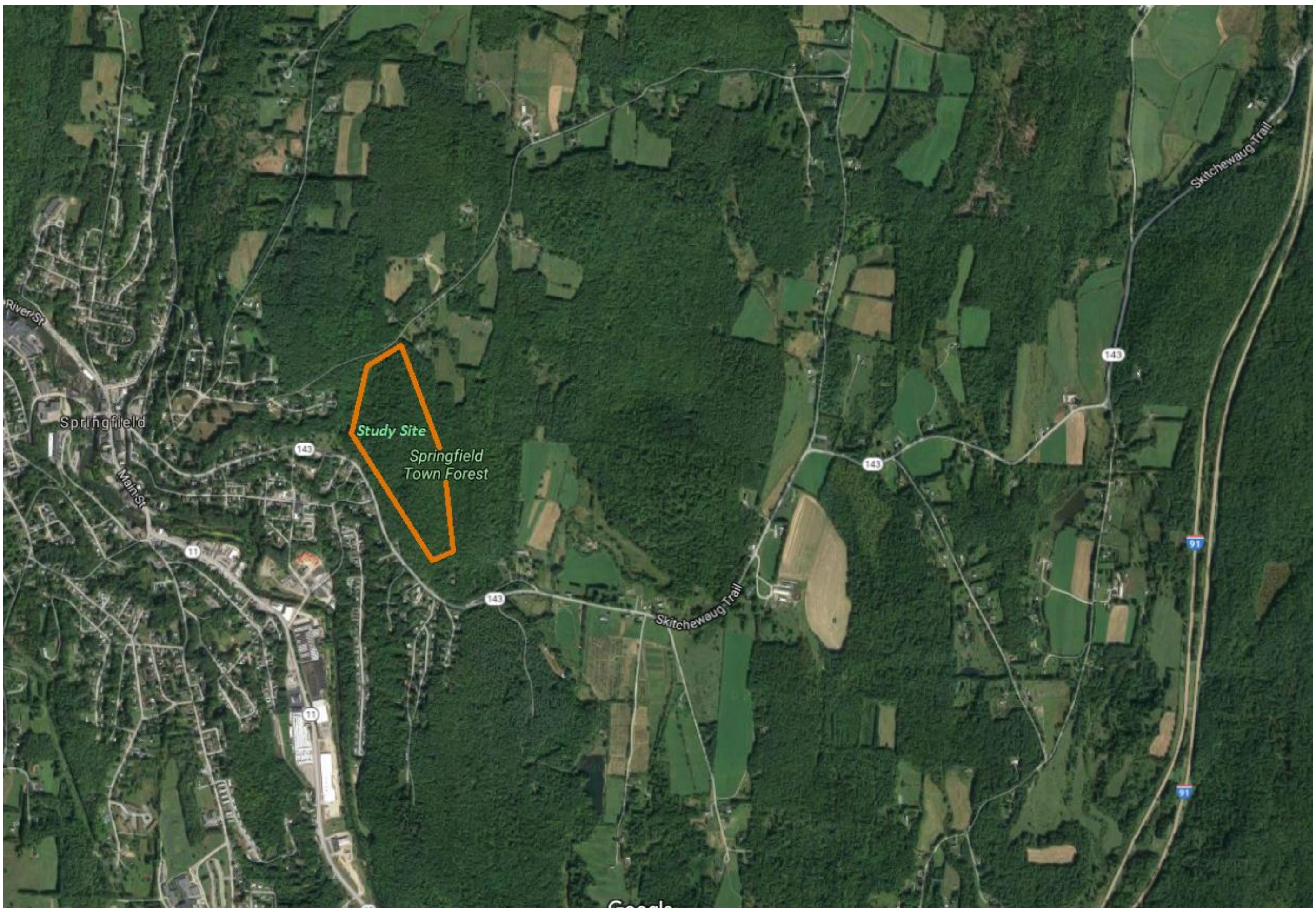
Springfield Vermont Town Forest: Explorations in Springfield's Natural History Through Hartness Park

