Geology, topography, climate, and soils are influential on ecosystem character.

Chapter 3

Enduring Features: Geology and Topography, Climate and Soil

The enduring features of a landscape — geology and topography, climate and soils — lend themselves readily to sensory impression. A person can feel hard bedrock underfoot, smell damp forest soil on an upturned tree root, or sense an icy wind or warm rain on the face. A practical aspect of ecological land classification is that it uses tangible physical features and measurable climatic phenomena to describe ecosystems.

Each enduring feature melds into the other in a continuum of interaction. Soils are derived partially from the action of climatic elements upon rock as the sun, wind, ice, and water take their toll on stone, hastening its physical and chemical degradation into soil particles. Geology and glaciation help to sculpt the topography of a landscape. Topography is decisive in creating climate through such factors as the relationship between temperature and elevation.

As noted in Chapter 1, the relative influence of these enduring features depends upon the geographic scale of observation. Together, the enduring or non-living features provide the more or less stable environment in which the biotic elements of fauna and flora exist.

Geology and Topography

Geology is arguably the most fundamental of all the enduring landscape features. Bedrock creates the structure beneath the countenance of landscape, although weathering and glaciation do much to soften and alter its face -- that is, to modify its physiography or topography.

The rocks of New Brunswick belong to the Appalachian Mountain Range, which borders the Canadian Shield that forms the core of North America. The Appalachians reach from central Alabama northeast to Newfoundland and were continuous with the Caledonides Mountain Range in northwest Europe until the two ranges became severed with the opening of the present Atlantic Ocean some 200 million years ago. As an example of this ancient marriage, a person walking in areas of west Saint John will encounter outcrops that belong to the same volcanic rock sequence as those seen by a hiker on the cliffs of St. David's Head in southwest Wales.

Geology with a Past

The rocks of New Brunswick cover a time period of about one billion years between the oldest rocks around Saint John and the youngest strata on Grand Manan Island. The time spans involved in geological reckoning have led to the development of a time scale with eras and periods covering millions of years.

New Brunswick's geological evolution has involved turbulent episodes of volcanism, tectonic rifting, continental collision, and mountain building, interspersed with unimaginably lengthy interludes of relative quiescence, drifting sedimentation, and gradual erosion.

Current geological thinking suggests the story began about one billion years ago when the world was already 3.6 billion years old, and the continents as we know them did not exist. Instead, there appears to have been a giant supercontinent that shifted about the planet before slowly breaking into tectonic plates or protocontinents around 600 million years ago. These plates can be thought of as rock islands floating on a sea of molten rock inside the earth's crust.

For another several hundred million years, the plates skimmed the globe, driven by intense heat and convection currents beneath earth's crust. Their movements resembled a very slow geological dance in which the plates repeatedly drifted apart and then collided with each other over time. The boundaries of plate separation changed with each opening and closing so that the resulting continents, including the region we now call New Brunswick, became a geo-montage of rocks of varying ages and type.

As the continental plates separated, whole oceans developed between them, and sediments eroding from the continents filled huge valleys beneath the expanding sea. In places where the plates merged together and the oceans closed, volcanoes erupted, and buckling mountains formed at plate margins. The mountainous edge of the west coast of the Americas is relatively youthful geologically, and reflects this process. Ordovician volcanic rocks from an early episode of ocean closure can be seen near Bathurst, where they are mined for their base-metal deposits. The earth of one billion years ago was a younger, internally hotter, more volcanic place than it is today.

The geological time scale.

Eon	Era	Period	Millions of Years Ago	Event
Phanerozoic	Cenozoic	Quaternary	24 to 1.8	Glaciation; first humans; modern mammals evolve; first grass
		Tertiary	65 to 24	
	Mesozoic	Cretaceous	142 to 65	Extinction of dinosaurs; first flowering plants
		Jurassic	200 to 142	First birds, dinosaurs prominent
		Triassic	248 to 200	First mammals and dinosaurs
	Paleozoic	Permian	290 to 248	Reptiles dominant
		Carboniferous	362 to 290	Extensive coal forming swamps; first reptiles and ferns
		Devonian	418 to 362	First trees; fish dominant; first amphibians
		Silurian	443 to 418	First sharks
		Ordovician	495 to 443	First land plants; invertebrates dominant
		Cambrian	545 to 495	First fish; diversification of invertebrates
Precambrian	Proterozoic		2500 to 545	First multicellular life; oxygenation of the atmosphere
	Archean		4000 to 2500	First unicellular life
	protogeological history of the earth		4600 to 4000	Intense meteor bombardment of the earth; oldest known rocks formed at the end of this era

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The Fossil Record

Some of the oldest known rocks in New Brunswick are Late Precambrian limestones that were deposited during an early period of ocean opening. These rocks occur near Saint John and hold ancient fossils known as stromatolites, remnants of algal reefs that lived some 980 million years ago. During the Late Cambrian, New Brunswick's fossil record reveals evidence of more advanced life forms, including oval-shaped creatures called trilobites that resembled horseshoe crabs, and brachiopods that looked somewhat like bivalve molluscs.

A camera lens cap provides a reference scale for fossil stromatolites located near Saint John. Photo courtesy of the *New Brunswick Museum.*

When the ancient oceans closed yet again during the Devonian, about 400 million years ago, molten rock that would later become massive bodies of granite called plutons intruded the older rocks. The resistant granitic plutons were less easily eroded than some of the surrounding rock types and today form areas of high elevation, such as the Christmas Mountains. Devonian granites in New Brunswick have been quarried for dimension stone and aggregate material and contain significant metallic minerals.

