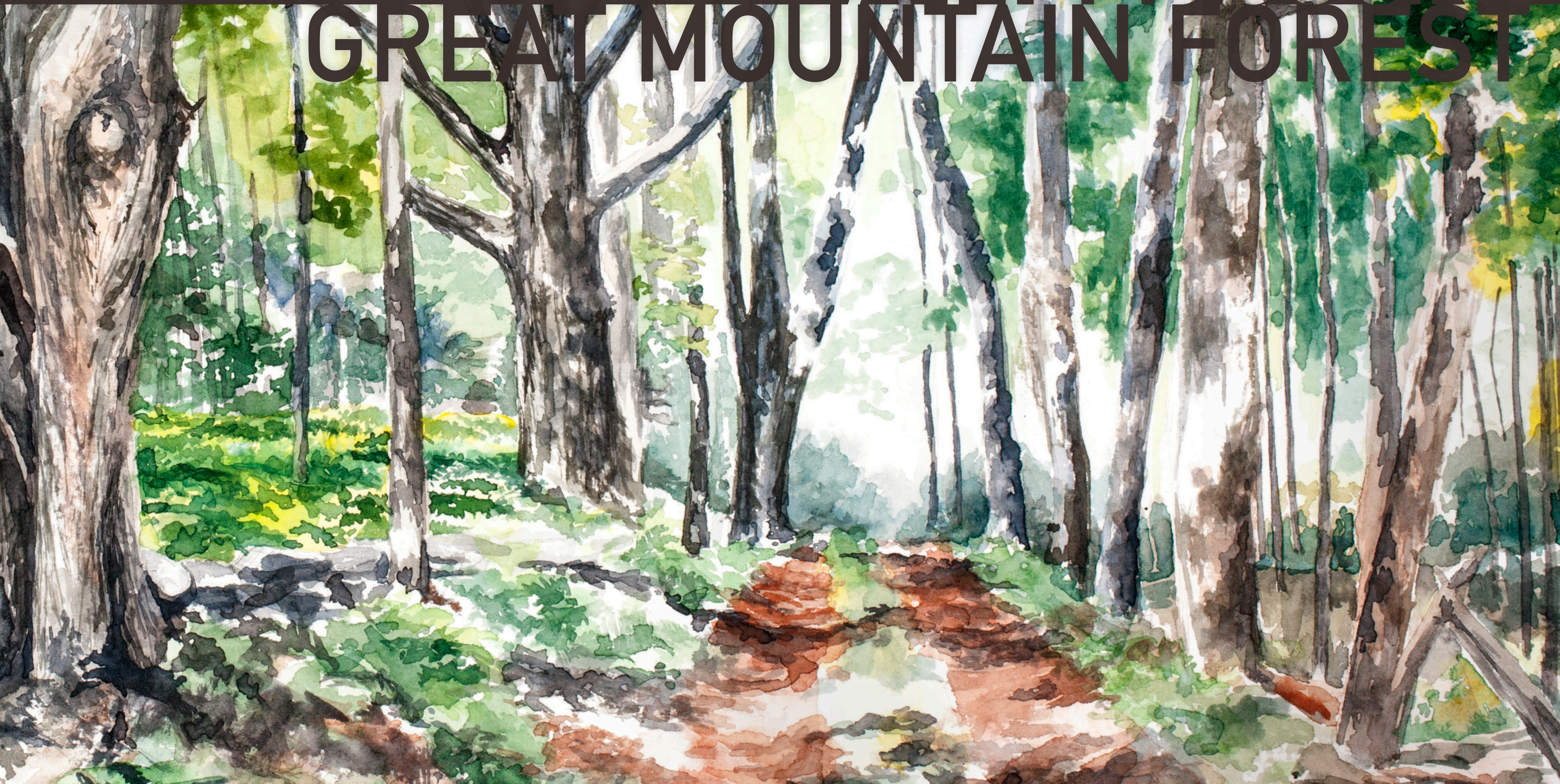
A FIELDBOOK
GREAT MOUNTAIN FOREST



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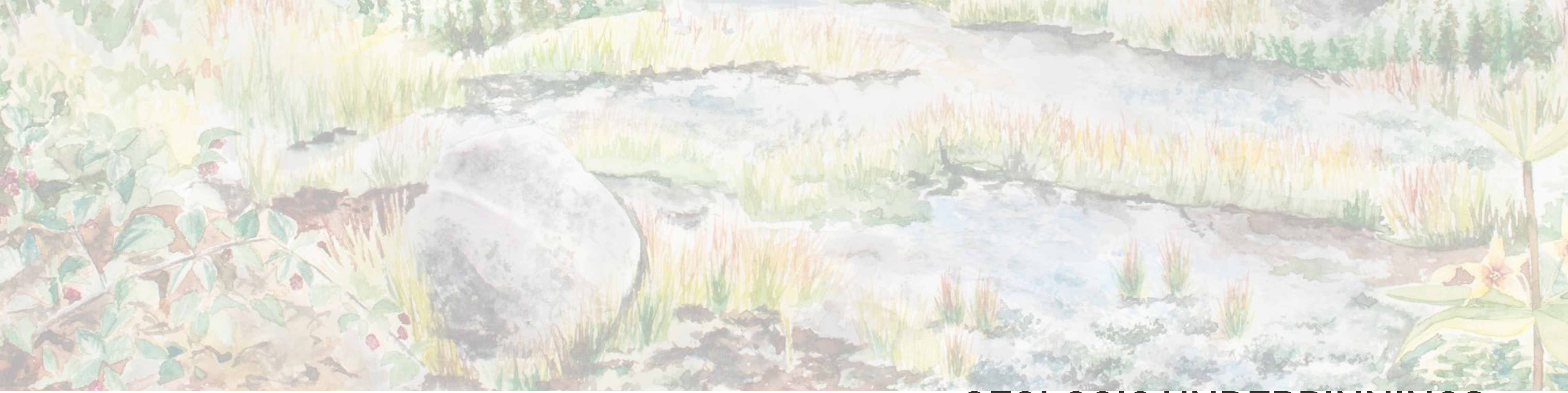


GEOLOGIC UNDERPINNINGS

THE PHYSICAL LANDSCAPE OF GREAT MOUNTAIN FOREST

Understanding a place, from its specific vegetation and fauna, to the various ways people have approached and shaped the land, necessitates beginning with geology. At GMF (as elsewhere) its nature and the history trace back to its geologic foundation. The cold summers ("Connecticut's Icebox") are driven by geology. The acidic, poor agricultural soil is driven by geology. The dominance of oak, northern hardwoods, and hemlock, is driven by geology. The rich talus wildflower community owes its existence to geology. The Forest's charcoaling history happened because of geology. And, the fact that a 6000-acre block of protected forestland exists in northwest Connecticut is, in fact, driven by geology. This brief introduction to the geologic story of Great Mountain Forest, and by extension Northwest Connecticut and New England in general, is intended to provide the reader enough geological background so they can more fully appreciate the complexity in the sites characterized in this document.

There are two critical background topics to review before any understanding of geology can take place. First, are the basic rock types. Geologists describe three basic rock types: igneous, sedimentary, and metamorphic. Igneous rocks began as molten lava beneath the surface of the earth. Igneous rocks may cool above the surface as a volcano (extrusive igneous rocks), or they may cool and harden deep below the surface (intrusive igneous rocks). Granite is an intrusive igneous rock. Sedimentary rocks are composed of eroded material, deposited and later coalesced into rock. Sandstone (derived from deposited sand) and limestone (from deposited marine shells) are sedimentary rocks. Metamorphic rocks may have begun as Igneous or sedimentary rocks, but then deep below the surface the forces of heat and pressure alter the rock enough that it recrystallizes. Metamorphic rocks may be "cooked" or squished multiple times and/or to varying degrees. Great Mountain Forest contains metamorphic rocks derived originally from sedimentary and igneous rocks. Northwest Connecticut contains all three types of rocks.