Study Site Overview

The area of study is an approximately 70 acre tract of Hartness Park land within the Springfield Town Forest in Springfield Vermont. Elevation varies drastically inside the park, altitude ranges between 600 to 850 feet: From the Dell Road entrance (the most Northwestern corner entrance), elevation changes by 200-250 feet in as little as .15 of a mile – in other words, you're going just as far up as you are across! Inclines in many areas are well in excess of 45 degrees and there are numerous rock outcrops. The site is approximately 1/3 a mile from the Black River at the closest point, which discharges into the Connecticut River 3 miles downstream. It is two miles from I-91, and is nestled adjacent to downtown Springfield.



History

Hartness Park was once part of the large estate owned by former Vermont Governor James Hartness. James Hartness was elected the President of the The American Society of Mechanical Engineers 1914, and Governor of Vermont in 1920. He was extremely successful, and owned a large segment of Springfield. Located on a steep hillside, Hartness Park was given to the Town of Springfield by Governor James Hartness in 1934, with the intention that the Park should be maintained by the Town and its citizens for public use as a picnic and recreation area. The area was classified as a Town Forest in 1955. The steep terrain of part of the park was used to house the Hillard Hill Ski Area, which housed several ski jumps, including one 40 meter jump that was used to train local high school athletes. The only remaining sign of these earlier developments are tree cuts and a boggy area at the base of where the larger jump landing must have been. Today's recreational use is primarily the trail system. A picnic area can be found on the southern end of the park.

Water/Watershed/Basin

Water plays a large role in Hartness Park. The park is located in the Black River Watershed. A watershed is an area of land that drains water, sediment, and dissolved materials to a common receiving body or outlet. Watersheds exhibit a constant cyclic flow in which an abiotic template of air, water, and soil is formed, upon which life can exist (Introduction to Watershed). One example of the cyclic cycle is the hydrologic cycle, which is the process of evaporation, condensation, precipitation, and runoff.

The Vermont Agency of Natural Resources lists areas of Hartness Park as Riparian Area ("BioFinder"). A band of riparian habitat lies adjacent to all rivers, streams, lakes, and ponds or to the valley bottom. Riparian habitat provides vital habitat for a rich assemblage of aquatic species, including fish, amphibians, reptiles, invertebrates, and plants. A segment of the park is a Riparian Wildlife Connectivity corridor and a small segment is a Highest Priority Wildlife Crossing area. Much of Hartness Park is a Physical Landscape Diversity Conservation area. The watershed for Hartness Park is the Black River Watershed, which is the southern half of the Black-Ottauquechee Watershed, also known as "Basin 10" by The Vermont Agency of Natural Resources. Springfield lies in the southeastern-most corner of Basin 10. The USGS explains that Hydrologic Units define drainage areas for surface water. Hydrologic Units are subdivided into progressively smaller units and each unit of measurement has a Hydrologic Unit Code (HUC) which describes the level of subdivision and the geographic location ("Watershed Boundary Dataset"). The Black River Watershed (USGS HUC: 0108010605) is nested inside the The Black-Ottauquechee Watershed (USGS HUC: 01080106), which is inside the Upper Connecticut Basin (USGS HUC: 010801), which is inside the Connecticut Subregion (USGS HUC: 0108), which is inside the New England Region (USGS HUC: 01). Hartness Park exhibits three primary surface water and water run off features: The primarily western-facing hillside that drains towards town and its numerous drainage channels, the primarily eastern-facing hillside that gently drains into Gould's brook that then feeds Muckross Pond, and ephemeral pools located on the flat summit areas of the ridgeline which dry up by mid-summer. In addition to these natural water features, the location was home to several ski jumps in decades past which resulted in flat areas on the west-facing hillside which form into small boggy areas, one of which lasts most of the summer and provides a water source and breeding habitat for wildlife.