Elsewhere in Devonian New Brunswick, future uplands were being deposited on the ocean floor from older, eroded material. These sedimentary rocks preserved the oldest vertebrate fossil in the province: a jawless fish, *Yvonaspis campbelltonensis*, so-named for its discovery location in northern New Brunswick near Campbellton. This extinct fish lived about 350 to 400 million years ago, had one central nostril between its eyes, and featured a protective sensor zone along the edge of its head shield.

A fossil trilobite from the New Brunswick Museum collection. Photo courtesy of the *New Brunswick Museum photo.*

About 370 million years ago, the nearly half a billion years of tectonic jostling subsided into a relatively tranquil era that spanned much of the Carboniferous and Permian. The land that became New Brunswick lay near the present-day equator at this time, and a shallow sea invaded the land.

Terrestrial or land-based plants, which had first appeared in the Silurian, came into their own during this humid time and grew in profusion across the Carboniferous landscape. One of the most interesting was a huge tree-like plant called *Calamites*. The Carboniferous also saw massive volumes of sediment eroded from mountain ranges to the west and transported by river systems to form huge deposits of sand, gravel, and clay. The sediments eventually consolidated into the sandstones, conglomerates, and shales that comprise the huge wedge of Carboniferous strata blanketing central and eastern New Brunswick.

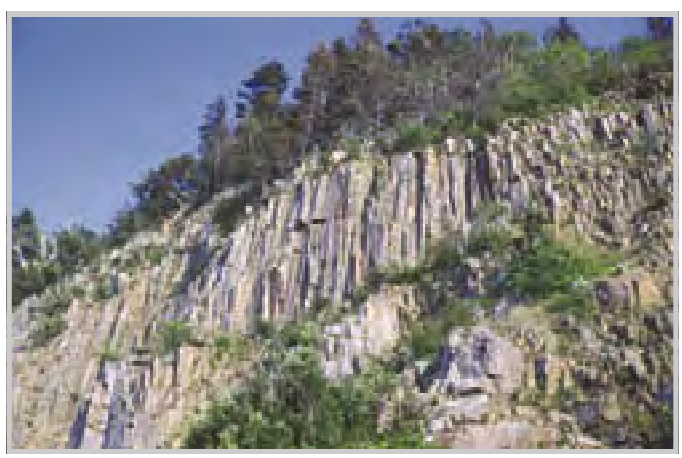
A final episode of continental rifting began in the Late Triassic with the opening of the present Atlantic Ocean, which is still widening today at a speed of about 4 cm to 5 cm per year, the growth rate of a fingernail. As the plates split apart, volcanic rocks called basalts filled the fractures caused by rifting. Such rocks can be seen in several New Brunswick locales, including Grand Manan Island where they contain rare minerals called zeolites that attract collectors from across the continent. These Jurassic basalts, along with some Triassic sandstones found along the Bay of Fundy coastline, constitute the youngest rocks in the province.

A Devonian fossil fish, *Yvonaspis campbelltonensis.* The photograph shows top view of the head shield and one visible eye. *Photograph courtesy of The New Brunswick Museum.*

Recent Geological Events

The beginning of the Tertiary around 65 million years ago marks the start of what is known as the Cenozoic Era in geological time. The end of the Tertiary coincides with what many scientists believe was a collision between the earth and an asteroid, a catastrophe that led, among other things, to the extinction of dinosaurs. New Brunswick rocks during this period became increasingly weathered and eroded down to a fairly level landscape surface that bore little resemblance to the contrasting highlands and lowlands of today.

The terrain appears to have remained gently undulating until the late Tertiary, when the entire area experienced another episode of broad regional uplift and tilting. This initiated a new cycle of erosion, during which the unsolidified sedimentary material and less resistant (mainly younger) rocks were worn down into valleys and lowlands. The deep stream dissection and incision of such waterways as the Upsalquitch River and much of the Saint John River apparently took



Columnar basalts are exposed at Grand Manan Island.

place around this time. The more resistant, older granitic and volcanic rocks gradually emerged from their weaker cover rocks to become highlands and uplands.

The Pleistocene ice ages constitute the most recent major episode in the geological history of the Maritimes. They laid a heavy hand on New Brunswick, as the province became inundated by glaciers that in places reached more than 2 km thick. Advancing ice sheets scraped up surface soil and plucked gravel and boulders from the surface and dropped them again, sometimes several kilometres away. Pebbles embedded in the base of the ice scoured and gouged the bedrock, leaving features such as glacial striations. When the glaciers paused or retreated, they laid down thick deposits of silt, sand, and gravel that disrupted drainage patterns, blocked streams and lakes, led to the formation of ponds and bogs, and gentled bedrock contours.

The study of existing glaciers helps geologists understand what might have happened in the past. Mount Edith Cavell Glacier, Jasper National Park, Alberta.