The second background process needed to understand geology is plate tectonics. The theory posits that the Earth's surface is broken up into a system of plates and these shallow lithic rafts float on a molten mantle. Slowly, through convection processes, the plates move around, coalescing, subducting, scraping, and bumping into one another. This process gives rise to volcanoes, mountains, earthquakes, and even the continents and oceans themselves. Plate tectonics is the driver that creates and erodes rocks and thus forms sedimentary, igneous, and metamorphic rocks.

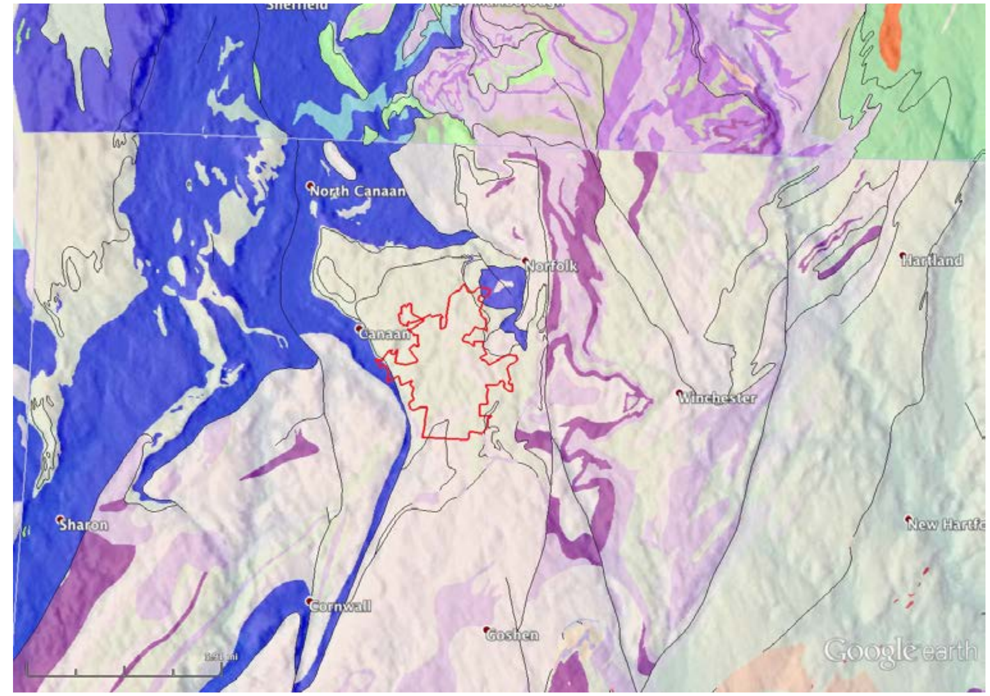
GEOLOGIC EVENTS

Geology is a vast topic and a proper understanding involves more depth and breadth than is provided here. Nonetheless, with important elements of geological background behind us we can outline the story of GMF's foundation.

Earth is 4.6 billion years old. For this description, however, we will fast-forward through the poorly understood first 3.5 billion years and begin with Connecticut's oldest rocks. The table on page 3 outlines the last billion years of geologic processes in Connecticut.

The hard, old gneiss, mainly metamorphosed granite, appear as purple and lavender areas of the map. These are the overthrust blocks heaved up during the Taconic Orogeny. The map shows the Housatonic Massif in the west and the Berkshire Massif in the east as mainly purple/lavender areas.