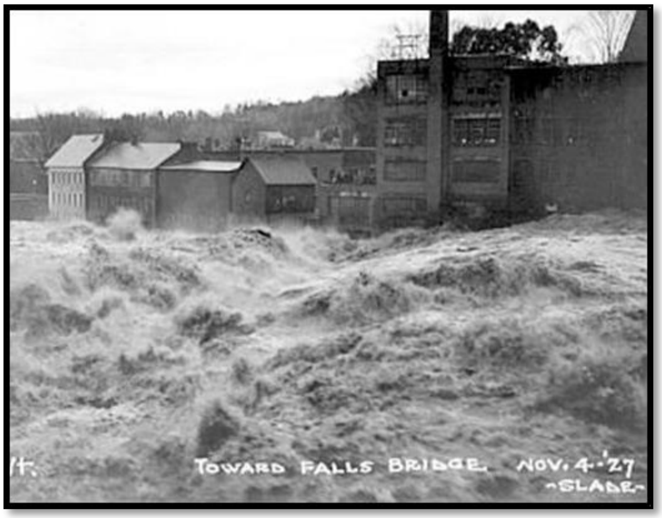
The Springfield Watershed Coordinator for the VT Agency of Natural Resources Department of Environmental Conservation, Marie Caduto, and Black River Action Team's founder, Kelly Stettner, were essential resources for collecting watershed data, and are the local watershed monitors. Due to the rocky ground (see Geology section), much of the precipitation in the area results in overland flow (runoff). Most of the water on the western side of the hill is surface runoff which, other than in a few small areas in which it collects into pools at the downhill locations of the prior ski jumps, feeds via small streams into the Black River. After it leaves the hillside, it feeds into the town drainage system, which carries it under the downtown area via culverts and tunnels and then outlets it at various locations feeding into the Black River. A segment of the western-facing hill near the Dell Road entrance has a flat area which was a former ski jump landing point which collects water and is somewhat boggy. Because of the slope, excess rainwater collected in this area drains down the hill, where it then eventually passes into a ravine with a small year-round groundwater-fed brook at the bottom in the Riparian Area. In the boggy area, there exists a gap in the canopy, allowing grass to grow, arranged in raised clumps and small islands and well mixed with small ferns. This is the only location in the park where significant amounts grass can be found, and it serves as a three season food source for foragers. Numerous instances of streamflow can be found depositing runoff into this basin, as there are many varying land contours that force the runoff into one direction or another, and the hill is curving, so many different angles are involved. On the eastern-facing side of the hill, all runoff feeds into Gould's Brook, which is a tributary of the Black River, and which has been dammed with a small hydro-power dam downstream, to form a pond called Muckross Pond. Muckross Pond has been very recently conserved and given state park status: Muckross State Park. It is well outside the study area but ecologically connected due to a tributary passing through Hartness Park's back side.

Statewide, Basin 10 (The Black-Ottauquechee Watershed) is part of the Connecticut River Drainage Basin, which covers most of Eastern Vermont along the path of the Connecticut River. Basin 10 is divided via a Northern and Southern division, and the southern half is called The Black River Watershed. This is where Hartness Park resides. The Black River Watershed lies within the Southernmost part of Basin 10, and the most recent action plan can be seen at Basin 10 Water Quality. The Black River Watershed is monitored by a nonprofit organization and community action team called Black River Action Team (BRAT), founded by Kelly Stettner. Conservation of the Basin 10 watershed is done in part by The Basin 10 Watershed Council and the Vermont Agency of Natural Resources in partnership with Black River Action Team, who actively sample the Black River at various locations around Springfield. The Black River is 40 miles long, and with its tributaries, drains an area of 202 square miles in Rutland and Windsor Counties along that length. About .70 of a mile of the Black River runs alongside Hartness Park and receives its runoff.

