New Brunswick is covered with ecosystems whose distribution and species makeup reflect natural and human influences.

Chapter 4

From Glacial Wilderness to a Home for Humanity

Since the retreat of the glaciers began about 11,000 years ago, a suite of historical factors has affected the distribution of species and ecosystems across the landscape, influences that linger to the present day. In this chapter, we give a few examples of how climate change, species migrations, and human activities have affected the distribution of species and ecosystems.

Climate Change Since Glacial Times

Natural trends in global temperature are related to 100,000-year-long cycles of change in the shape of the earth's orbit about the sun and the tilt of the planet's axis relative to the plane of its orbit. Described in the scientific literature as the Milankovitch theory, these cycles help to explain the occurrence of glacial and interglacial periods in North America. Since the glaciers melted 11,000 years ago, the global temperature has peaked (6,000 years ago) and started a decline toward the next glacial period. If climatic theories are correct, current global warming, though profound in its possible consequences for life as we know it, may be considered a 'blip' within a long-term trend of climatic cooling.

Between the early creation of tundra-like landscape in post-glacial New Brunswick and the subsequent development of forests on the landscape today, there has been a series of shifts in climate and associated vegetation.

Nature has left us a few clues — refuges of formerly abundant arctic-alpine plants here, and fossils there — that suggest the look of wild lands, even on today's most pristine natural landscapes, was very different in the past than it is now.

Remnants from a Warmer Time

As the glaciers began retreating from the land now known as the Maritimes, plants and animals gradually expanded their ranges beyond glacial refugia south of the ice sheet, colonizing the barren lands exposed at the edge of the receding ice. At first, the vegetation would have resembled the plant life presently found in the far north of Canada - shrubby and barren in places, with scattered clumps of trees such as tamarack, black and white spruce, and birch. Mastodons were among the now extinct mammals that were native to the Maritimes at the time.

In many parts of North America, fossil finds suggest there was a dramatic rise in global temperatures around 6,000 BP (years before present) that caused plant and animal species to migrate northward beyond their present-day northern limits. Buried layers of 6,000-year-old charcoal have been found in places too cold presently to support tree growth. In Labrador, for instance, huge spruce logs dating from this warm time have been found preserved in peat bogs that now occupy areas of stunted, cold-climate forest and treeless tundra.

The present range of Blue Cohosh in New Brunswick is probably smaller than in the past.

In New Brunswick, the evidence of this past warm interval is suggested by the patchy, discontinuous ranges of some plants and animals that are more typical of present-day warmer climates found farther south. A warmer climate facilitated the spread of these plants before their ranges were restricted as the climate cooled again after 6,000 BP. For example, the deciduous ironwood tree was probably more widespread in New Brunswick in the past than it is today; the small pockets of ironwood found at higher elevations in the

province are likely the last remnants of a broader distribution. Similarly, an isolated remnant population of butternut occurs near Havelock, King's County, on limestone-derived soils. Although butternut occurs throughout much of the Grand Lake Lowlands Ecoregion, the Havelock population is outside the main contiguous range of butternut in New Brunswick. Studies of fossil pollen and twigs preserved in lake bottoms suggest that red oak and white pine were both more prominent and more widespread in New Brunswick 6,000 years ago than today. The maidenhair fern, Canada violet, blue cohosh and leatherwood are just a few of the plant species whose ranges have shrunk since early post-glacial time.

Maidenhair fern is believed to have been more abundant in New Brunswick in the past than it is today.

Ecologists have noticed that the broken, patchy distribution of these remnant populations coincides with places where soils are derived from limestone or calcareous rock. Geographic ranges of these populations may have shrunk in part because soils elsewhere became too acidic to support them, due to the natural soil leaching and acidification that occurs over thousands of years in areas where annual precipitation exceeds evapotranspiration. The bleached, whitish soil horizon situated immediately below the surface of the leaf litter in Maritime forests is evidence of this slow, long-term acidification process.

Meanwhile, cold- and acid-tolerating balsam fir, spruce species, jack pine, tamarack, and aspen were favoured by the cool climate regime developing after 6,000 BP.

Remnants from a Colder Time

Today, some colder-than-average habitats in New Brunswick still harbour plants and animals that were more abundant during the region's early post-glacial period. Many of these species occur along the coastal cliffs and on peat bogs of the Fundy Coast Ecoregion, where the cold waters of the Bay of Fundy have greatly affected the climate over many thousands of years. Curly-grass fern is among the plant species that have found a refuge near the Bay. A deep ravine in southeastern New Brunswick is home to many plants, now rare in the Maritimes, that once were among the most common plant species in the region. These plants include entire-leaved mountain avens, myrtle-leaved willow, small-flowered anemone, and soapberry. Another remnant cold-climate species, alpine bilberry, is

Entire-leaved mountain avens are found only in one location in New Brunswick, but are widespread in the Arctic. *Drawing from Britton and Brown (1913) and copied from USDA, NRCS (2006).*

now known only from mountaintops in north-central New Brunswick and from Miscou Island. Dwarf birch is similarly restricted in distribution here, but is abundant in high boreal forest areas near the treeline in Québec and Newfoundland.

