the shipping records. There is no doubt, however, that as population of the province increased, so accordingly did forest harvesting. Usually pine and spruce were the genera of choice cut by the early lumberman as they were the most merchantable timber of the era. Only the tallest and most suitable white pine were used for masts. Wynne (1981) suggested that "masts" were over 50m in height and had a diameter of over 2m per tree. Even though the British navy used New Brunswick as a source for masts, exports rarely exceeded 2, 000 masts before 1805. Most likely, the greatest number of white pine trees were cut after the turn of the nineteenth century. Because there are not any suitable harvesting records, the quantitiy of white pine before1800 is unknown.

As settlement and forest clearance increased so the number of sawmills. Although the first sawmill in New Brunswick was built in 1696 at Fort Nashwaak, it was not until the late 1760's and early 1780's were any significant sawmills built (Defebaugh 1906). For example, in Charlotte County the number of sawmills increased from eight to twenty-three between 1785 and 1803 (Wynne 1981). In New Brunswick, by 1841 the number of sawmills had increased to over 570. Most of the early sawmills were located by rivers and streams and relied upon water to create energy necessary for production. It was not until 1822 and the introduction of the steam sawmill to New Brunswick gave operators new technology to cut more timber. Although the early sawmills were primitive in there construction, they did provide a means to saw lumber and gave pioneers a modest way of making a living.

The greatest weakness in the estimation of forest clearance in New Brunswick before 1800 is the lack of harvesting records. It was not until 1817 when the Department of Crown Lands instilled the "petition" and "license" policy. Each potential lumberman had to apply for a petition to cut a certain amount of timber. Upon reception of the petition, the lumberman would then apply for a license that outlined where and how much timber would be cut. This process guaranteed the Provincial Government a fee for the amount of timber to be cut and also kept a watchful eye on where the lumber was coming from. However, the actual amount of timber cut was not recorded. Thus, only speculation of forest harvesting can be examined before 1850.

METHODS

New Brunswick Pre-Settlement Surveys

The surveys of Kings County land grants were made between 1784 and 1900. The survey plans are in the Provincial Archives of New Brunswick in Fredericton. Generally, the New Brunswick surveys followed the earlier ones produced in the St. Lawrence River Basin, in that these prepared for the settlement along the banks of the most navigable river systems arranged in a northwesterly, southeastern direction, unlike the pattern of geometrically square township holdings (9.7km X 9.7km) adopted by the English colonies to the south (Thomson 1966).

All of the early deputy surveyors were Loyalists with military experience as engineers. They not only surveyed but held other jobs or positions and sometimes evaluated improvements, arbitrated minor disputes, supervised town settlements, verified old surveys, explored, mapped and reported on land (Thomson 1966; Fellows 1971). Most of Kings County was surveyed by seventeen men over a period of one hundred and thirty-five years including Daniel Micheau, Samuel Fairweather, Anson Williams and coming from. However, the actual amount of timber cut was not recorded. Thus, only speculation of forest harvesting can be examined before 1850.

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Nelson Arnold. Normally, both qualitative and quanitiative data were recorded by the surveyors. In order to mark the position of early settlers' land grant lines on the ground, surveyors "blazed" and marked "witness" or "tie" trees at the corners of each grant and recorded the species name for permanent boundaries. If a "witness" tree was absent from the specified corner, a wooden stake (made from a branch or sapling from a nearby tree) or a wooden stake and stones would suffice as the marker. Most surveyed farms plotted approximately 50-500 acres in size, rectangular in shape with the breadth usually one-third of their length and set side by side perpendicular to the river or stream. This way all settlers who were granted land had equal access to the much sought after fertile river land (Thomson 1966; Fellows 1971).

The amount of description varied considerably from one surveyor to the next. Some surveyors kept field notes or journals, however, if they did they are not available now. Only a few of the early Deputy Land Surveyor journals have survived over the past two centuries. Although some difficulty arose in translating the handwritten notes, they do give an interesting sidebar of information about lists of trees, changes in species composition, a marked distance at each landscape or landmark transformation, as well the areas of fire, blowdown, barren plains and the beginning and end of swamps and marshes. For example Deputy Surveyor Samuel Fairweather wrote in July 1831:

> For George W. Price 400 acres to cover a mill cite[sic] on Thorn's Brook. Chained by John Perry and Samuel C. Price.
> Began at a Cedar Post on Reserve Road S.W. Angle of Lot No. 6 3rd Tier.

	chs. lks	
thence North	34.00	Met a small Brook Westerly
	90.00	A great quantity of Pine Timber has been taken from this Section
	105.00	Good land begins and Heavy Timber
	130.00	descent ends
	179.00	Small Brook Easterly
	193.00	Blazed and marked a Poplar Tree
	255.00	Steep descent begins
	256.50	descent ends and Intervale soil
	260.00	Blazed and marked a large Elm Tree
thence West	2.00	Met Thorn's Brook Northerly
	4.00	steep descent begins
	6.00	descent ends and Burnt Land begins
	12.00	descending ground
	61.00	Blazed and marked a White Maple Tree

At the Provincial Archives in Fredericton 667 original, hand written survey notes which are stored in five volumes and two flatbooks (PANB RS 637 series, Vol. I-V Survey Plans and Vol. I-II Flatbooks, Kings County, New Brunswick) were consulted from the years 1765 to 1840. Approximately 85-90% of the survey notes used for this study were from 1785-1820, inclusively. Each witness tree was transcribed and recorded in its respective position on 1:24000 Department of Natural Resources and Energy cadastral maps. A tally was made of trees of each species. Witness trees and survey point locations were digitized using PC ARC/ INFO and intersected with the physical variables of the Ecological Land Classification System. Witness tree data represent the forest cover of circa 1800. Each witness tree recorded at a grant corner and along grant line was considered one sample point in the database.

Interpretation Of Species Names

Throughout many of the land survey records, there was some uncertainty in deciphering the surveyors' names for species and shrubs. Names listed together in Table 1 indicate ones treated as synonyms for the analyses. For example, "white pine", "yellow pine", "dry pine" and "green pine" were grouped as "pine". A number of monographs were consulted as to the historical usage of common names and for the range and habitat of potential species (Perley 1843; Springer 1851; Munro 1863; Bailey and Jack 1876; Leavitt 1933; Morton 1961; Hosie 1990; Burns and Honkala 1990). Latin nomenclature follows Laird (1995).

Surveyors frequently used the term "maple". They also used "rock maple", "sugar maple", and "hard maple" which are clearly references to *Acer saccarum*. Because of the distinct difference among the surveyors at the scale of the land grants in the use of "maple" versus "rock", "sugar" and "hard" it is obvious that much of the maple included *Acer saccarum*. Thus, for most analyses these four terms were treated with a single "maple" taxon.

Some confusion arose when surveyors mentioned "white" maple. An interpretation is that "white" maple (mentioned 199 times) could be either *Acer saccarinum* (silver maple) or *Acer rubrum* (red maple). Because most of the references to "white maple" were found in the most northeastern part of Kings County where *Acer saccarinum* is almost out of its range, and that *Acer rubrum* is found widely throughout New Brunswick, it is assumed that the surveyors meant "white maple" to be "red maple". "White maple" that is found in floodplain areas could be silver maple as it does not grow away from rivers and streams (Laird 1995). It is likely that "maple" included both *Acer rubrum* and *Acer saccarinum*, as well as *Acer saccarum*. One species of maple that can not be disputed is "moosewood" or "moose-maple" (mentioned 15 times by the surveyors) which is *Acer pennsylvanicum* commonly known today as striped maple.

Surveyors addressed the 618 occurences of "birch" either as "birch", "paper birch", "white birch", "yellow birch", or "black birch". "White birch" and "paper birch" are likely *Betula papyrifera*, or *Betula populifolia*, though some could also be called "wire birch". "Yellow birch" is no doubt *Betula alleghaniensis*, however, some confusion arose in the species identity of "black birch". Most likely "black birch" is *Betula alleghaniensis* since the bark of a very mature "yellow birch" becomes almost black and broken into flat plates, thus leading the surveyor to believe it is another species. The common reference to "birch" by the surveyors could be either *Betula papyrifera, B. alleghaniensis* or the less common *B. populifolia*, thus for most analyses "yellow birch", "white birch", "paper birch" and "black birch" were merged with "birch".