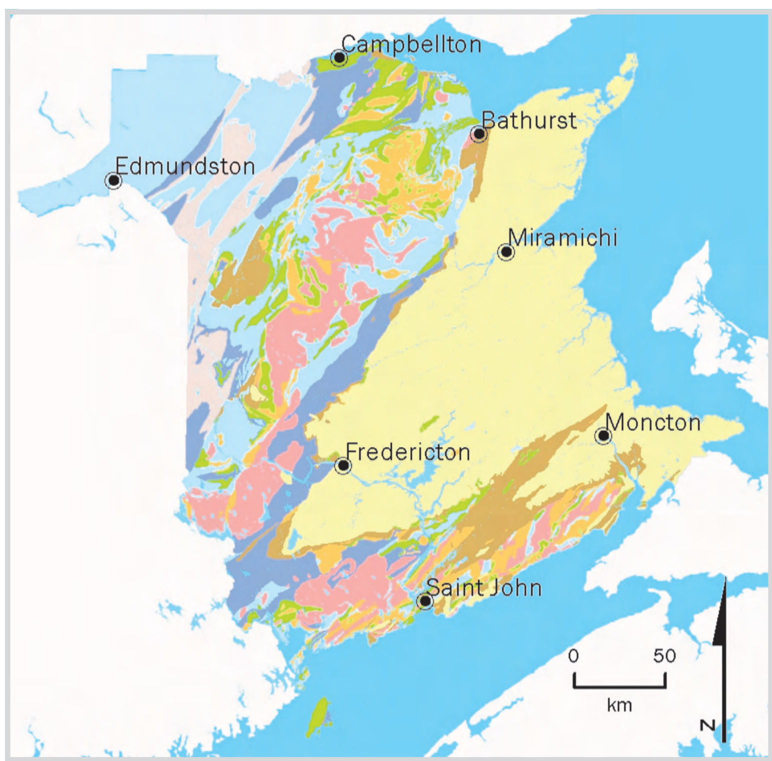
The glaciation events that essentially defined the surface of modern-day New Brunswick commenced about 100,000 years ago, waxed and waned, then ended about 11,000 years ago. Sometime in those distant icy millennia, the first human inhabitants arrived in North America. Scientists are still debating where they came from, when they arrived, and how they got here. The prevailing wisdom is that they crossed between Siberia and Alaska at least 12,000 years ago, or perhaps much earlier, across Beringia, a vast plain that once connected the two landmasses when sea levels were lower.

We do know that, as the glaciers eroded and disappeared around 11,000 years ago, the first post-glacial boreal forest gradually expanded over the land, and the earliest Paleo-Indians ventured into the Maritime region. Their arrival on the heels of the retreating ice signifies the tantalizing but hazy origins of the Early Period in Maritime human history.

A Coastline in Flux

One of the more intriguing aspects of the Pleistocene glaciations has been their effect upon sea levels. The colossal weight of ice warped and depressed the earth's crust by perhaps 100 m in places. At the same time, the ice sheets tied up massive volumes of water, causing the sea level to fall by more than 100 m below present levels. When the glacial ice began to melt, sea levels rose and partially flooded the land, then retreated again as land gradually lifted up from the loss of the ice's weight. The dynamic interplay between glacial rebound (also called isostatic rebound) and increased meltwaters entering the ocean (called eustatic change) caused shorelines to shift back and forth for several millennia.

Since about 3,000 years ago, the net effect has been a creeping rise in sea levels, such that our coastlines in most places are gradually submerging at a rate of several centimetres a year. The drowned forests in salt marshes at the head of the Bay of Fundy testify to a time of lower sea levels. Many of the oldest Paleo-Indian sites, too, are believed to rest beneath the ocean adjoining the present shoreline, hiding unknown relicts of an ancient people who once dwelled close by the sea.



The Geological Picture Today

The foregoing events have combined to create the geological patchwork quilt of New Brunswick. It is a mosaic composed of tectonic units, microcontinents, and rock terranes all stitched together along faults and other geological features, and then modified by recent tectonic and erosional forces to create the landscape we see today.

The results of past geological events and processes are summarized by the bedrock geology map of New Brunswick. It depicts

Geomorphological Regions of New Brunswick, after Bostock (1970).

an extensive wedge of low-lying Carboniferous sedimentary rocks bordered on one side by the Northumberland Strait, and on the two remaining sides by areas of higher elevation composed of mainly older igneous, sedimentary, and metamorphic rocks.
When bedrock geology is considered together with elevation and relief (topography), New Brunswick falls naturally into six geomorphologic regions. Each region delineates an area that differs from adjoining regions on the basis of bedrock type, relief, and elevation. This is the simplest depiction of the variety of landscapes in the province.

The significance of geomorphology to ecological land classification becomes apparent when we correlate geology and elevation with climate. As described in detail in the next section, New Brunswick's abrupt changes in elevation are partly responsible for its variable climate and, hence, for the diversity in natural vegetation that characterizes the landscape.

What Affects Our Climate?

Most of New Brunswick possesses a singularly unmaritime climate, despite its geographic placement in Maritime Canada. No part of the province lies more than 200 km from the ocean, yet its climate is distinctly continental, with hot summers and cold winters.

The climate of the province reflects an amalgam of three basic factors: latitude, proximity to large bodies of water, and elevation. The most significant of these is latitude, which determines the amount of radiation received from the sun. New Brunswick lies at approximately the same global latitude as Bordeaux, France, and Venice, Italy; however, their climates are quite unlike our own, being much warmer. Obviously, other climatic factors must come into play. We will examine these factors in the sections below.

Large Bodies of Water

The Bay of Fundy, Chaleur Bay and the Northumberland Strait embrace the south, north and east coastlines of New Brunswick, respectively. Yet, despite sharing a common association with the Atlantic Ocean, these large expanses of water exert substantially

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different effects upon the landscape.