The marbles of the Stockbridge Formation (blue colored on map) occur largely in the valleys of Canaan, Salisbury, the Hollenbeck River, and Norfolk. Marble is softer and thus more prone to erosion. The Norfolk marble area, referred to as the Norfolk Window, is a peculiar one. The overlying Canaan Mountain Schist (overthrust) was folded in such a way as to erode, exposing a window into the younger marble below. As metamorphosed limestone, made largely of calcium carbonate marine creatures and sediments, marbles create rich soils for forests and agriculture. GMF contains two areas with marble: around Toby Pond, where it doesn't expose, and the Chestnut Orchard and the Rich Talus Slope in the west. Those sites are described in this book.



General geologic map of Great Mountain Forest (red boundary) and surrounding areas of Northwest Conn. (Geologic layers from USGS)

Stockbridge Marble, Cambrian age: Forms small areas of GMF at low elevations near Tobey Pond and the Talus Slope (Natural Communities) and Chestnut Orchard (Forest Management).

Gneiss of Proterozoic age: oldest rocks in Conn. Forms a small portion of southern GMF.

Canaan Mountain Schist of Cambrian age: Forms the majority of GMF rock and is exposed on rock outcrops of the Matterhorn, Stoneman, Collier's Cliff, and Blackberry Hill (see Bedrock Sites).

Dalton Formation quartzite of Cambrian age. This is believed to be the nearest site for pure quartzite (metamorphosed sandstone) and may be the source of the stones at the Dean Farm (see Land Use History Dean Farm).

The non-descript beige areas, which form the majority of GMF, are Canaan Mountain Schist. The rock began as sediments along the continental margin, probably eroding off the Grenville Mountains. The slabs were thrust westward during the Taconic Orogeny. Canaan Mountain Schist is much more resistant to erosion than marble and therefore forms the highlands whereas marbles form the valleys.

Several of the geological events noted in the geologic timeline do not play out directly in Northwest Connecticut rocks and landforms.