The pines were frequently not differentiated in the survey plans. Of the 144 references to "pine", ten were mentioned as "white pine", five were known as "yellow pine", four as "dry pine", three as "green pine" and the remaining 122 as "pine". The species "white pine", "yellow pine" and "green pine" were no doubt *Pinus strobus.* "Yellow pine" could be white pine but is also an alternate name for *Pinus resinosa.* It is clear that "dry pine" is "jack pine" or *Pinus banksiana* because of its dry, scrubby like appearance. For anaysis purposes, as it was unclear how many of the 122 "pine" were *Pinus strobus, P. resinosa* or *P. banksiana* all were merged with "pine".

Habitat was a clue to species identification in several other cases. Species of the genus *Picea*, commonly known as "spruce" were not differentiated by the surveyors. *Picea glauca, P. mariana* and *P. rubens* are all common in New Brunswick. Of these, *Picea mariana* would be most likely to be found in sphagnum bogs, on the margins and other lowlying areas and are often in pure stands; *Picea rubens* is usually found on well-drained loams, moist valleys, is often intermixed with other speces and does not occur as commonly in pure stands; *Picea glauca* frequently lives on well-drained moist soil, on the edge of swamps, is mixed with red and black spruce and can be found in pure stands in an area that is an artifact of abandoned fields or has a fire history (Burns and Honkala 1990). In New Brunswick, however, usually white spruce is not common in a natural condition. Because of shared characteristics by these three species, it is no wonder that surveyors used the term "spruce" to generalize the *Picea* genus. Since it was not known how many of the 757 "spruce" were *Picea glauca, P. mariana* or *P. rubens*, it is difficult to specify which species of spruce the surveyors referenced. In this study "spruce" represents the three spruce species found in Kings County. The ashes were also not differentiated often in the land survey records. On thirteen occasions surveyors recorded "black ash", while "white ash" was mentioned eight times. Since some surveyors distinguished "black" from "white" as witness trees, both species were probably included in "ash" along the land grant lines. In swampy areas surveyors would probably be referring to "black ash", while on fertile, upland, moderately well-drained soils, "white ash" would be more likely (Hosie 1990; Burns and Honkala 1990). Since it was unclear on how many of the remaining 207 "ash" were *Fraxinus nigra* or *F. americana* all were merged as "ash".

"Hornbeam" and "ironwood" apparently referred to *Ostrya virginiana* rather than *Carpinus caroliniana*, since both "ironwood" and "hornbeam" are sometimes mistakenly identified as "blue-beech" which is not presently found in New Brunswick. However, Moses Perley, a nineteenth century lumber agent who assisted American investors in his, "Descriptive and Statistical Account" of the New Brunswick forest describes what was sure to have been *Carpinus caroliniana.* The surveyors identified both "cherry" and "bilberry" trees. Most probably they were identifying "cherry" and "bilberry" as either *Prunus serotina* (black cherry), *P. pensylvanica* (pin cherry) or *P. virginiana* (choke cherry), all of which are common to New Brunswick. In this study "cherry" and "bilberry" will be merged as "cherry". The poplars were also not differentiated. Since it was unclear how many of the 168 "poplar" or "popple" were *Populus tremuloides*, *P. grandidentata* or *P. balsamifera*, all were merged with "poplar".

Table 1. Names of trees from the survey plans and the likely equivalent genera and species. Latin nomenclature follows Laird (1995).

Surveyors' Names	Likely Species	
Fir	*Abies*	*balsamea*
Maple	*Acer*	*rubrum, saccharum, saccharinum*
White maple	*Acer*	*rubrum, saccharinum*
Hard, Sugar, Rock maple	*Acer*	*saccharum*
Moosewood, Moose-maple	*Acer*	*pensylvanicum*
Alder	*Alnus*	*rugosa*
Birch	*Betula*	*papyrifera, alleghaniensis, populifolia*
Yellow, Black birch	*Betula*	*alleghaniensis*
White, Paper birch	*Betula*	*papyrifera, populifolia*
Beech	*Fagus*	*grandifolia*
Ash, White, Black	*Fraxinus*	*nigra, americana*
Butternut	*Juglans*	*cinerea*
Tamarack, Larch, Hackmatack	*Larix*	*laricina*
Ironwood, Hornbeam	*Ostrya*	*virginiana*
Spruce	*Picea*	*glauca, mariana, rubens*
Pine, Yellow, Green, White	*Pinus*	*banksiana, strobus, resinosa*
Yellow pine	*Pinus*	*resinosa, strobus*

Dry pine	*Pinus*	*banksiana*
Poplar, Popple	*Populus*	*balsamifera, grandidentata, tremuloides*
Cherry	*Prunus*	*pensylvanica, serotina, virginiana*
Oak	*Quercus*	*rubra*
Willow	*Salix*	
Cedar	*Thuja*	*occidentalis*
Hemlock	*Tsuga*	*canadensis*
Elm	*Ulmus*	*americana*

Evaluating Pre-Settlement Surveyor Bias

Frequently, questions are asked to determine possible bias of tree selection. For example: 1) Do surveyors show a certain bias towards a certain species in the selection of witness trees? and 2) Do the surveyors have the ability to identify a tree on a genus level correctly? Since the surveyors recorded a large amount of the indigenous species of New Brunswick as witness trees (Table 1) and the recognition of the somewhat uncommon types of trees argues that the surveyors were more than competent in their working knowledge of the many genera of New Brunswick. It was also no coincidence that Surveyor General George Sproule had hired former Loyalist military engineers whose ability, experience and reputation were highly regarded.

There have been some suggestions that surveyors preferred a particular tree species. Lutz (1930) remarked that surveyors may have marked gum, oak and sugar maple before choosing other species. In southwestern New York, Gordon (1940) proposed that beech was the preferred tree species, while in Michigan, Bourdo (1956) argued that medium-sized trees are used more frequently. However, New Brunswick land survey records were not based on the size of the tree or a certain type of tree, the trees that were recorded by the deputy surveyors represented corners where the boundaries of other Loyalist settlers' land. can not be applied to the data of the New Brunswick surveys considered here. Other American studies suggest significant bias in witness tree selection has not been found in other surveys (Kenoyer 1930; Bourdo 1956; McIntosh 1962; Siccama 1971; Delcourt and Delcourt 1974, Delcourt 1976, Delcourt and Delcourt 1977, Lorimer 1977, and Frelich et al 1991). Therefore, it is assumed that to reconstruct forest composition and distribution, land survey records may be used and that they provide a representative picture of the forest cover of the pre-European settlement Kings County, New Brunswick.

The basic assumption in utilizing land survey records to reconstruct forest composition and distribution is that they constitute a representative sample of the forest cover of the pre-European settled forest and that bias in the species selection was not significant (Curtis 1959; Barber 1976). Bourdo (1956) suggests some problems with surveyor bias in the General Land Office surveys in the United States. Bourdo's (1956) method relies upon readily reidentified points and the rectilinear survey method based on the computation of the mean distance from the corner posts to the witness trees of each dominating species within a given forest community. Bourdo (1956) also proposes that size, longevity, bark characterisics and suitability for cutting may have influenced the surveyor. Because the colonial New Brunswick and the General Land Office surveys differed significantly, the techniques for determining bias proposed by Bourdo (1956) are not readily applicable to data from New Brunswick surveys. Unlike the General Land Office surveyors who marked a witness tree, estimated its height and measured its d.b.h. at each quarter mile or mile and rated the soil and tree species on a prescribed scale, the deputy land surveyors of New Brunswick normally recorded one witness tree at each grant corner, each of whose location was set in a different compass quadrant. Also, the compass bearing, distance from the corner and occasional line trees were noted. Furthermore, the New Brunswick surveys were made on private lands and were of various sizes, usually between 50 and 500 acres, the General Land Office surveys were set in a grid pattern of townships 9.66 km. square, with each township subdivided into thirty-six sections. Unfortunately, few colonial New Brunswick witness trees can be relocated on which Bourdo's (1956) test could be based for his statistical analysis. Although it is likely that there could be some bias in selecting the corner witness trees, it is expected that there would be much less bias in the case of line trees because no information was gleaned or inscribed on the tree. It is assumed that surveyor bias was not a significant factor because of a circular distributed in June of 1785 by Surveyor General George Sproule describing, "General Instructions to be Observed by Deputy Surveyors". Sproule warned the twenty-seven new surveyors that:

> You are to certify the nature and quality and produce of the land you survey or passover and the growth and quality of the timber...and that you will be very attentive to establish sufficient and permanent boundaries in your several surveys...and careful to fix permanent bounds at the beginning or junction of each lot on the base line and describe the same upon the plan you return to this office ranging the sidelines of the lots by two marked trees or other durable marks...and you must be particularly careful that the instrument you use in all surveys is correct and true (Sproule 1785).