Bodies of water that remain unmixed tend to become stratified, with the warmest layer on top in summer and the coldest layer on top in winter. The Bay of Fundy, however, undergoes daily mixing when incoming ocean tides from the southwest strike underwater reefs at the mouth of the bay and bring its bottom waters to the surface. The bay thus remains cold in summer and unfrozen in winter. This has a strongly moderating effect upon the climate of adjacent land areas and supports a distinctive red spruce-dominated forest, as well as wetlands that are home to a number of regionally rare plant species.

Tidal mixing also causes fog development along the Bay of Fundy, especially in spring and summer when the cold waters contact the warm, humid air from the interior regions. The fog increases moisture levels and decreases summer temperatures by masking the sun. Springs and summers along the Fundy coast, therefore, see cool temperatures that are more typical of those felt in the northern highlands. By way of compensation, the warmer winter ocean gives the south shore a frost-free period that is equal to, or longer than, anywhere else in the province.

The shallower waters of the Northumberland Strait and Chaleur Bay, on the other hand, are often frozen by mid-January, then grow as balmy in August as the sea off Virginia. They tend to warm the adjacent land areas during winter, but their moderating effect is less noticeable in summer, partly because prevailing winds are offshore. Indeed, the Northumberland coast experiences some of the highest summer temperatures and lowest summer precipitation amounts in the province.

Another summer hot spot is the Grand Lake area, which is protected from the prevailing westerlies by higher ground to the west. This large inland lake covers about 16.5 sq km and effectively acts as a lacustrine heat sink. By storing heat over the summer and releasing it over the fall and early winter, the lake bequeaths to the surrounding land an extended frost-free period. As a consequence, the area hosts a number of plant species with southern affinities.

Elevation

Elevation, together with the maritime effects of the Bay of Fundy, is a major influence on New Brunswick's regional climatic variation. Elevations shift from sea level at the coast up to more than 800 m in the northwest and central regions. The accompanying

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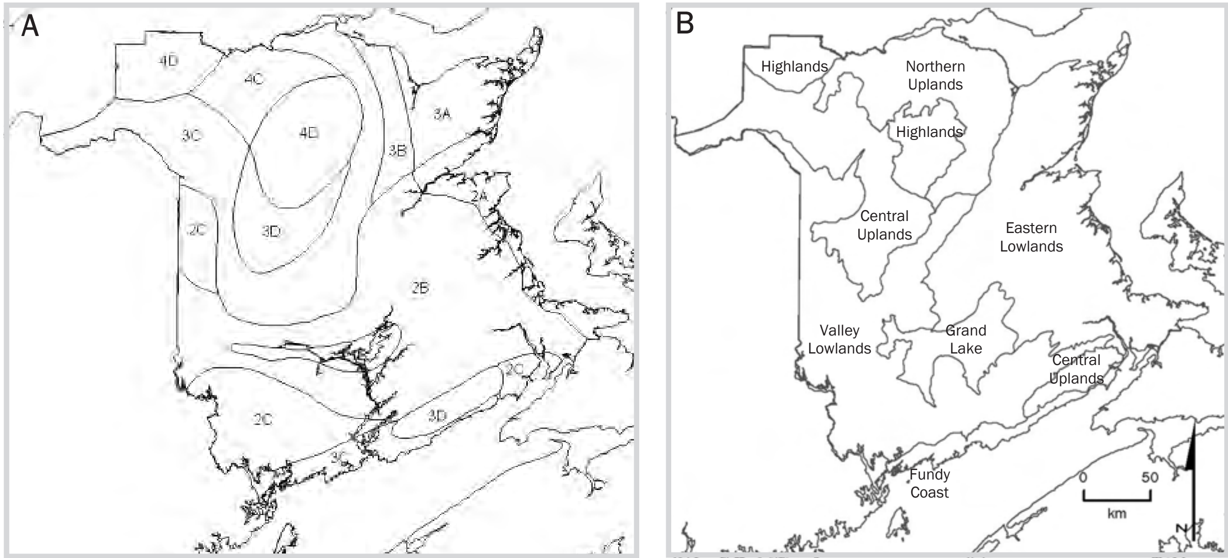

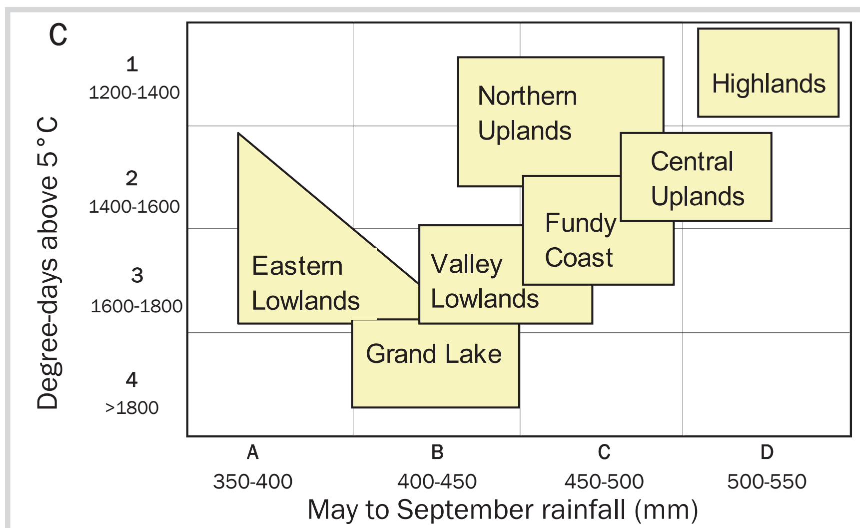

Inset A: Map of climate regions of New Brunswick based on summer precipitation and growing degree-days above 5°C (after Dzikowski *et al* 1984). Inset B: The ecoregions of New Brunswick. Inset C: A graphical representation of the climatic variability of the New Brunswick ecoregions. Axis labelling (1-4, A to D) corresponds with Inset A map labels. Wet and cool ecoregions appear in the upper right; dry and warm appear in the lower left.

temperature drop with elevation rise produces variations in temperature and precipitation.