Human Influences

It is difficult to separate the effects of humankind's activities from simply 'natural' influences on the distributions of plants and animals. The question arises: Are people part of Nature, or are they separate from it? Philosophers and ecologists have debated this issue at some length without a satisfactory resolution. At one end of this philosophical spectrum are those who believe that the earth belongs to humanity and that stewardship is mostly about satisfying human needs. At the other end are those who believe that humans are just one species of many who participate in a biotic community, all of whose members deserve respect and accommodation. In the sections that follow, we will limit ourselves to briefly demonstrating how humans have influenced the present distribution of several plants and ecosystem types in our region.

Dochet's Island in the St. Croix River, scene of Sieur de Monts' first encounters with Passamaquoddy people.

First Inhabitants

Over the last 300 years, the imprint left by humankind on the distribution of New Brunswick plants and animals has grown exponentially. For several thousand years prior to Sieur de Monts winter on St. Croix Island, Aboriginal peoples had been drawing sustenance from the plant and animal life of the coastlines and the uplands. Fire was used in various ways, including cooking and heating. Fires may have also been deliberately set to maintain "barren" areas free of trees, where blueberries and other wild fruit might thrive, or to create browse for caribou, moose, or deer. However, the first human inhabitants of the Maritime region do not appear to have relied on agriculture to the same extent as did other Aboriginal peoples who occupied the upper St. Lawrence Valley, and who used fire as a tool to clear land to make room for the cultivation of corn and other crops. Thus, it's possible that fires had a smaller effect on the look of the land in pre-contact time in the Maritimes, northern New England, and the Gaspé than it did in areas farther west and south where land

clearing using fire was practiced.

The first humans to live in what is now New Brunswick probably facilitated the establishment of some medicinal and food plants by carrying them back from journeys to other parts of the continent. One unusual site in southern New Brunswick, for instance has wild leek as the dominant forest understorey plant over a fairly large area, which suggests cultivation or propagation in the past. Yet wild leek is normally rare in the province. Is it possible that bulbs of wild leek first arrived in the region in a leather pouch, having been carried a great distance on foot and by canoe? Bur oak is another species suspected of having been introduced to New Brunswick from points farther west. The map of its North American distribution shows it is widespread in the east and centre of the continent, yet it is an unusually patchy and discontinuous distribution that is shown. Did the aboriginal ancestors find that flour made from bur oak acorns was less bitter and therefore better flavoured than that made from local northern red oak?

Wild Leek. *Photograph courtesy of Stephen Clayden.*

Arrival of Europeans

With the coming of Europeans to North America, there arrived not only a new array of associated plants, animals, and microbes, carried both deliberately and inadvertently, but also a cultural outlook that contrasted with the indigenous culture.

Bur oak acorn and leaves. *Photograph courtesy of the online USDA Plants database (USDA, NRCS 2006).*

Physical evidence suggests that the earliest European colonists allowed or encouraged substantial alteration of the physical environment. For example, Acadian colonists in the 17th and 18th centuries built earthen dikes to control tidal flooding of fertile salt marshes to make them available for agriculture. So extensive and complete was the diking and cultivation of salt marshes along the inner Bay of Fundy that few areas were left unaffected. The Acadians were followed by United Empire Loyalists and other British and European

Acadian dike building, ca 1880. *Photograph courtesy of Université de Moncton library archives.*

colonists who cleared forests for settlement and agriculture. They also harvested large amounts of wood for buildings and fuel wood, for the domestic shipbuilding industry, and for large-scale export to Europe and to New England.

Agricultural practices of the early colonists introduced many exotic plants and animals, including plants that are present-day staple foods in North America. Europeans introduced a significant portion of the continent's present flora and fauna. Around 20% of known vascular plant species found in New Brunswick are originally from Eurasia. Most of these plants probably arrived as seed mixed with shipments of agricultural seed, or as seed attached to clothing,or in ship ballast.