New Brunswick Forest Development Surveys

The forest development surveys (FDS) of New Brunswick were carried out in 1986 and 1993 to aid provincial foresters to project forest development. Relatively homogeneous stands were delineated on 1:12500 colour aerial photographs. Randomly selected stands were sampled.

Generally, the FDS were completed by field parties consisting of two-person crews; one cruiser and one cruiser assistant. The two-person crew followed strict procedures when determining and measuring each FDS. Stands selected to be cruised were delineated from aerial photographs and included the entire range of classification elements. For example, types of forest conditions, species composition, crown closure and developmental stages were considered when determining FDS plots. Cruise lines were outlined on aerial photographs and subsequently traversed on the ground. The starting point of each cruise line was flagged. At fifty metre intervals (100 m in large stands), a sample point was marked. Usually, cruise lines included five sample points. At each sample point, a prism was used to determine which tree would be measured (in trees). Small trees would only be included if they were close to plot centre. Upon completion of marking the sample points, a prism plot was completed at each sample point. Age, height and the diametre at breast height were measured for "in" trees. Also, at each prism plot all "in" trees were recorded by species, grade and age class. Tree quality with respect to tree ages and stand maturity by species was classified according to New Brunswick Department of Natural Resources and Energy FDS Classification System (1985). All information recorded in the field was transferred to a computer file tape. For more detailed procedural guidelines of prism use, classification system, d.b.h., height and age measurement see New Brunswick FDS Field Manual (1987).

At the Department of Natural Resources and Energy in Fredericton, 958 FDS sample points or cruise lines from 1986 and 1993 were consulted. Each FDS line was isolated and the data was averaged over sample points to give mean percentage by species was calculated with respect to density (stems/ha), volume (m3/ha) and basal area (BAF 2) for each line. Each FDS line was intersected with Ecological Land Classification System data and the combination of the two criteria represented the forest cover type of circa 1993. All FDS lines were considered one sample point and were determined to be an individual sample.

Forest Development Survey Analysis

The data sources representing circa 1800 and the present are fundamentally different. The pre-settlement land surveys were based on individual trees, while the present day data were fixed percentages of species at points on a cruise line. Yet, this study considered comparisons between the two to be possible. Three FDS measures were used to compare with the pre-settlement land survey data. Density, basal area and volume per hectare were examined. Basal area per hectare was considered to be the measure that is most comparible to the colonial surveys for several reasons. First, density was calculated as the number of stems per hectare. The number of stems is a poor measure of the number of mature trees in a stand because of self-thinning. There is a species bias because some species, for example, balsam fir commonly constitute a dense understory whereas others do not. Small understory trees would not have been used as witness trees but could constitute a significant proportion of a cruise plot. Second, volume (m3) was calculated only for tree species that had a d.b.h. greater than 9cm. Most likely nothing less than 9cm. would have been used for witness trees, as the surveyors needed a secure "tie" tree. If one compares this with density, an opposite effect would occur. Rather than overestimate the number of stems per hectare (density) of small trees of particular species, volume would only single out larger trees and overestimate the volume of certain species while underestimating others. For example, if in a prism plot two, 25cm spruce trees were found while none of the other spruce trees were registered, the volume calulated for those two, 25cm trees would show an inaccurate herbacious layer. Thus, the outcome of volume calculated per hectare would be biased and would not be a good measure for comparing species composition over the past two hundred years. Three, basal area serves as the most logical means to measure species composition change versus the pre-settlement surveys. Basal area includes all species within the prism plot and does not bias for small or large trees. In turn, basal area is a good relative indicator of biomass of all areas measured and does not overestimate the density and volume of smaller and larger trees, respectively.

Evaluating Forest Development Survey Bias

Often, questions are asked to determine possible of tree selections. For example, 1) Are the Forest Development Surveys weighted toward recording softwood species? and 2) Are the number of cruise lines in proportions to the type of species that exist? Data and area summaries were calculated and showed that there was a small bias toward softwood species, however, it was not significant. For example, these summaries determined the size and the number of samples taken in a specific area. Whereupon, the number of sample is compared to the size of the area and have shown that the number of samples are proportionate to what type of species are located in the area. Usually, there is some bias towards softwood species if the licensee has favoured softwood species that are merchantable. However, most data and area summaries have discovered that the likelyhood of a softwood species bias is very small and is not significant.

ECOLOGICAL LAND CLASSIFICATION DEFINITIONS

Levels

In order to determine predictors of plant community association and composition climate, topography, soil and natural disturbances such as fire, wind and insect epidemics the Ecological Land Classification of New Brunswick (ECL) was derived. In New Brunswick, forests occur on a unique combination of climate, soil fertility, elevation, moisture and slope and are represented by six levels. The first level of relevance to this study is ecoregion. There are seven ecoregions in the province. This level is determined by elevation, broad-scale aspect and proximity to the oceans as these affect the maritime climatic influence. The second level is ecodistricts. Thirty-four ecodistricts are found in New Brunswick. Ecodistricts are derived by elevation, slope, aspect, terrain features and the basis of rock formations of uniformity and age. Vegetation patterns are correlated with climatic influences. The third level is ecosite which represents a coarser resolution. Twenty-six ecosites are found throughout New Brunswick. This level is determined by a combination of broad landforms, local climate and the underlying bedrock. Soil lithology is used as a tool to show the variation of vegetation. Kings County has parts of three ecoregions, ten ecodistricts and twenty-six ecosites. Within each ecodistrict different definitions of ecosites exist. For example, in ecodistricts 29 and 12, both might have ecosite 2 assigned to it, however, the definitions of each individual ecosite in each ecodistrict is different. The use of ecosite as a tool is very important. Not only does it clearly separate plant communities and stand types, but it filters out differences between stand types. For example, there could be two red spruce stands, one on a plateau and one in a valley. Both stands look the same by species composition, however, on a landscape level both could be very different in terms of soil, elevation, drainage, understory and overstory species composition. Since an ecosites are defined differently from one another, these two red spruce stands could be classified as "red spruce" stands, but if they were looked upon as ecosites, they would probably differ. In turn, ecosites are used in this study because they unite the many components found in a landscape and are the best measure of plant communities. Because this study is a vegetation-site reconstruction the use of ecosite as a stratification variable for comparison of the pre-settlement and present land surveys would be the most logical. As a result, a detailed methodology for determining ecosite classification is included in this section. Moreover, the task of analyzing the methodology of ecoregion and ecodistrict construction is beyond the scope of this study. For more on the methodology to determine ecoregions and ecodistricts see Ecosystem Classification Working Group (1996).

Ecosite Methodology

At the Department of Natural Resources and Energy, four layers from the geographical information system (GIS) were intersected to provide information on the physical variables of every forest stand in New Brunswick. By combining the existing Ecological Land Classification that contains ecoregions, ecodistricts and ecosections, the ecodistrict layer was used as the upper level to act as a surrogate for climate and disturbance regime. Soil and drainage were obtained from the digital form of the Forest Soils of New Brunswick while elevation and slope classes were obtained from Digital Terrain Mapping. Also, vegetation percent cover of major tree species were derived from the digitized layer of interpreted aerial photos (1:25000). These four layers were used in the delineation process.

Fifty forest soil units, ten slope classes based on percent slope, seven drainage and forty 20m elevation classes were used. Forest stands were grouped into eight forest communities and represented broad coniferous, mixed-wood and deciduous types. Early successional forest stands that were a reflection of human caused disturbance were removed from the dataset.