Where elevation is more uniform from north to south, as along the Northumberland Coast, the climate remains relatively consistent. Yet, where it increases substantially such as rising from sea level at Kouchibouguac National Park up to 820 m at Mount Carleton, climatic differences are dramatic. Because air temperatures normally decrease at a rate of 0.4° C for every 100-m gain in elevation, an increase in elevation is comparable, temperature-wise, to an increase in latitude.

When moist air of the prevailing westerlies meets elevated land, it cools as it flows upwards, causing its water to condense and fall as rain or snow. This is nowhere more apparent in New Brunswick than in the northwest and north-central highlands. There, the

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western slopes receive extremely high precipitation amounts, leaving rain shadows on the adjoining eastern flanks.

Lower lying areas, such as the Northumberland coast, gain less precipitation than the higher, inland locations. Air masses arriving at the coast from the uplands already will have dropped some moisture, but also are able to retain more water because they are descending and have become warmer.

Climate, Macro to Micro

Comparing New Brunswick's climate regions (inset A) with the ecoregion map (inset B) reveals similar geographic patterns at a very broad scale. At finer scales, the climate affecting a particular site is a function of three climatic levels acting simultaneously. Macroclimate, as we have just seen, is the relatively uniform climate of a region — the climate zone. Topoclimate refers to the typical weather conditions of smaller areas, such as valleys and ridge tops, which reflect such factors as aspect, slope steepness, slope position as it affects the amount of incident radiation, and cold air drainage. Microclimate describes the actual local conditions in which an organism lives.

Ecological land classification considers different climate-controlling attributes, depending on the scale of observation. Macroclimate is a major criterion for delineating ecoregion boundaries and is also a factor in ecodistrict analyses. Topoclimate will be revisited later, in Chapter 5.

Soils

Soil is regarded as one of the three enduring features, but, in fact, embodies the interface between the organic and non-organic worlds. It straddles and links the living world of micro-organisms, bacteria, fungi and plants, and the non-living world of humus, mineral grains, bedrock, atmosphere, and precipitation. Soil also represents the dynamic interplay between climate and geology, as it manifests the action of climate upon rock through the phenomena of erosion and weathering in soil formation. Soil is used in ecological land classification to delineate the boundaries of ecosections and ecosites, two levels in the NBELC structure.

Glacial Processes and Soil Deposits

The landscape of New Brunswick is covered with a relatively fresh mantle of soil material composed of rock and mineral

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fragments that have been influenced by the crushing, grinding, washing and sorting processes associated with advancing and retreating glaciers. The mantle is 'fresh' in the sense that the glacial activity which ended 11,000 years ago exposed much unweathered rock and minerals to weathering and soil formation, whereas areas outside the farthest southern extent of the Laurentide ice sheet (Connecticut and points south) are covered by relatively old soils that have been in place for a much longer period of time.

Landscapes dominated by basal till deposits. Because basal tills were spread uniformly by advancing ice sheets, the surface shape of the land reflects the shape of the underlying rock..

Basal Till Deposits

We must now imagine an advancing glacier as it gathers together soil, gravel, and boulders into its mass. It then grinds it into paste, and smears this crushed rock and mud mixture over bedrock beneath the glacier, not unlike peanut butter spread over a cracker with a knife. Soil deposited in this type of environment is known as basal till; it is relatively fine textured and compact below the rooting zone, a legacy of the huge weight of the ice bearing down on the material at its base. Basal till tends to conform to the shape of the underlying bedrock. It may be between 0.5 m to 20 m or more in depth, but is, on average, about two metres thick in New Brunswick. This is the predominant type of glacial deposit covering the hilly uplands of the province. Compared with other types of glacial deposits, basal tills have good nutrient-holding capacity related to their higher silt and clay content. Soils that are high in silt and clay and low in sand and gravel have a greater total surface area per volume of soil to which nutrient molecules may adhere. As we will see in Chapter 5, soil nutrient content has important implications for vegetation.