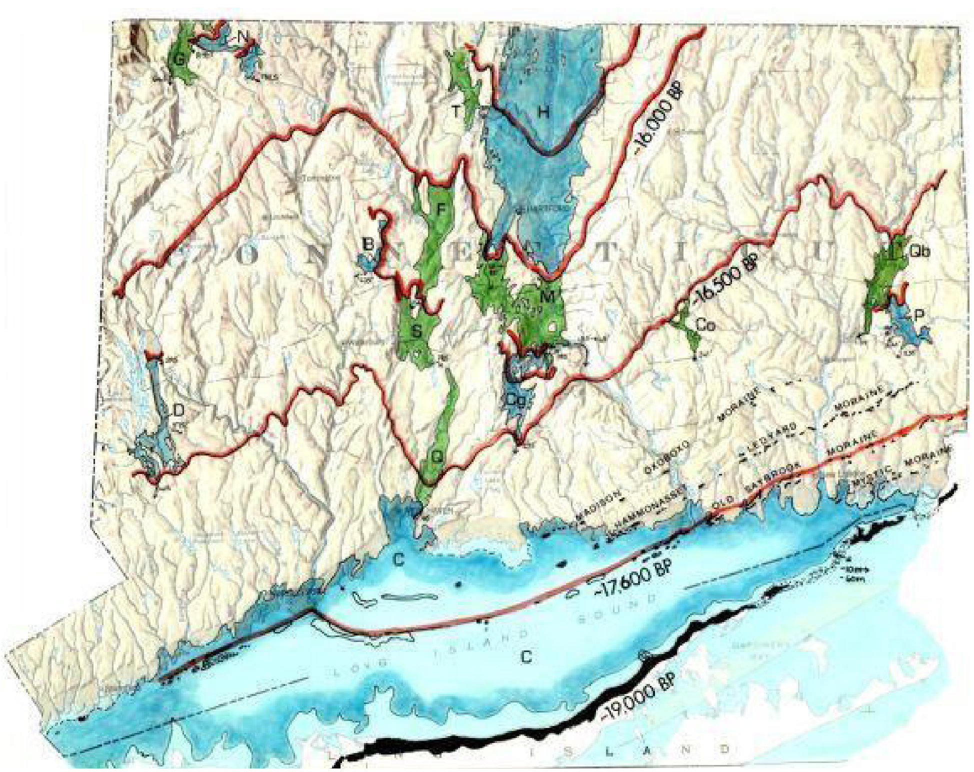
CONNECTICUT'S OLDEST ROCKS

YEARS BP	AGE	EVENTS SHAPING GREAT MOUNTAIN FOREST / NORTHWEST CONNECTICUT
1 Billion +	Middle-Proterozoic	Grenville orogeny mountains rise from the formation of the supercontinent Rodinia. Metamorphosed gneiss from this event forms the bedrock of the Housatonic, Berkshire, and Hudson Massifs in western Connecticut. These are the oldest rocks in the state.
750 million	Late Proterozoic	Rodinia rifts apart forming the continents Laurentia and Gondwana. The gneiss, now western Conn., formed the east coast of Laurentia at the time.
500 million	Cambrian	Marine sediments, in an environment similar to today's Bahamas, settle in the sea east of Laurentia. These limestones will later metamorphose into Stockbridge Marble (metamorphosed limestone). Eroded sediments settle on the continental slope that will later metamorphose into Canaan Mt. Schist (the dominant rock of GMF). Schist is a meta-sedimentary rock.
450 million	Ordovician	Taconic Mountain orogeny ensues as an island arc similar to present day Japan, collides with Laurentia. In the process marine rocks are scraped up and thrust overtop existing continental rock layers, placing older layers atop younger layers. This includes thrusting Canaan Mt. Schist, the dominant GMF rock. The heat and pressure created by the collision metamorphosed and folded the sedimentary rocks. Thus today we find folded marbles, quartzite, schist and other metamorphic rocks from the collision. The original island volcanoes occur today as a line of meta-igneous domes in west-central Connecticut.
400 million	Devonian	Avalonia microcontinent collides with Laurentia causing increases in pressure on the abovementioned rocks and sediments furthering metamorphism of the rocks.
275 million	Permian	Additional landmasses coalesce and form supercontinent Pangaea.
200 million	Jurassic	Pangaea rifts apart and opens the Atlantic Ocean. The Hartford basin of the Connecticut River valley forms as a failed rift valley where Pangaea split. Basalt ridges found from New Haven to central Mass. in the Conn. River valley form as a result of crustal thinning volcanism in the rift valley.
2.5 million	Pleistocene	Begins Pleistocene Ice Age of repeated glacial and interglacial periods.
21,000	Late-Pleistocene	Most recent glacial maximum; Laurentide Ice Sheet reaches its southern-most extent. Connecticut is covered by ice. Long Island NY forms as a terminal moraine deposit from eroded Connecticut sediments. Contemporary topography of GMF is shaped.
16,000	Late-Pleistocene	Ice melts south to north and GMF landscape is revealed. Large glacial lakes occur in Long Island Sound, Connecticut River Valley, and NW Conn. Glacial Lake Norfolk and Glacial Lake Hollenbeck, to the northeast and southwest of GMF respectively, occurred as ice-dammed glacial lakes. Glacial Lake Great Falls occurs as sediment-dammed lake.
10,000-present	Holocene	Present interglacial period. Vegetation spreads from south stabilizing glacial sediments and building soil. With warming and cooling climate, GMF sees tundra, spruce forest, and deciduous forest. Humans enter and hunt megafauna-mammals to extinction. They shape the landscape to their ecology. Europeans enter and additional extinctions occur, native culture is largely eliminated, and land largely deforested. Later forest returns. Substantial amounts of carbon are added to atmosphere from deforestation and burning ancient plant matter. Humans dominate most aspects of land cover, hydrology, and many wildlife populations.

Therefore we gloss over 300 million years of time because no features from that period occur in Northwest Connecticut. From here, then, we move on to the effect of Pleistocene glaciations, especially the recent Wisconsin glacial period.