Percentage summaries of forest communities by soil unit, elevation, drainage and slope classes per ecodistrict were generated. For example, in the Anagance or ecodistrict 29 at elevation class 19 (380m ASL), 33% of the stands are spruce-balsam fir, 32 % are tolerant hardwood-mixed-wood, 15 % are tolerant hardwood and 11 % are pine-jack pine. Trends of increasing and decreasing percentages of certain stand types with increasing and decreasing elevation could be readily detected. Elevation classes were grouped into elevation "groupings" depending on striking differences in occurences of certain stand types at particular elevation "breaks". For example, in the above ecodistrict, tolerant hardwoods almost disappear at 240m ASL whereas spruce-balsam fir stands markedly increase. This is an elevation break and elevation classes above 240m are grouped into a elevation grouping. The same procedure was carried out for the other three variables. All four physical variables are joined together to become the ecosite. For example, all areas that are well-drained (drainage classes 1-2), moderate to rich fertility (a grouping of high fertile soil units), steeply sloping (above slope class 8) and above 240m forms an ecosite.

An edatopic grid was used as a setting for naming the ecosites (Fig. e. grid). The combination of soil fertility, soil drainage, slope and slope position was assigned to a particular position on the grid. For example, wet, poor sites are always named "3", while dry, moderately rich sites are "9". Letter codes were given to ecosites that were not covered under this system (Table 3).

Table 3. Nutrient and moisture regime edatopic grid

Letter Code	Definition
m	mining debris
s	steeply sloping
h	high elevation
c	calcareous soils
l	limestone soils
b	bog/bottomland
t	coastal marsh

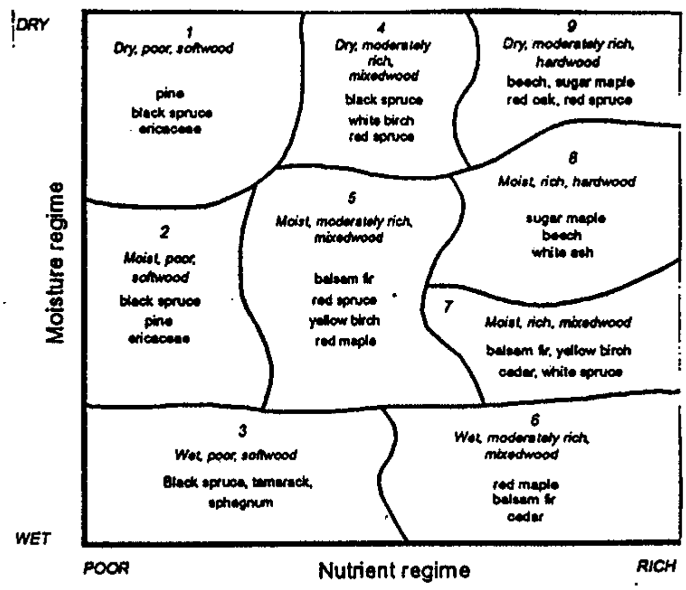


Fig. 2. Nutrient and moisture regime edatopic grid.

Ecosite Definitions

Parts of three ecoregions, ten ecodistricts and twenty-five ecosites fell within the boundaries of Kings County Table 3 defines each ecosite per ecoregion and ecodistrict in Kings County. Because each ecoregion contains various ecosites that differ in terms of soil, drainage, elevation and species type each ecoregion is considered mutually exclusive from one another and analyzed accordingly. For example, ecoregion 3 has ecosites 2, 3, 4, 5, 6, 7, 8 and 9. These ecosites have different characteristics than those of the same ecosite number in ecoregion 4 or ecoregion 5 (Table 3). The percent change per genus level from ca. 1800 to ca. 1993 was calculated per ecosite. Data comparison was at the genus level because during the Loyalist period several common names were often used for more than one species.

Table 3. Definitions of each ecosite per ecoregion and ecodistrict

Ecoregion	Ecodistrict/s	Ecosite Definition
3	12	2. Transitional conifer on moist acidic, ablation 3. Transitional conifer plateau on wet, acidic soil 4. Transitional mixedwood on dry, steep valley slopes 5. Transtional mixedwood slopes on moist, acidic soil 8. Transitional hardwood ridges on moist, acidic soil 9. Transitional hardwood ridges on dry, steep slopes
4	32	2. Coastal conifer on moist, acidic soil 3. Coastal conifer plateau on wet, acidic soil 3b. Coastal bog 4. Coastal conifer steep slopes on dry, acidic soil 5. Coastal conifer slopes on moist, acidic soil 7. Coastal mixedwood ridges on acidic soil
5	16, 25, 26, 28, 29, 30, 31, 32, 33, 34	1. Acadian conifer on acidic ablation 2. Acadian conifer gentle slopes on moist, acidic soil 3. Acadian conifer plateau on wet, acidic soil 3b. Acadian continental bog 4. Acadian mixedwood slopes on dry, acidic soil

5. Acadian mixedwood on moist, acidic soil
6. Acadian conifer slopes on wet, acidic soil
6b. Acadian wet bottomland
7. Acadian mixedwood slopes on moist, soil
7b. Acadian bottomland
7c. Acadian mixedwood slopes on moist, calcareous soil
8. Acadian hardwood ridge on moist, acidic soil
9. Acadian hardwood ridge on dry, acidic soil

RESULTS

A total of 3881 witness trees were recorded in 667 original pre-settlement land survey records. A total of 958 forest development surveys were obtained from the New Brunswick Department of Natural Resources and Energy and represented present forest conditions in Kings County.

Aggregates were calculated to determine the frequency distribution of species and genus levels for pre-settlement and present day surveys. The results are presented graphically in Figures 3-5, for each genus that made up more than 5% of the total composition of the pre-settlement or present day ecoregions of Kings County. The percentages of individual species and genera per ecosite can be found in Appendix I.

In Kings County, New Brunswick, over the past two hundred years there has been a shift in species composition away from the late successional species. In the three ecoregions, the percentage of shade intolerant species, such as white birch, poplar and red maple has increased. The percentage of balsam fir has increased in all ecoregions since 1800 and today it is the dominant species in ecoregion 5. Spruce spp. has remained the dominant species in ecoregions 3 and 4, while co-dominant in ecoregion 5. On hardwood ridges in ecoregions 3 and 4, the percentage of beech, yellow birch and sugar maple have either change very little or increased. In ecoregion 5, on harwood ridges, the percentage of beech, yellow birch and sugar maple have decreased and have been replaced with a spruce and balsam fir forest. In ecoregions 4 and 5, cedar has decreased. In ecoregions 3 and 4, hemlock has increased, while in ecoregion 5, along with ash and tamarack has decreased.