Ablation Till Deposits

Ablation tills are formed as glaciers melt and retreat. As the late

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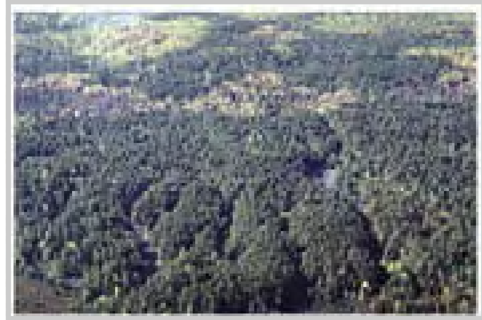
Pleistocene sun beat down on the tops of the glaciers, it exposed some of the rocks and rubble tied up in the glacier's mass. Exposed rocks absorbed heat from the sun and accelerated the process of melting around them, making holes in the glacier into which more and more gravel, sand, and mud would fall. With continued melting, the holes in the ice containing this debris would become inverted, the debris coming to rest as mounds on the earth's surface once the melting was completed. Today, well developed or typical ablation deposits appear to be dumped mounds of boulders, stones, cobbles, gravel, and coarse soil, the tops of which are separated by distances of perhaps 100 to 200 metres. The intervening hollows between the mounds are typically poorly drained forest or wetland. In some circumstances, drainage of the land is impeded to the extent that lakes or ponds form behind ablation deposits. Due to washing of the material as a glacier melts, ablation till lacks the silt and clay content of a basal till, is coarser-textured, and tends to support plant communities tolerant of nutrient-poor, acidic soil conditions.

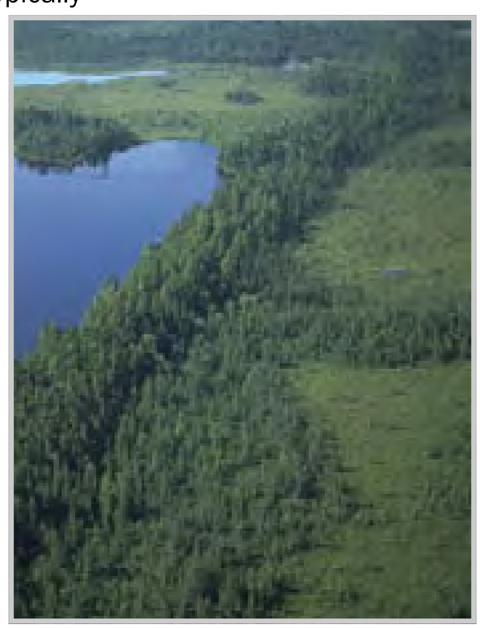


Examples of ablation till deposits. The surface shape of ablation tills reflects the shape and thickness of the glacial deposits themselves, and not that of the bedrock.

Glaciofluvial Deposits

Glaciofluvial deposits are typically well sorted deposits of silt, sand, and gravel. These deposits formed in the rush of water while the great continental glaciers were melting. They are the ancient fans, beaches, and gravel bars that formed in proximity to immense rivers that drained meltwater from the retreating ice sheets. A unique form of glaciofluvial deposit is an esker, which is typically deposited in a meltwater tunnel inside a melting glacier. Eskers are long, snake-like ridges of sand and gravel.

An esker at Little Tomoowa Protected Natural Area.



Organic Deposits

Organic, or peat, soils have formed since the retreat of the glaciers in cool, poorly drained, acidic environments where the growth and accumulation of (typically) sphagnum moss exceeds its rate of decay. The thickest peat deposit on record in New Brunswick was recorded at Gallagher Ridge and measured 9.9 m thick. The average depth of the larger peatlands is between 2 m and 3 m.

Recent Soil Deposits

Other soils have formed in relatively recent, post-glacial time. These include the intervale soils found along the major

The Juniper Barren has a remarkable variety of wetland types.

Top: Riverlain recent soil deposits near Jemseg. Below: Mudflats are recent soils deposited in a marine environment.

river valleys and the tidal soils that underlie the brackish estuaries where rivers meet the sea. Both soil types are formed when silt-laden water settles over the land during high-water times that coincide with the seasons or the tides. The soils are favoured for agriculture because they are virtually stone-free, moist, and enriched by seasonal floodwaters carrying silt, clay, and other organic materials.

Soil and Nutrients

Nutrients are the chemical elements or simple mineral and organic compounds used by plants and animals to obtain energy or develop cellular matter. A forest ecosystem receives its nutrients from three basic sources. Some are derived from the breakdown of forest litter, such as fallen leaves, branches, and animal wastes, while others, such as nitrogen and sulphur, can be drawn from the atmosphere and incorporated into plant material by specialized organisms. The ecosystem's primary nutrient source, however, is the soil parent material, called regolith. Regolith is the layer of unconsolidated silt, sand, gravel, and rock fragments that overlies bedrock, but lies beneath the live soil layers containing roots and soil organisms. An important attribute of regolith is the lithology, or geological rock type, of its constituent rocks and pebbles.

The regolith is the main source of calcium, magnesium, phosphorus and potassium, which, along with nitrogen and sulphur, are known as the macroelements because they are used by plants in relatively large quantities. The regolith is also the source of a number of microelements, or trace minerals, which,

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although used in much smaller quantities, are still required for plant growth. These include iron, manganese, copper, zinc, boron, molybdenum, chlorine, and cobalt.

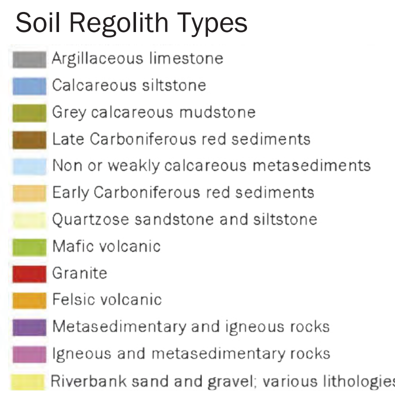
In order to gain a more detailed understanding of the relationship between soil, regolith, vegetation and forest growth, scientists have compiled nearly half a century's worth of soil data into a detailed forest soil map.