The Laurentide Ice Sheet had its origins in what is today northeast Canada. A cooling Earth allowed snow to accumulate faster than it melted. Like metamorphic rocks, when snow is put under pressure the crystals change to form glacial ice. The ice is plastic, meaning it bends and flows under its own weight and the forces of gravity. The ice, therefore, oozed down from Canada shaping the landscape as it went.

The flowing glacier carried rocks, gravel and other material to create a sandpaper-like mechanism on the landscape. Mountains were smoothed over, valleys deepened, and material moved. The original



Map of glacial retreat in Connecticut. Red east-west contours show dates of glacial melting. Green and blue show post-glacial lakes. Note Glacial Lake Norfolk on the northwest corner. The lakes are identifiable today from lacustrine (lake bed) sediments. Map source: Long Island Sound Resource Center, University of Connecticut, after Stone et al., 2005.

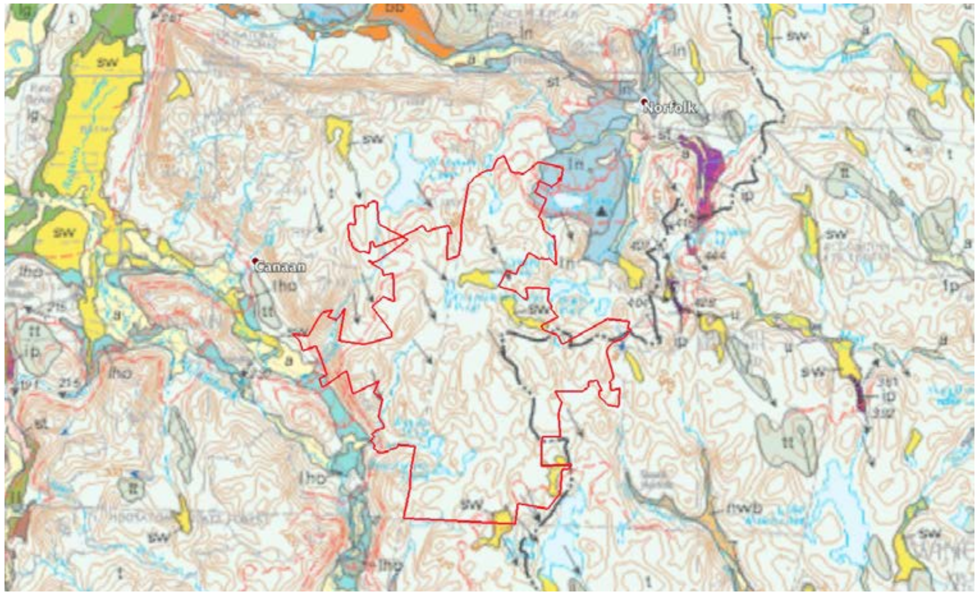
topography guided the ice's direction, and the specific bedrock types were altered according to their properties for resisting erosion. Soft rocks rapidly eroded, while hard rocks resisted erosion.

With larger-scale planetary processes driving small changes to climate, the great ice sheet reached its peak at 21,000 years, and melted back from south to north thereafter. The map at left shows how that process occurred on Connecticut's landscape. By about 16,000 years ago, the area of GMF was deglaciated, with melting, glacial lakes formed as a result of sediment dams and ice-dams. The map left shows the glacial lakes of Connecticut. Glacial Lake Norfolk was an ice-dammed lake formed at about 15,500 years ago and a later lake formed just to the north. Today Tobey Pond remains in the bounds of Glacial Lake Norfolk.