Ecoregion 3--Southern Uplands

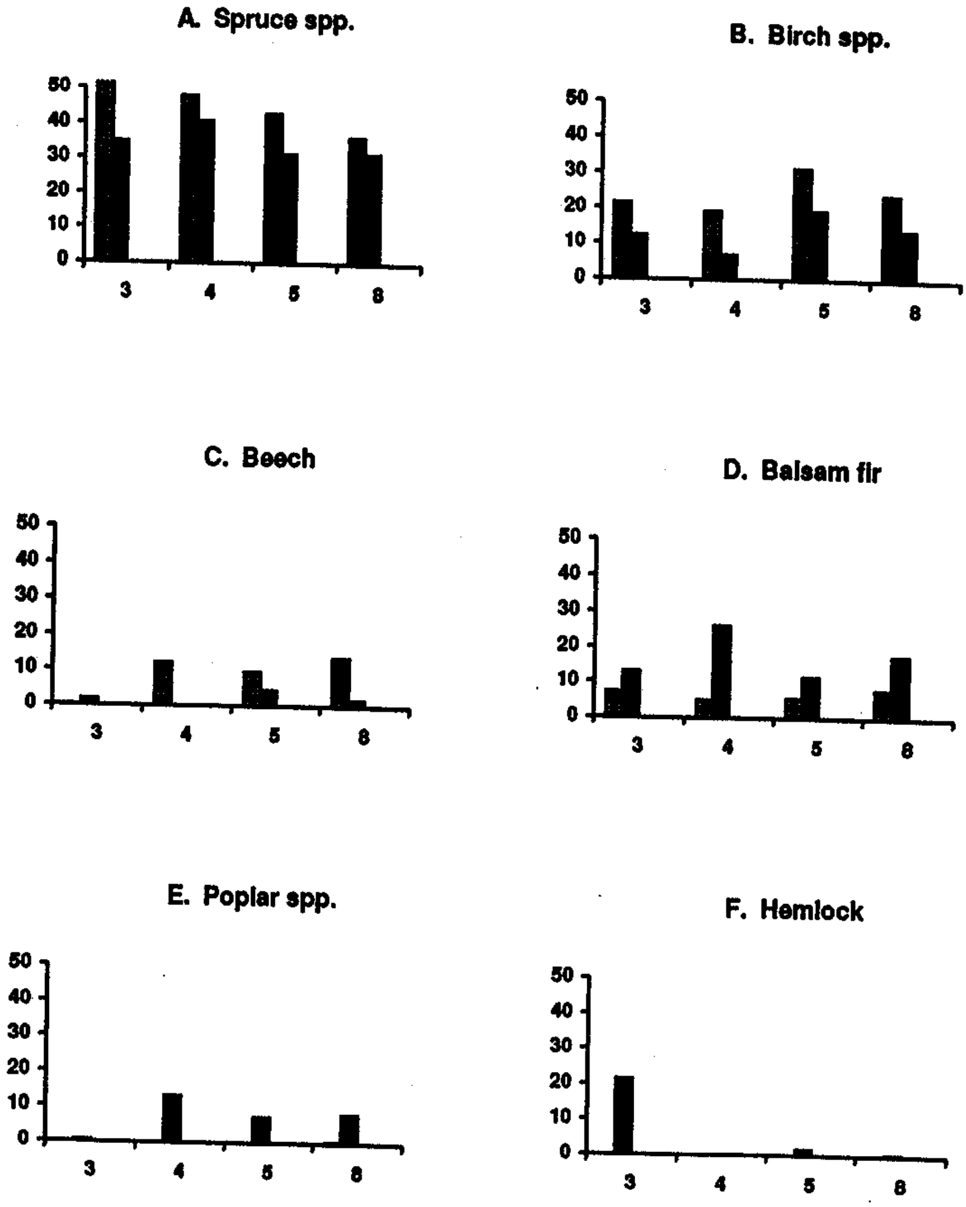
The percentage of pre-settlement land surveys completed in ecoregion 3 comprised 11% of the total number of trees found in Kings County. The percentage of forest development surveys completed were 8% of the cruise lines found in present day Kings County (Table 4). It is assumed that this constitutes a representative sample of each species in both pre-settlement and present day forests. Present day data is lacking for ecosites 2 or 9; therefore, the percent change in species composition cannot be estimated for those areas. Four ecosites were used for analysis purposes (Table 4).

Table 4. The number of witness trees and FDS cruise lines per ecoregion and ecosite circa 1800 and 1993.

Ecoregion	Ecosite	# of Witness Trees	# of FDS Cruise Lines
3	2	27	--
	3	14	3
	4	42	4
	5	73	13
	8	279	56
	9	11	--
4	2	12	1
	3	13	1

	3b	4	--
	4	11	8
	5	35	3
	7	17	2
5	1	97	20
	2	312	68
	3	182	21
	3b	22	7
	4	376	154
	5	1167	294
	6	108	12
	6b	52	7
	7	381	122
	7b	1	1
	7c	152	36
	8	321	80
	9	172	45
Totals	--	3381	958

Over the past two centuries percentage of spruce spp. and birch spp. in ecoregion 3 have decreased in each ecosite (Figs. 3A and 3B). Birch showed the most drastic decline as the percentage dropped on average 10% per ecosite. The percentage of beech declined in ecosites 4, 5 and 8, while only increasing in ecosite 3 (Fig. 3C). In ecosite 8, beech declined by over 16%. On the other hand, the percentage per ecosite for balsam fir and poplar increased (Figs. 3D and 3E). In ecosite 4, both balsam fir and poplar increased the most: 21.1% and 13.1%, respectively. Hemlock increased in all ecosites except in ecosite 8 where no change was measured (Fig. 3F). In ecosite 3, hemlock increased by over 21%. The percentage of maple spp., increased in ecosites 3 and 5, while it decreased in ecosites 4 and 8 (Fig. 3G).



G. Maple spp.

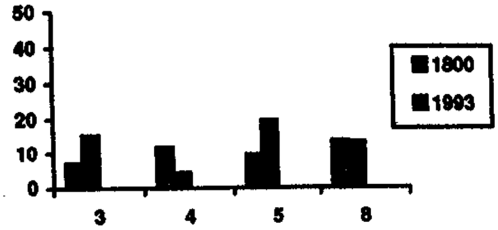
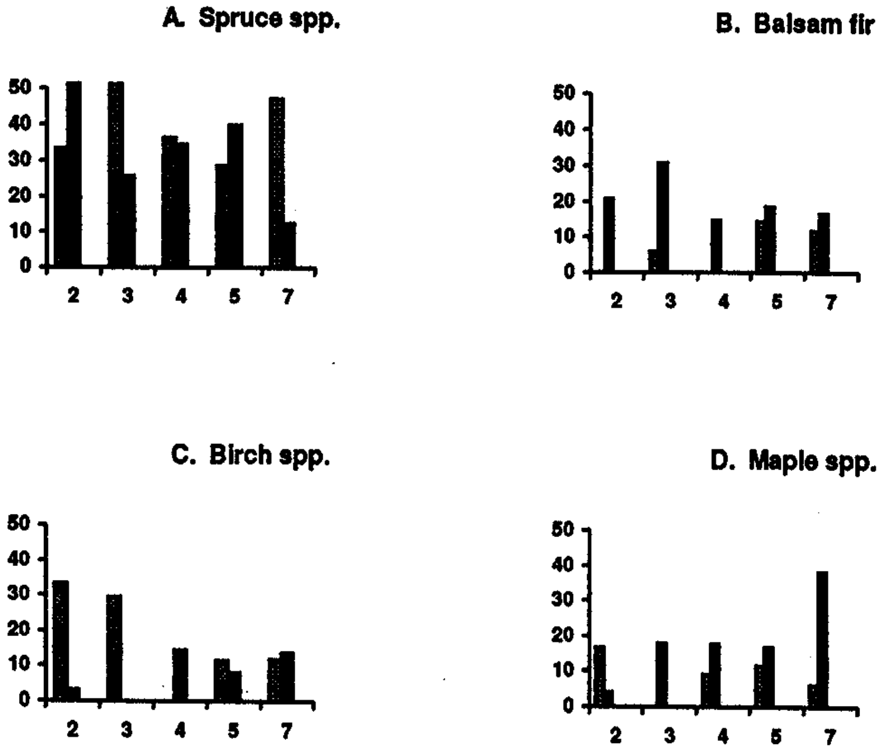


Figure 3. A comparison of pre-settlement and present day frequency circa 1800 versus 1993 in Southern Uplands Ecoregion in Kings County, New Brunswick; x-axis = ecosite; and y-axis = percent.

Ecoregion 4–Fundy Coastal

In the Fundy Coastal ecoregion only 2% of the witness trees and 1.5% of the forest development surveys were taken in this part of Kings County (Table 4). Although the percentages represent a very minor component of the whole county, the data can yield an idea of the change in species composition for a small land base.

From circa 1800 to 1993, the percentage of spruce spp., increased over 30% in ecosite 2, but decreased in all other ecosites (Fig. 4A). In ecosites 2 and 3, balsam fir increased over 20% and 30%, respectively (Fig. 4B). Also, balsam fir increased in ecosites 4 and 5, but decreased 5% in ecosite 7. Birch spp., almost disappeared in ecosites 2, 3 and 5 while they increased in ecosites 4 and 7 (Fig. 4C). The percentage of maple spp., dramatically increased by 18% and 32% in ecosites 2 and 7, respectively. In all other ecosites, maple percentage decreased (Fig. 4D). The percentage of poplar increased in all ecosites except ecosite 2, where there was no measurable change (Fig. 4E). Cedar has disappeared from ecosites 2, 3 and 7 and is all but gone in ecosite 4 and 5, where two hundred years ago it made up almost 20% of ecoregion 4 (Fig. 4F).