Weather and Climate

Historically, the entire state of Vermont has undergone numerous climate changes. At one point of the Holocene, between about 4000 to 6000 years ago, we experienced a hypsithermal interval (also known as a climatic optimum) which negatively impacted vegetation such as the hemlock, says Yan Zhao et al, in a research paper titled *Hemlock (Tsuga canadensis) declines at 9800 and 5300 cal. yr BP caused by Holocene climatic shifts in northeastern North America*. Although this paper was written about the area of New Jersey, it is safe to presume that quite similar affects were felt here as well. Another smaller scale climate shift was the "Little Ice Age" which occurred between approximately 1200 and 1700, and even smaller, the 1940 - 1942 global climate anomaly. In Vermont in the most recent era, the Holocene, as the ice sheet retreated further north, the temperatures slowly warmed. What was once a cold arid climate moderated to the seasonal patterns of today. In the land of Vermont, during the tail end of the Pleistocene period, glacial till clogged many valleys. Approximately 14000 years ago, Glacial Lake Hitchcock filled the area currently housing Connecticut River valley until around 13500 years ago when the moraine dam disintegrated and drained the primary southern Glacial Lake Hitchcock basin. Slowly, the Connecticut River Valley was cut into the landscape, and land vegetation could take hold. We know that the area was temperate 8000 years ago, when forests of oak, beech, birch, maple, elm, and ash mixed with hemlock and white pine in deciduous-coniferous lowland forests.

Today, the climate of the Southern Vermont Piedmont is some of the warmest in the state. Summer highs rarely break 100 degrees and most summer days sit in the mid 80s to lower 90s, and winters are generally mild, typically ranging in daytime temperatures between 10 to 40 degrees (though it may dip below zero on the coldest nights). Rain is common, and increasingly, thunderstorms often happen multiple times per week in the summer months. It's a bit drier in the winter, although snow accumulation varies with the temperatures it rarely reaches more than a foot deep. Throughout the 1900s, there were numerous flooding events that affected the Black River valley below the park. These dramatic events led to the construction of a flood control dam in North Springfield from 1958 – 1960.



Downtown Springfield VT, 1927

North Springfield Flood Control Dam, n.d.

If weather patterns continue to trend towards increasingly stormy weather, it is likely that more are yet to come. The park itself is not prone to flooding, being on steep terrain, any excess runoff does just that, it runs off. On the ridgeline, small pools of rainwater tend to form, but these are self-limiting in that they have a maximum depth and any excess water will simply overflow and run down the hillside.

Geography and Geology and Topography

Hartness Park is an 85 acres park which sits in the southeasternmost corner of Windsor County in Southern Vermont. The centermost part of the park lies at 43.297193, -72.466099. Altitude ranges between 600 to 850 feet, and the terrain is rugged, with steep hillsides leading up to a flattened ridgeline. Hartness park lies in the rolling hills of the Vermont Piedmont physiographic region.

Over 1 billion years ago, Laurasia (Proto-North America) collided with another continent in the Grenville Orogeny, forming the supercontinent Rodinia. The Grenville belt of continental margin sediment was wedged between the colliding continents and thrust up onto the side of Laurasia. This impact created the Grenville Mountains in our area. These mountains are the earliest evidence of mountain building in our region, and the rocks remaining from that ancient mountain chain are the oldest rocks that we see exposed at the surface in the Northeast today.

The Grenville rocks themselves have quite a story. The intense heat and pressure generated from the collision produced volcanic material, injected hot molten rock into the crust, and metamorphosed the sediments that had eroded from the margin of the Precambrian shield before the collision occurred. Evidence of this violent past is clear in the Grenville rocks, which are usually metamorphosed sedimentary rocks with igneous intrusions (from the hot molten injections) that have been folded and overturned by the collision-induced compression.

Hartness Park very nearly borders a thrust fault that is described as “syn-metamorphic or post-metamorphic with respect to either Taconian or Acadian metamorphism”. Nearby is a Strike-slip fault mark which shows a sense of lateral relative movement with an age of principal movement is considered Acadian or Alleghanian. This bedrock map also informed me that the majority of my study site is situated atop DSws, a slate and phyllite member which is predominantly dark to light-gray, lustrous, carbonaceous chlorite-biotite-muscovite-quartz slate, phyllite, or schist, and contains thin beds of quartzite and only sparse layers of punky-weathering limestone, however, after emailing one of the primary geologists who mapped this area, he sent me a much better more detailed KMZ overlay map, and it shows that my site has DSw (gray carbonaceous schist), DSwqs (quartzose schist), and Dg (Gile Mountain Formation granite).