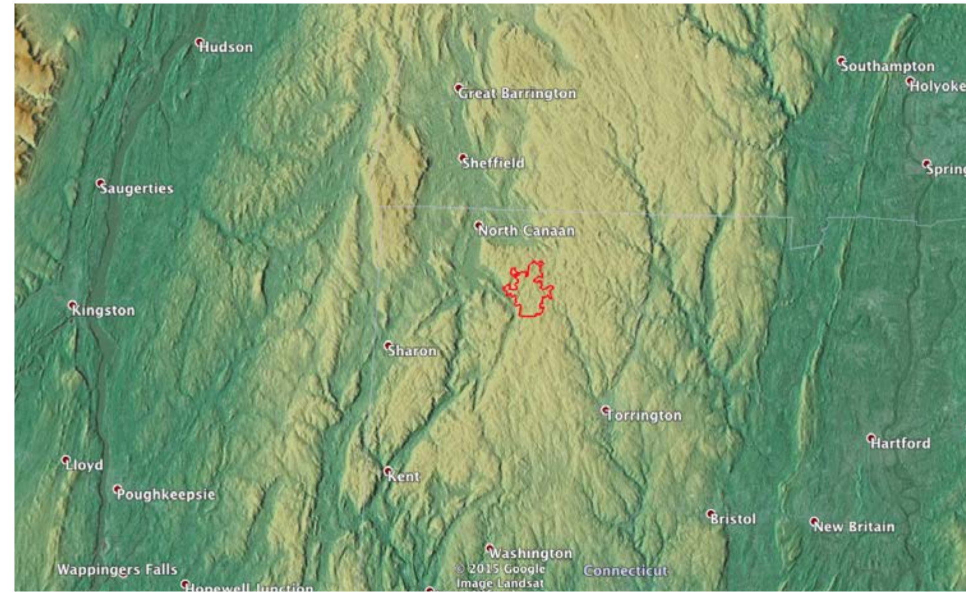
The uncovering of the landscape from tens of thousands of years of glacial cover, revealed one full of erosional and depositional geomorphic features. Erosional features include contemporary lakes, valleys, and smoothed-over mountains. A particular erosional feature, called a roche moutonnée is named for the wigs worn by French elites in the 1700s. The landform has a long gentle approach on upstream side created by the ice smoothing it (remember the sandpaper) and then a steep cliff on the downstream side created by ice plucking bedrock as it rode over. Since ice moved north to south in New England, we find many south-facing steep slopes and cliffs in Connecticut and Great Mountain Forest. The steep slopes above Wampee Pond, Wapato Pond, and Crissey Pond are all such features. The depression below (the ponds or originally wetlands) were formed from the increased pressure of downward flowing ice below the steep cliff. Such a pond is called a tarn.

Depositional landforms are created when a glacier deposits material. Long Island, NY is a terminal moraine deposit from the southern extent of the Laurentide Ice Sheet. Eskers, long meandering piles of material carried as a streambed flows within a glacier are created after the ice melts away, and a snake-like relief of unconsolidated sediments remains. Eskers occur near Tobey Pond. Glacial till consists of unsorted sands, gavel and boulders left as a glacier melted. Most of GMF is covered in glacial till. It's hard not to find boulders and stones on the ground in Great Mountain Forest.

The map on page 5 (please forgive its lack of sharpness) shows the boundary of Great Mountain Forest on a USGS map of glacial geology by Stone et al. (2005). Northeast of GMF, including the area of Toby Pond and Toby Bog is the light blue Glacial Lake Norfolk. Within that, red dashed lines show moraines from glacial deposition. The black arrows



Great Mountain Forest boundary (in red) on Glacial Geology Map (Stone et. al, 2005). Villages of Norfolk and Canaan shown.



Topographic relief and position of Great Mountain Forest (red outline) in the tri-state area between the Hudson and Connecticut Rivers. Terms described in the text.

indicate the direction of travel of the ice, which at GMF was south to southeast. Yellow shows postglacial swamps we see today. Note a small piece of Glacial Lake Hollenbeck on the west edge of GMF. This, today, is the site of the Chestnut Plantation. The majority of GMF has no color on the map, which indicates glacial till, the random unsorted deposit of sand, silt, gravel, and boulders. A walk in GMF reveals this. It's typical of rocky uplands in postglacial environments. The more interesting depositional features (lakebeds, moraines, etc.,) tend to occur in valleys.