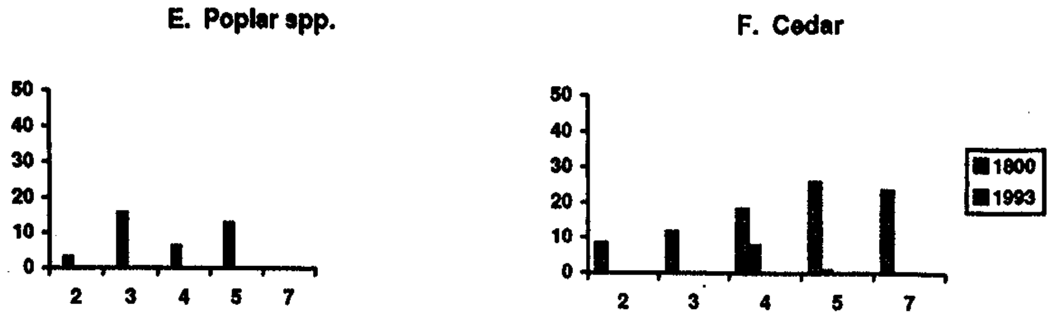


Figure 4. A comparison of pre-settlement and present day frequency circa 1800 versus 1993 in Fundy Coastal Ecoregion in Kings County, New Brunswick; x-axis = ecosite; and y-axis = percent.

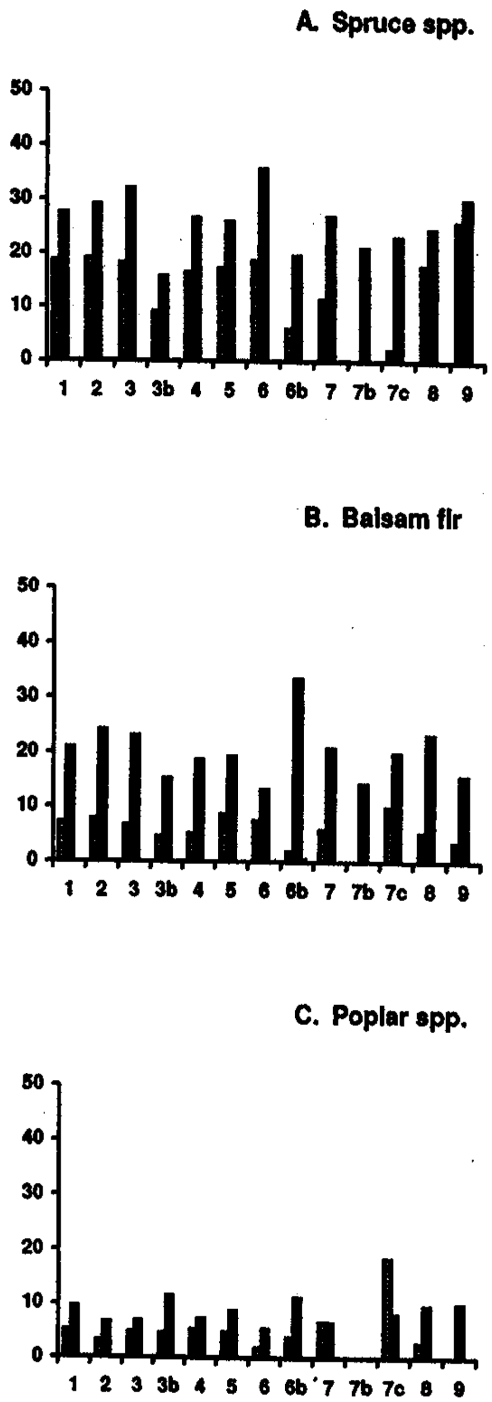
Ecoregion 5--Continental Lowlands

In the Continental Lowland region both pre-settlement and present day data comprised over 85% of the total data collected (Table 4). Thirteen ecosites were used for analyses purposes (Table 4). Species that did not make up over 5% of the species composition in ecoregions 3 and 4 were addressed in this section. For example, ash spp. and eastern larch did not make up 5% of ecoregions 3 and 4 to faciltate any analysis, but did in ecoregion 5. As a result, these species were examined in this section.

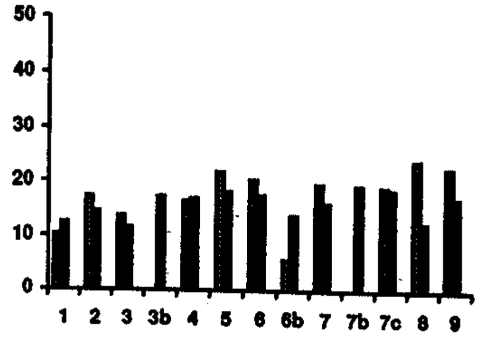
In the last two hundred years in ecoregion 5, the percent of spruce spp., increased in every ecosite (Fig. 5A). In ecosite 7c, spruce increased by over 20%. The percentage of balsam fir increased at least 10% per ecosite, except in ecosite 6 where it increased by only 6% (Fig. 5B). Poplar increased in all but two ecosites (Fig. 5C). The most dramatic change occurred in ecosites 6b and 9 where poplar increased by 7% and 10%, respectively.

Over the past two hundred years, the percentage of maple spp., birch spp. and beech generally changed in the same direction in any given ecosite (Figs. 5D, 5E and 5F). The three genera decreased in ecosites 2, 5, 7c, 8 and 9; the last two ecosites being mostly composed of acadian, hardwood ridges (Table 3). In ecosites 8 and 9, beech decreased the most, declining more than 10% per ecosite. In ecosites 3b, 6b and 7b all three genera increased. Maple and birch increased in ecosite 1, while beech decreased. Maple and beech increased in ecosite 7 while birch decreased. In ecosite 4, the percentage of maple increased while birch and beech decreased. Beech and maple decreased, while birch increased in ecosite 6. Finally, maple and birch decreased in ecosite 3 as beech increased.

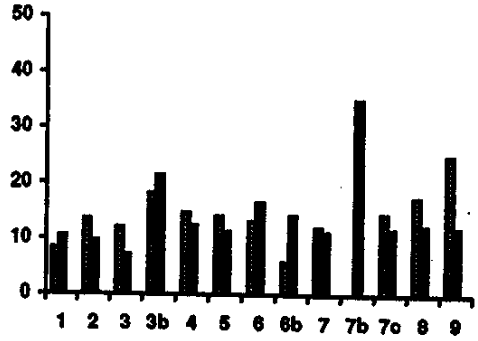
Percentages of cedar, tamarack, hemlock and ash spp., declined in most ecosites. Cedar decreased in all but two ecosites with almost a 30% drop in ecosite 6b (Fig. 5G). Tamarack dwindled in every ecosite except 6b, where it increased (Fig. 5H). Most significant was a decline of 11% in ecosite 3b. Hemlock decreased in all ecosites except 7b, where it increased by only 4%. Ash spp., showed the most dramatic decrease as percentage declined in every ecosite (Fig. 5I). In ecosites 3b, 6b and 7b it dropped by over 20% in each ecosite.


A. Spruce spp.
50
40
30
20
10
0
1 2 3 3b 4 5 6 6b 7 7b 7c 8 9
B. Balsam fir
50
40
30
20
10
0
1 2 3 3b 4 5 6 6b 7 7b 7c 8 9
C. Poplar spp.
50
40
30
20
10
0
1 2 3 3b 4 5 6 6b 7 7b 7c 8 9

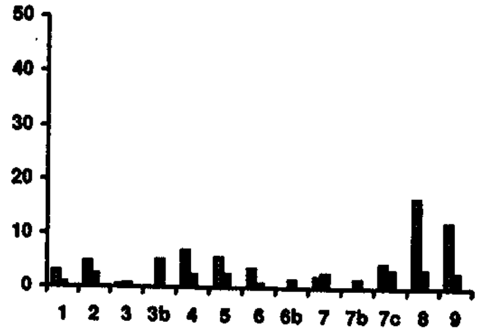
D. Maple spp.