Both maps agreed that there is a narrow eastern-most border of Dg class granite from the Devonian period, a late-metamorphic intrusive rock also known as “Chester Dome Granite”, described as “light-gray to white, garnet-muscovite-biotite granodiorite, and whitish-gray muscovite-rich quartz monzonite and granodiorite, granite pegmatite, and aplite which occur as crosscutting non-foliated dikes within the core of the domes and as folded and well-foliated dikes on the east and west flanks of the Chester and Athens domes”. The Dg area has varying degrees of foliation, and consists of muscovite-biotite-quartz-microcline-plagioclase granite to granodiorite dikes and sills that cross cut foliated “country rocks”. The term "country rock" refers to the older rock into which plutonic rocks, such as granites, intrude. It is sometimes called "host rock". I took the liberty of emailing a couple of geologists that have mapped my area, to see if they could give me any tips on the best sections of my study site to scope out this week for geological features. In my study site area, gray slate and phyllite is the country rock. The granite will be light tan to light gray, and the slate will be dark. I am looking for evidence that the granite intruded into the gray slate. With some deep research, I believe the Dg Devonian easternmost border of my study site may be part of the Gile Mountain Formation, although I have no maps or data to confirm, it is noted to occur in Windsor county, is said to occur from Windham to Orleans counties, which would definitely cover my site.

***Important Geology Terms*:**

Foliation, in geology, refers to repetitive layering in metamorphic rocks. Each layer may be as thin as a sheet of paper, or over a meter in thickness. I like to think of it as those flaky layer biscuits that you can buy in the refrigerated isle at the grocery.

Granofels is a field name on a par with such terms as gneiss, schist, and slate.

Gneiss is a high grade metamorphic rock, meaning that it has been subjected to higher temperatures and pressure. It displays distinct foliation, representing alternating layers composed of different minerals.

Thrust faults are reverse faults that dip less than 45°. Thrust faults with a very low angle of dip and a very large total displacement are called overthrusts or detachments; these are often found in intensely deformed mountain belts. Large thrust faults are characteristic of compressive tectonic plate boundaries.

Reverse dip-slip faults result from horizontal compressional forces caused by a shortening, or contraction, of the Earth’s crust. The hanging wall moves up and over the footwall.

Shear zones are volumes of rock deformed by shearing stress, and often occur at the edges of tectonic blocks, forming discontinuities that mark distinct terranes.

A *terrane*, which is not the same as 'terrain', is a fragment of crustal material formed on, or broken off from, one tectonic plate and accreted or "sutured" to crust lying on another plate.

Metamorphic rock is a type of rock which has been changed by extreme heat and pressure. Metamorphism is alteration of the composition or structure of a rock by heat, pressure, or other natural agency.

Orogeny is not synonymous with “era” but is rather indicative of a geologic process in which the earth’s crust is folded and deformed by lateral compression which then forms mountains.

The Acadian orogeny is a long-lasting mountain building event which began in the Middle Devonian, reaching a climax in the early Late Devonian.

The Devonian is a geologic period and system of the Paleozoic era, spanning 60 million years, and beginning 416 million years ago.

The Taconic orogeny was a mountain building period that ended 440 million years ago in the latter part of the Ordovician period.

The Ordovician period was in the second period of the Palaeozoic era, between the Cambrian and Silurian periods, which lasted for 45 million years during which marine invertebrates flourished.

The Alleghanian orogeny (sometimes spelled Alleghenian) occurred approximately 325 million to 260 million years ago, and is responsible for forming the Appalachian Mountains, with greatest amount of deformation associated with the Alleghanian orogeny occurring in the Southern Appalachians. It also formed the Allegheny Mountains, for which Pennsylvania is famous. Experts disagree on if this orogeny had any effect on any of the landforms in our state.