GMF IN CONTEXT

Finally, the contemporary landscape is revealed showing Great Mountain Forest's topographic position. The specific topography - the uplands, valleys, and rivers, is driven by the geologic story discussed above, and the final shaping by repeated glaciations. The biologic landscape – the flora and fauna – responds to this. For example, rattlesnakes find habitat on the steep south-facing, warm rocky slopes of a roche moutenee. And red spruce trees inhabit the low, cool, moist bottomlands. In time, culture followed these cues with settlement occurring primarily in the rich marble valley soils of the Stockbridge formation and later, and only temporarily, in the cool, acidic, poor upland regions of GMF and elsewhere.

A few additional aspects of the physical landscape worth mentioning specifically:

Geographic Terminology

The shaded relief map provides labels of the upland areas of inland southern New England. The Taconic Mountains occur mainly along the borders of New York and Vermont, Massachusetts and Connecticut. As noted previously, though the Canaan Mountain Schist of GMF was an overthrust of the Taconic Orogeny, it is not considered a part of those mountains. The Housatonic Valley defines the Taconic's eastern edge. (Recall valleys erode easier and they show a weakness where different physical provinces meet.) The Berkshires include the mountains and hills of western Massachusetts, east of the Taconic Mountains. They are geologically a part of the Green Mountains of Vermont; the Berkshires is a cultural term for the same physical feature. Similarly, the Litchfield Hills is a cultural name for the same geologic feature occurring in northwest Connecticut.

Elevation

Great Mountain Forest averages approximately 1500 feet (450 meters) in elevation. The highest ridges reach over 1750 feet (530 meters), while the lowest point occurs at 730 feet (220 meters) in the Hollenbeck Valley at the American chestnut plantation.

Hydrologic setting

Great Mountain Forest sits in a high upland of the Housatonic River watershed. It sits on a watershed divide: the north section drains northeast into Spaulding Brook, which feeds the Blackberry River, and on to the Housatonic; the western extent drains into Wagnum Brook, through GMF, down to the Hollenbeck River Valley, joining the Housatonic River near Robbins Swamp; areas in the southwest of GMF drain through small tributaries to the Hollenbeck River; and areas in the southeast drain through small streams and reservoirs and eventually into the Naugatuck River. The Naugatuck joins the Housatonic almost 50 miles from GMF, just 10 miles from Long Island Sound.

Soils

The study of soil is perhaps the least appreciated component of ecosystem science. Soil is formed by the interactions of five components: parent material; climate; organisms; topography; and time. The soils of New England are largely driven by glacial activity. Most of GMF contains glacial till. A few areas contain swamp soils or lacustrine glacial lakebed sediments. In terms of plant productivity, generally, deeper, mesic, nutrient rich soils are best, for both forests and human uses. GMF does not contain many of these soils, and for that reason agriculture was short-lived, and today forest dominates.

Places to observe geologic features in Great Mountain Forest

Geology can be observed anywhere in Great Mountain Forest. Listed in the Geologic Special Places are sites to find specific bedrock types, glacial features, and locations where the physical landscape (geologic and geomorphic) meets the cultural one.

RESOURCES

Skehan, James. 2008. Roadside Geology of Connecticut and Rhode Island. Mountain Press Publishing. Long Island Sound Resources Center. 2011. The Grain of the Land. Retrieved from: http://www.lisrc.uconn.edu/lisrc/geology.asp?p2=History&p3=glhct

Stone, Janet, et al. 2005. Quaternary geologic map of Connecticut and Lond Island Sound basin. United States Geoogical Survey and Connecticut Department of Environmental Protection, Geological and Natural History Survey. http://pubs.usgs.gov/sim/2005/2784/