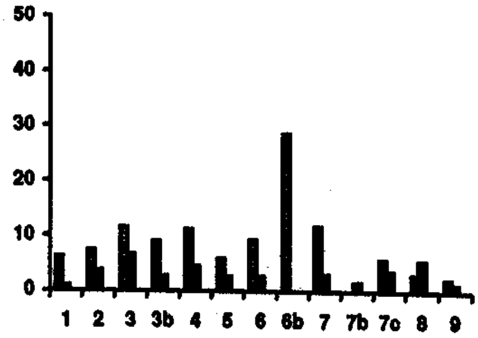
E. Birch spp.



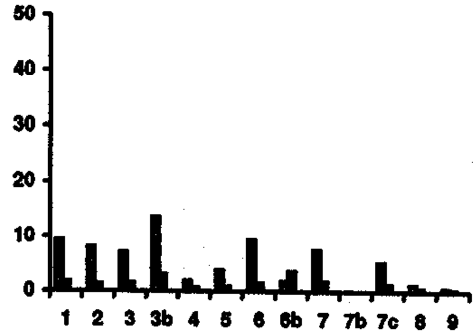
F. Beech



G. Cedar



H. Tamarack



I. Ash spp.

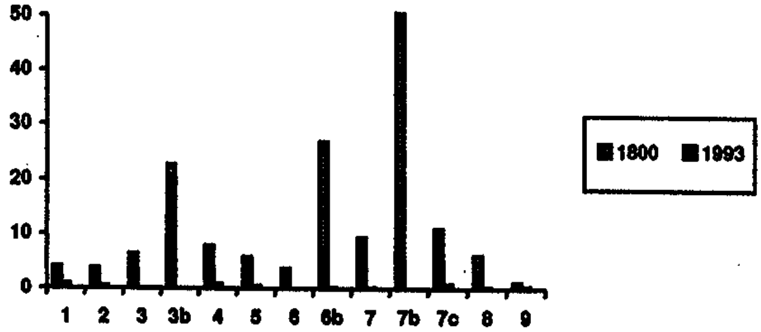


Figure 5. A comparison of pre-settlement and present day frequency circa 1800 versus 1993 in Continental Lowlands Ecoregion in Kings County, New Brunswick; x-axis = ecosite; and y-axis = percent.

DISCUSSION

In all three ecoregions, the Deputy Surveyors of the pre-settlement era did not distinguish the species types when referring to spruce, birch, maple, poplar, pine and ash. However, late successional species, in particular, commonly occur in predictable associations and grow in somewhat specific environmental conditions. Using knowledge of species associations and environmental conditions (ecosite descriptions) the "most likely" species can be determined in many cases.

In Kings County, the Deputy Surveyors did not distinguish between the three spruce species. Most likely in Southern Uplands, Fundy Coastal and Continental Lowlands Ecoregions red spruce is the primary spruce species (Rowe 1959; Loucks 1962). However, in poorly drained, on moist acidic soils could dominate (Laird 1995). Also, on abandoned fields or disturbed areas, white spruce, an old-field conifer, could dominate (Laird 1995). Usually, on Acadian mixedwood and hardwood ridges, slopes or plateaus, red spruce in association with beech, sugar maple and yellow birch is likely to occur (Rowe 1959; Loucks 1962; Laird 1995).

Over the past two hundred years, in Ecoregions 3 and 4, the percentage of spruce has decreased. On the other hand, in the same ecoregions, the percentage of balsam fir has increased 10% and 15%, respectively. In Ecoregion 5, spruce spp. and balsam fir have increased in every ecosite and today make up over 45% of the total species composition compared to only 18% two hundred years age. In terms of species composition change since pre-settlement times the major question is: Why has the percentage of spruce spp. and balsam fir changed so much in all ecoregions in the past two hundred years? Several important answers and conclusions can be drawn from data analysis: (1) Disturbance has played key role in the increase of spruce spp. as the major species in Kings County. Most likely, early settlers or industrial forestry are the catalysts for the increase in spruce spp. In late 1700's and early 1800's land along the Long Reach of the Saint John River and Bellisle Bay through to the Millstream, Smith Creek, Kennebecasis, Anagance Hammond Rivers was settled. As a result, land near most rivers systems in Kings County were cleared for agricultural, fuelwood, fences, buildings and sawmill purposes. Because white spruce is the usual old-field conifer, the increase of spruce spp. in most ecosites in Ecoregion 5 suggests land abandonment was evident. Also, in Ecoregion 3, (ecosites 3, 4, 5 and 7) where there is an increase in percentage of balsam fir, it is likely disturbance played an important role in altering the species composition. By mid to late 1800's New Brunswick was well established as a world timber trader. In turn, due to the demand of softwood lumber, it would have to be harvested farther and farther inland until the decline of merchantable species was immanent. By cutting pulpwood species, gaps are created from tens to thousands of hectares leaving prime space for spruce spp. and balsam fir to regenerate. In Ecoregion 5, on acadian mixedwood and hardwood ridges, which were probably inaccessible to early settlers were mostly untouched (ecosites 7c, 8, 9). Over the past two hundred years, due to advances in forestry machinery, the once dominant shade tolerant hardwood species were cut and replaced by a spruce-fir forest. In those same ecosites, spruce spp. has increased by 30%, 25% and 16%, while the shade tolerant hardwoods have decreased by 5%, 51% and 48%, respectively. This suggests that the once thought inaccessible ecosites were heavily disturbed; (2) In New Brunswick, industrial forestry companies have promoted the use of plantations for regeneration of softwood species such as black, and white spruce; and jack pine. Because approximately 95% of Kings County is owned by private interests, however, today there are very few plantations of any significance and would cast doubt on any species composition change by way of plantations; (3) Although it is very difficult to estimate windthrow, insect epidemic and fire regimes, these natural disturbances cannot be ruled out. It is thought that in New Brunswick, the cycle of windthrow is in excess of 1000 years (Methven and Kendrick 1995). Despite, strong winds that cleared 15, 413 ha in two days of the autumn of

1994 in central New Brunswick, damage by wind usually occurs at a local level (Methven and Kendrick 1995). Since 1760, there have been six outbreaks of spruce budworm epidemics. Blais (1983) found that the cycle was approximately 40-70 years before 1900 and 19-35 years after 1900. Blais (1983) suugests that there is a direct correlation between the size and rate of disturbance with the increase of the cycle of the spruce budworm. As more areas were disturbed by humans, the chance of attack by the spruce budworm was greater and occured more often. By the 1940's and 1950's forestry agencies suppressed the spruce budworm by spraying insecticides. Rather than letting the budworm complete its cycle, suppression led to longevity in spruce-fir stands allowing the species to regenerate over a larger area which led to a greater percentage of spruce and fir in Kings County. In the Continental Lowland Ecoregion, spruce spp. has almost doubled in percentage with an increase apparent in each ecosite. Not only does spruce spp. and balsam fir dominate acadian conifer ecosite, but acadian mixedwood and hardwood ridges. There is no doubt that if industrial forestry continues to manage for softwood pulp species, shade tolerant hardwoods will continue to decline and an increase in the spruce-fir forest will occur over the next fifty years.

In all ecoregions, the Deputy Surveyors did not differentiate between birch spp., maple spp. and poplar spp. White birch and red maple are most likely to be found in transitional, coastal and Acadian confier and mixedwood ecosites on either moist or dry, acidic soils in association with balsam fir and poplar spp. (Rowe 1959; Loucks 1962; E. C. L. Working Group 1996). Along with white birch, red maple and poplar spp. are primarily early successional species, will grow in most conditions, will invade abandoned fields or cleared areas and will usually regenerate quickly (Burns and Honkala 1990; Laird 1995).