Introduced plants include the common garden weed "plantain", which 17th-century aboriginal people in Massachusetts gave the name 'white man's footprint.' A number of animal species besides the familiar farm animals were also introduced, including the Norway rat, the European sparrow, rock doves, and starlings. The ravages inflicted on indigenous human populations by introduced pathogens, such as smallpox and tuberculosis, are well documented. In addition, pests and pathogens of native plants were introduced from other continents through North American ports. One

example is a scale insect that was introduced through the port of Halifax, around 1890. This insect carries the *Nectria* fungus, the pathogen that causes the canker so prevalent here today on the bark of beech trees. Invasive organisms from other continents have continued to be introduced in recent times.

Plantain (top) and dandelion (bottom) are familiar garden weeds that were introduced by European colonists.

Colonists, Homesteading, and the Forest

Early colonists were aware of the relationship between landscape position, soil type, vegetation type and good farming prospects. Areas typically cleared for houses, farms, and fields later became larger settlements or towns that we now associate with the strong farming traditions of southeastern New Brunswick, the Saint John River valley and its tributaries, the Bay of Chaleur shoreline, and the lower Miramichi valley.

Since 1940, the percentage of land area devoted to agriculture in New Brunswick has for a variety of reasons declined significantly. Forests have become re-established on abandoned crop and pasture land. White spruce is often referred to as old-field spruce because of its association with abandoned farm fields. Poplar, white birch, grey birch, and alder are also commonly found in old-field stands. Their light seeds are widely scattered by wind, and their seedlings can compete successfully with the common grasses and herbaceous field and pasture species. Where a seed source exists close by, white pine may also become established on old fields.

On aerial photographs, it is common to see sugar maple-yellow birch-beech stand types separated by a straight-line boundary from dark-coloured, conifer-dominated stand types. These conifer-dominated stands mark the previously cultivated fields or pastures of old homesteads. Common speedwell and yarrow are two understorey plants introduced from Europe that commonly persist under forest cover on old fields; our native wild strawberry is another. In fact, the presence of these species can alert a naturalist that a forest stand probably has a history of ploughing or pasturing. A dark-coloured upper soil layer composed of mixed organic matter and mineral soil, with the presence of earthworms, can also indicate a history of ploughing or intensive upper layer soil disturbance by the hooves of farm animals.

Homesteading, New Denmark area. *Photograph courtesy of the Provincial Archives of New Brunswick.*

Remnant patches of historically-

prevalent forest exist alongside current agricultural land and typical old-field stands. In the Saint John River valley, the abundance of formerly common tree species such as butternut, bur oak, black cherry, and basswood, has decreased since the period of homesteading colonists. More recently, inundation of islands, riverside forests, and wetlands by hydroelectric dam projects in the 20th century has had an unquantified negative impact on the extent of a species rich forest type called the Appalachian Hardwood Forest.

Old-field white spruce (dark patch in lower left) contrasts with the original vegetation on a tolerant hardwood ridge.

The original Land Grant Surveys dating from the 18th and 19th centuries, and now housed in the Provincial Archives of New Brunswick, have proved to be a valuable resource for reconstructing New Brunswick's precolonial forest. Colonial surveyors systematically recorded the tree species present at regular intervals along survey lines. These records provide a fascinating glimpse of past forest composition and allow us to measure the change.

Effects of Forest Harvesting

Logging, and land clearing to had significant effects on the composition and extent of New Brunswick's forests. In the 1700s and early 1800s, logging efforts were concentrated almost exclusively on New Brunswick's legendary white pine forest. By the latter part of the 19th century, spruce had supplanted pine as the most important species on the annual log drives on New Brunswick's major rivers. The harvests of spruce were highly selective, focusing on large trees that, for

Old-field white spruce stands often are very branchy and conceal the evidence of homesteading, such as rock piles and stone fences.

the most part, occurred in the well drained stands with good access to rivers and streams for log driving. These harvests focused in the three lowland ecoregions and did not penetrate to the uplands and highlands until later. Anecdotal evidence suggests that hemlock was also a prominent tree in much of the forest of New Brunswick in the middle of the 19th century, but its abundance was diminished greatly after hemlock bark became in high demand as a source of tannin for leather-making.

The Changing Character of the Forest

As markets grew through the 19th century and large-diameter trees became scarce, accessible stands were cut repeatedly for sawlogs, each time with a lower minimum log diameter limit. 'Leave anything smaller than 12 inches diameter at breast height (DBH)' was the common rule of thumb. After the pulp and paper industry became established in the early 20th century, woodlands already cut over for pine and spruce sawlogs were re-harvested to even smaller diameter limits. In the 1940s, clearcutting began to emerge as the predominant forest harvesting practice.