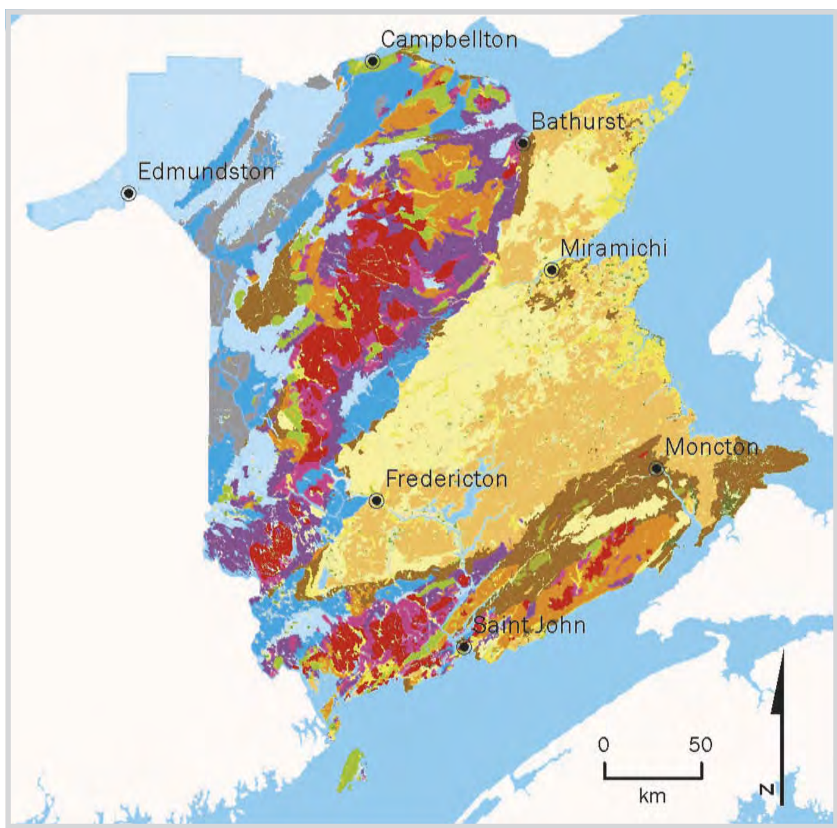
The Forest Soil Map

A map called the Forest Soils of New Brunswick identifies forty-six different forest soil units based on lithology of the regolith, soil texture, method of deposition, and other factors. In addition to glacial tills, three other soil genesis types are identified: floodplain soils (interval and tidal), organic soils, and an anthropogenic soil composed of mining debris. A simplified version of the map is presented on this page.

The map allows us to predict the potential of each soil unit to supply elements important in plant nutrition. This potential depends mainly on the mineral composition of the primary rock types found in the soil. First, as mentioned above, the regolith is the source of a number of plant nutrients, with different rock types containing different amounts of these elements. In addition, mineral composition, especially the richness of calcium, magnesium and potassium, plays a major role the soil's ability to buffer or neutralize acidity.

Soil acidity is influenced by acid precipitation, by the weathering of rock types, and by certain organic processes. Its influence on the availability of various nutrient elements to plants is complex. Most nutrients are most readily available in slightly acid to neutral conditions (pH range





from about 6 to 7). At extremes of acidity and alkalinity, different ions increase in availability, even to levels of plant toxicity. However the occurrence of such extreme conditions are rare in New Brunswick, particularly in the high pH range

While some important elements, such as nitrogen, are not a component of the regolith, the regolith is very influential on the acidity of the soil chemical soup, which is in turn influential on the biological processes that incorporate nitrogen into soil. For example, nitrogen-fixing bacteria are more active in soil of low acidity. Thus, nitrogen incorporation is indirectly related to regolith type.

A second biochemical means by which regolith affects soil fertility is through the effect of soil acidity on the breakdown of soil organic matter. Dead organic matter in the ecosystem is an important source of recycled nutrients. In order for the nutrients held within dead tree stems, sticks, leaves, insects, roots, skeletal remains and other detritus to become available to plants, there must be breakdown of those materials into simple molecular components. Soil dwelling insects, earthworms, nematodes, and numerous micro-organisms, such as bacteria and fungi, perform this essential service. In extremely acidic environments, such as the surface layers of a peat bog, very little or no decomposition occurs. On the most productive forest sites for tree growth, detritus on the forest floor is rapidly broken down and drawn into roots and into living biomass. The depth of litter on the forest floor is a good predictor of overall soil fertility and forest productivity.

Lithology and Fertility

Rock types containing minerals with elevated concentrations of calcium, magnesium, and potassium generally weather into less acidic soil types than do rocks containing minerals low in these elements. In New Brunswick, the best lithological sources of calcium, magnesium, and potassium include limestone, calcareous sedimentary rocks, feldspathic sedimentary rocks, and mafic igneous rocks. Limestone and calcareous sedimentary rocks contain relatively high concentrations of calcium and/or magnesium carbonate. Feldspathic sedimentary rocks contain some calcium, potassium or sodium, and can yield moderately fertile soils, whereas siliceous or quartzose sedimentary rocks are high in quartz, but low in nutrient elements.