While the percentage of poplar spp. has increased in every ecoregion, birch spp. has decreased in 75% of all ecosites. On the other hand, maple spp. has increased in Ecoregions 3 and 4, but decreased in most ecosites in Ecoregion 5 (ecosites 2, 3, 5, 6, 7, 7c, 8 and 9). Two major questions arise from shade intolerant data analysis: (1) Why has the percentage of some intolerant shade hardwoods increased in all ecoregions?; and (2) Why has the percentage of various shade intolerant hardwoods decreased in Kings County? By the early 1800's in ecosites where poplar spp., white birch or red maple have increased, in its quest to maintain the demand for softwood species, industrial forestry probably cleared dominant coniferous areas and facilitated the growth of shade intolerants. In Ecoregions 3 and 4, when the percentage of balsam fir and red maple has gone up, so has poplar spp. In Ecoregion 5, since Loyalist settlement in those ecosites (1 and 6) where white birch, red maple and poplar spp. are most likely dominant, the percentage of each has increased. Also, in Ecosites 3b, 4, and 6b white birch and poplar have increased in percentage. The increase of poplar spp. in all but one ecosite suggests disturbance played a significant role altering species composition in the Continental Lowlands. It is not surprising that poplar spp. has increased up to 18% in some ecosites. Because of its adaptability to grow under almost any conditions, being pioneer species that invade abandoned land or newly cleared areas, poplar spp., red maple and white birch will continue to increase in Kings County as long as new gaps are created in the forest and as long as early successional forest is maintained through disturbance.

Generally, birch spp. has decreased in the three ecoregions. In ecosites where birch spp. has declined, climate and birch dieback of the 1930's could have been factors. In Ecoregions 3 and 4, the moist, cool influence of the Bay of Fundy tends to favour red spruce and balsam fir over all other species (Rowe 1959; Loucks 1962). By the mid-twentieth century, Pomerleau (1954) suggested that forty-five million hectares in Quebec, New Brunswick, Nova Scotia and Maine were affected by the birch dieback disease which could have seriously altered the regeneration and growth of birch spp.

In Ecoregion 5, tamarack has decreased in all, but Ecosite 6b. Most likely, tamarack has been damaged by the larvae of the larch sawfly (*Pristiphora erichsonii*) which feed on the foliage (Laird 1995).

In all ecoregions on hardwood ridges, dry or moist soils with steep slopes (ecosites 8 and 9), yellow birch, sugar maple, beech and hemlock would be the most likely species when associated with red spruce (Rowe 1959; Loucks 1962; E. L. C. Working Group 1996). Generally, in hardwood ridge ecosites, there has been a decrease of yellow birch, sugar maple, and hemlock. On conifer, mixedwood, hardwood or bottomlands with moist, acidic soils where cedar and ash spp. are most likely found, both species have decreased. In transitional conifer zones, especially in river valleys and along waterways, silver or striped maple could be the likely species. However, silver and striped were not recorded in the FDS survey, a judgement cannot be made regarding species composition change.

There are several reasons to explain the decrease of yellow birch, sugar maple and beech on Acadian hardwood ridges: (1) The continuation of disturbance on hardwood ridges will lead to a disappearance of shade tolerant hardwoods; (2) Disturbance on these ecosites have taken place over the past two hundred years and continue today. Early settlers and private woodlot owners have either cleared areas for agriculture or high-graded merchantable hardwood. For example, yellow birch was used for veneer, furniture, cabinet

Beech was used as ship

wet conditions (Perley 18

beech has declined the m

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yellow birch along with bee

forest cover on Ecosites 8

beech comprise only 15%

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beech. The beech canker ca

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Generally, cedar, hemlock and ash spp. have declined in Kings County. Several reasons could explain the decrease of these shade tolerants: (1) In pre-settlement times, cedar was a, "perfect wood resists the succession of dryness and moisture for a great length of time, and this constitutes it great value for fencing" (Perley 1863). Also, cedar was used for ship utensils, posts, pailings and the top timbers of ships; (2) Since European settlement, cedar was a great source for shingles as they are known for durability, strength and being rot resistant; (3) Cedar swamps were cleared, drained and clover was produced in great quantities; (4) The leaf and twigs are a favourite of white-tailed deer and deer yards are often close to cedar groves; and (5) The increase in deer populations probably reduces regeneration success of cedar (Perley 1863; Laird 1995); (6) In the 1800's, hemlock was used as coarse lumber for building. Also, the bark was used as a commercial source of tannin. Bare logs were often left in the woods and wasted; and (7) Ash spp. was used for snowshoes, canoe ribs, basketware and barrel hoops. Also, ash dieback called "ash yellows" predisposes ash to other damaging agents. The cause is unclear, however, the decline in percentage could be attributed to climactic and induced stress (Laird 1995).

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CONCLUSIONS

In Canada, very few studies have been conducted on pre-European settlement forest composition. An evaluation of the majority of the Crown Lands Office surveys of Kings County (1785-1820), private diaries and personal journals kept by the early timber barons, surveyors naturalists and geographers and the Forest Development surveys of 1986 and 1993 identified the forest cover of Kings County to have changed by species composition percentage since Loyalist settlement. The purpose of this study was to use the original land survey records and early historical writings to interpret the species composition and distribution and to compare them to a respresentative sample of today's forest for Kings County, New Brunswick. It is one of the most efficient means available to provide study of present day forests in New Brunswick.

Human caused and natural disturbances played key roles in altering the species composition of Kings County. A human caused disturbance pattern could be broadly outlined in a hierarchial scale: (1) 1780's-early 1800's--by the early 1800's, early settlers cleared land for agriculture and survival purposes. Over 20,000 acres (Fellows 1973) were cleared by 1800, and by 1850 over 650,000 acres were considered "improved" (JLA 1851); (2)

1800's to late 1800's--in this period, New Brunswick was a chief player in the world timber trade market. Commercial forestry operations increased harvesting and everything from masts to shingles were being taken out of the forests to heed the world markets; (3) late 1800's to today-- industrial forestry had secured thousand of acres of forest to be cut for pulpwood and has managed forests for species specific for its own use. After the Second World War, the threat of the spruce budworm infestation brought suppression of the disease in the form of insecticides. Through massive spraying, the budworm was suppressed and the continuation of a source for softwood pulp species occurred. The combination of these many factors could have led to the change of the species composition of Kings County.

Some general conclusions persist: (1) In the three ecoregions, the percentage of intolerant shade species, such as white birch, poplar and red maple has increased in areas where they were absent two hundred years ago; (2) In all ecoregions, the percentage of balsam fir has increased; (3) Despite declinining in percentage, spruce has remained the dominant species in Ecoregion 3 and 4. In Ecoregion 5, spruce has increased in percentage and along with balsam fir make up 45% of forest cover; (4) In Ecoregions 3 and 4 on hardwood ridges, the percentage of beech, yellow birch and sugar maple have either registered little change or increased. On the other hand, in Ecoregion 5 on hardwood ridges, they have declined and have been replaced by a spruce-fir forest; (5) In Ecoregions 4 and 5, cedar has decreased; (6) In Ecoregions 3 and 4, the percentage of hemlock has increased, while in ecoregion 5 it has decreased; and (7) In Ecoregion 5, the percentage of ash spp. and tamarack have decreased.

It is very difficult to predict the future change of species composition in Kings County. Because this portion of New Brunswick was settled very early it is hard to establish a disturbance regime. Most likely, early disturbance were confined to spatially local areas, creating small gaps in the forest. It is unknown whether all disturbances were created by humans or nature, we can only assume that the combination would wrought change of species in the forest. As settlement and the need for merchantable timber increased so did the chance that the forest cover would be disturbed. From the data analyzed a few predictions can be made: (1) It is obvious that in Ecoregion 5 on hardwood ridges, shade tolerant hardwoods have been harvested by early settlers or private owners changing the composition of the forest to a spruce-fir cover. As a result, in Ecoregions 3 and 4, if private owners continue to high-grade merchantable shade tolerant hardwoods, the species composition will result in a spruce-fir cover limiting shade tolerant hardwoods to a minimal percentage; (2) If disturbance continues on a wide basis, the percentage of spruce, balsam fir and shade intolerant species will increase.

Overall, this study has completed its objectives. The results of this study will allow ecologists, biologists and foresters to envision the forest cover of pre-European settlement and how it has changed over time as compared to today's forest cover in Kings County. With this ability to identify and understand the past species composition it is well suited as a tool for ecological study and management. The application of this study could be used as a basis for: (1) Environmental assessment and monitoring; (2) Landscape analysis and conservation planning; (3) Part of development of preliminary management guidelines for Fundy Model Forest; (4) Determing land-use and resource allocations.

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APPENDIX

APPENDIX I

PERCENT FREQUENCEY PER SPECIES BY ECOSITE IN KINGS COUNTY

Table I 1. Percent frequency per species by ecosite in Kings County circa 1800.