Soils

Soil Report, Soil formation/rock weathering/ how soil forms on rock via lichens (*Physical weathering*/freezing and thawing, *Biological weathering*/ Primary succession/living organisms break down rock/pioneer species like lichens, algae, fungi, moss, grasses, shrubs, how roots break down to form humus to make soil), Hartness Park lies on rocky terrain, outcrops of bare rock are plentiful, and on these outcrops one can find lichens and mosses.

sediment/glacial till, soil horizons, significance of earthworms, mounds and dip in forests, decomposition of felled trees and their significance (See Food Webs), how litter breaks down/humus

Commonly called “snow fleas” or “springtails”, both misnomers, Collembola are hexapods which are over 400 million years old and still present today in Vermont (Janssens). They are important decomposers and play a significant role in the food chain where they eat decaying vegetation, fungi, and rotifers, and in turn feed mites, ants and other insects.

, soil porosity/permeability, infiltration/runoff:

Vegetation

Keeping in mind that the history of vegetation in general is a topic well beyond the scope of this paper, I will briefly recount the ancient vegetative history of the continent(s) that eventually came to house our state. Much of the history of plant life on earth occurs between the time of the two major supercontinents, Rodinia and Pangaea. When the supercontinent Rodinia broke up about 575 million years ago in the Neoproterozoic, the land that would become the state of Vermont sat at the edge of the Iapetus Ocean in a continent called Laurasia (also called the Grenville Supercontinent or Proto-North America). About 450 million years ago, in the Ordovician when vegetation was first developing on Earth, Laurasia was colliding with the Taconic Island Arc to form the Taconic and Green Mountains. 50-100 million years later, Laurasia would again collide with the land mass of the Avalonian Island Arc to further develop the Green Mountains in an enormous event that added all of New England east of the Connecticut River to the continent. During the Devonian, yet another mountain building event would occur, the Acadian orogeny.