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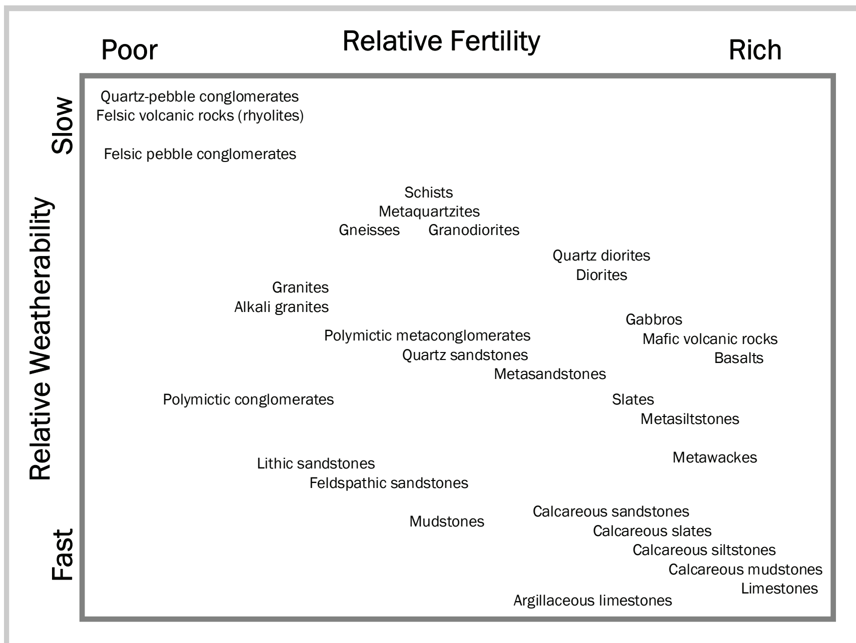
Felsic igneous rocks, such as granites and rhyolites, have a high quartz content, but a relatively low percentage of minerals containing the nutrient elements. They often weather very slowly. Mafic igneous rocks, however, contain minerals that are rich in iron, calcium, and magnesium, and consequently can yield moderately fertile soils.

Weatherability

Relative weatherability is an important factor in assessing the potential fertility of a forest soil unit. Rocks that weather or break down readily yield more nutrients than do rocks that resist weathering.

Among the sedimentary rocks, calcareous sedimentary rocks and limestone weather the most rapidly of all rock types under moist conditions, as they react chemically with the carbonic acid often found in precipitation and groundwater.



Rock types shown here are plotted according to their relative fertility and weatherability. Rock types producing nutrient-poor soils appear in the upper left, and rock types associated with rich soils are in the lower right.

Next in weatherability are the non-calcareous sedimentary rocks with a significant clay component, such as greywackes, mudstones, and siltstones. Clay particles resemble tiny, loosely connected mineral wafers and have an extremely high surface area relative to their volume (not unlike a stack of soda crackers). Water and acids are able to penetrate deeply into the interior of the grains to pry loose essential nutrients. The exposure of such a large surface area to the weathering agents of water, wind, sun and ice can result in rapid weathering.

Sandstones are less easily weathered, because sand grains display low surface area relative to volume (a sand grain as a solid glass ball comes to mind). Water and acids may pluck nutrients only from the outer surface of the grain. Feldspar grains, also a constituent of many types of sandstone, are more susceptible than

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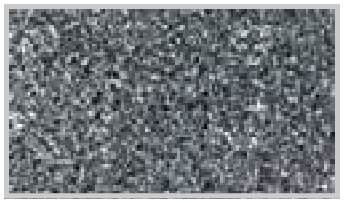
quartz grains to chemical weathering; *feldspathic* sandstones therefore disintegrate more quickly than *quartzose* sandstones.

Mineral grains in sedimentary rocks essentially are ‘glued’ together by a cementing matrix. Igneous and metamorphic rocks, in contrast, are “fused” together in an interlocking pattern that makes them less easily weathered than sedimentary rocks.



Smoothed rock surfaces reveal the mineral composition of felsic (above) and mafic (below) igneous rocks. Note the contrasting light and dark coloration.

Mafic igneous rocks generally contain minerals bearing calcium, iron, and magnesium. These minerals undergo chemical weathering more quickly than do the siliceous minerals in felsic igneous rocks. The weatherability of metamorphic rocks varies with their relative content of mafic and felsic minerals. The highly foliated, intensely compressed rock types, such as schist, tend to weather more slowly than do the less foliated types, such as slates.

Soils and Ecological Land Classification

The approach to soil mapping used in producing the *Forest Soils of New Brunswick* is unique in that it focuses on features known to affect natural soil fertility, in addition to the other features noted above. This contrasts with more traditional approaches to soil mapping that focus less on lithology and inherent fertility. This aspect of soil mapping allows us to indirectly categorize the nature of the soil solution containing the nutrient elements that help to determine the rate of ecosystem processes, such as growth and decay. Scientists, managers and educators also have used the map to describe habitat and ecosystem types, to search for occurrences of rare flora and fauna, and to develop research, planning and conservation tools.

Conclusion

This chapter has described the geological pre-history of New Brunswick that explains both the unique physical layout of highlands, uplands, and lowlands, and the reasons why the province is so geologically diverse. It has also described the present day climate and related this to broad scale topography. The chapter concluded by describing forest soil and how its influence on plant growth is related to lithology and the mineral composition of rocks. The next chapter continues the story of ecological land classification by broadly describing the sweep of human history from glacial times to the present and speculating on how this has influenced the makeup and character of ecosystems.

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