An ecological consequence of clearcutting was to create large open areas in the forest where the remaining vegetation, including understorey plants and tree seedlings, is subject to extremes of temperature and moisture. In clearcut areas where natural regeneration has developed, this has led to an increase in the percentage of balsam fir and a decline in the percentage of spruce in coniferous forested areas. This effect is more pronounced in the three lowland ecoregions and the Fundy Coast Ecoregions, where in pre-contact times fir is believed to have been a subdominant species, while red spruce was the predominant spruce species. The increase of fir at the expense of spruce is due to the genetic tendency of fir to grow longer roots in the seedling stage than spruce seedlings of similar size. Young fir seedlings can, therefore, gain access to sources of soil moisture unavailable to spruce seedlings and are consequently better able to withstand the tendency to dry out when the forest canopy is removed and the young trees are exposed to extreme wind and sun.

The balsam fir population also expanded after implementation of the insecticide spray program against the spruce budworm, balsam fir's major insect pest, from the late 1950s until the 1980s. Although the budworm attacks both fir and spruce, fir is less able to withstand sustained defoliation and, thus, succumbs more readily.

Species or Genus	*Circa* 1800	*Circa* 1993
Spruce	19.4	27.8
Maple	18.4	16.4
Birch	15.8	11.7
Cedar	7.2	3.5
Balsam fir	7.2	19.7
Beech	6.9	2.5
Ash	5.8	0.5
Hemlock	4.4	0.9
Aspen/ poplar	4.4	8.8
Tamarack	4.2	1.9
Pine	3.7	3.6
Other hardwoods	1.1	2.4
Oak	0.5	0.2
Alder	0.4	0.0
Ironwood/ hornbeam	0.3	0.2
Butternut	0.3	0.0
Total	100	100

The change in percent frequency of common tree species and species groups between 1800 and 1993 in Kings County, New Brunswick. The increase in spruce abundance probably reflects the combined effects of a decline of red spruce and an increase of white spruce on

Several scientists have speculated that the predominance of red spruce in forests of the three lowland ecoregions and the Fundy Coast Ecoregion in the 19th century and early 20th century reflected the role played by spruce budworm in limiting the balsam fir population. Fire suppression during the 20th century is a third factor that contributed to the expansion of balsam fir. Balsam fir is extremely vulnerable to fire, whereas morphological adaptations often allow spruce seed to withstand wildfire and to re-establish itself by scattering seed over burned areas.

Thus, over the past half century the high proportion of balsam fir in the forest has been an important determinant of natural forest dynamics and of forestry policy in New Brunswick. Because balsam fir lacks the longevity and budworm resistance of spruce, industrial forestry has been geared for many years to harvest stands first where tree mortality and its associated volume loss is imminent. This has also led to the widespread planting of spruce, with the intention of improving per-hectare timber yields and secondarily to begin to reverse the predominance of balsam fir in the forest.

Among the plant species considered vulnerable to drying out following clearcutting are the Calypso orchid (top), the showy ladies slipper (middle), and the clustered coral lichen (bottom).

Current Trends of Ecosystem Change — Detectable or Not?

Several of the narratives presented in this chapter were elaborated with the help of knowledge gained through ELC. Trends are easier to detect with the benfit of hindsight than they are to predict before many years have elapsed. Ecological responses to disturbances often are so complex and variable seasonally or from year to year that they are undetectable through observations made over only a few years or even a decade or two. Many of the effects listed in this chapter, such as those associated with the red spruce-balsam fir dynamic, were impossible to detect until sufficient time had passed and sufficient area had been affected that a trend became recognizable.

Questions about the effects on species and ecosystems of challenges posed by air pollution, water pollution, and climate change are some of concerns that preoccupy society today. For example, there is evidence that the effects of acid rain and ground-level ozone in the Bay of Fundy region causes damage to the outer waxy coating of leaves of birch trees, thus facilitating fungal infection, which causes leaves to brown and fall prematurely. In southwestern Nova Scotia, the acidity of lakes in spring sometimes reaches levels that can affect the reproduction of salmon and trout.

Can similar effects be expected in New Brunswick? Does mercury contamination of New Brunswick trout show regional variation related to ecosystem attributes? How will climate change affect New Brunswick ecosystems?

The NBELC can help address these questions to the extent that it helps scientists to recognize and identify the uniqueness of regional or local environmental circumstances. It is one tool in the toolkit of scientists who must also describe the problem, imagine or *model* how the problem comes about, test the model in the real world, and let others know about what they found.

Conclusion

In this chapter, we have examined past events and their role in determining species distribution in New Brunswick, with a specific focus on postglacial migrations, climate change, and the dimensions of human. Together, past events and their effects comprise one of the major influences on 'what lives where, and why'. Ecological gradients also play an important role in ordering many aspects of the natural world. In the next chapter we will leave the past behind to again focus on the specific ways that these attributes of the physical environment or ecological gradients today affect the makeup of biological communities and the distribution of species in modern-day New Brunswick.