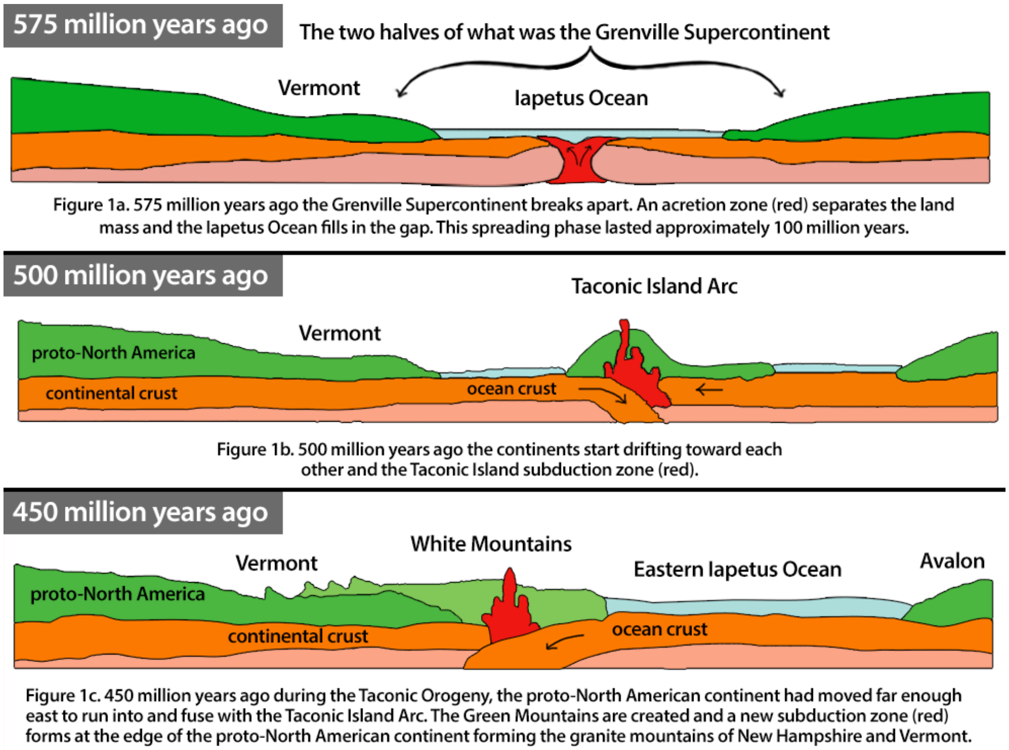


Figure 1a. 575 million years ago the Grenville Supercontinent breaks apart. An acretion zone (red) separates the land mass and the Iapetus Ocean fills in the gap. This spreading phase lasted approximately 100 million years.

Figure 1b. 500 million years ago the continents start drifting toward each other and the Taconic Island subduction zone (red).

Figure 1c. 450 million years ago during the Taconic Orogeny, the proto-North American continent had moved far enough east to run into and fuse with the Taconic Island Arc. The Green Mountains are created and a new subduction zone (red) forms at the edge of the proto-North American continent forming the granite mountains of New Hampshire and Vermont.

The Taconic Orogeny in Vermont (credit: University of Vermont)

These events resulted in the land that would become Vermont being a high elevation alpine region (Howe). The massive amounts of volcanic activity and land disturbance likely meant there wasn't much possibility of vegetation growing here, even though the first vegetation on Earth was beginning to colonize the land at the end of the Ordovician. These were tumultuous times for the land that would become Vermont, and any guesses I could make about whether plants were developing here would be speculation. A warm, shallow sea covered Cambrian Vermont which remained in place into the Ordovician when the sea covering the state deepened. Sea levels continued to rise during the Silurian period. It is an unfortunate fact that the intense heat and pressure caused by later subduction and compression metamorphosed the rock which formed in the orogenys that followed, thus destroying any fossils from this period that might tell us about pre-Carboniferous vegetation (Howe). Furthering the problem, the fact that the post-mountain forming event land was in an alpine environment was not favorable for fossils that followed. The result is that we have found no pre-Cenozoic land vegetation fossils in Vermont. The "Brandon lignite" from Forestdale, Vermont, contains the only known "window" into the land fossil record for the period between 350 million to 12000 years ago. It is likely that vegetation was present between the end of the Alleghenian orogeny, when Vermont moved inland inside the supercontinent Pangaea, and the Mesozoic, when it was covered by the sea. From there, much of the history of Vermont was under water. These issues combined mean we have little data about the evolution of vegetation in our state. That being said…

We know from other areas that early Ordovician plants evolved rapidly and mossy plants that spread via spores dominated the swampy landscapes of the time. The early Devonian period saw the evolution of trimerophytes, an early branching plant lacking leaves or roots that eventually became the ferns we know today.

By the end of the Devonian, forests of progymnosperms, woody plants that formed into trees but spread via spores rather than by seed, covered the land. Archaeopteris, one of the earliest trees, could reach heights of almost one-hundred feet, and had fern-like structures attached to its branches rather than leaves (Bagley). As the land dried out by the end of the Devonian, early seed-bearing plants had appeared, replacing the sporereproduction plants. A list of known Devonian land plants can be found at [Wikipedia](). Several mass extinction events occurred at the end of the Devonian, but it did not have much impact on vegetation. It is theorized that the increased plant life many have been a contributing factor, since the forests significantly changed the climate to one much cooler and more oxygen-rich than the animals had evolved in (Bagley). This is a little scary if you think about it, because our climate is changing rapidly now – are we on our way to another mass extinction event? If the growth of vegetation caused the climate to change so much as to cause mass extinctions, how can we ignore the impact of removing that vegetation today? Moving along…

In the beginning of the Carboniferous there existed a tropical, humid climate in which plants flourished. When the continent Gondwana collided into Laurasia (also called Proto-North America) and land-forming event occurred as the colliding land masses pushed upwards, creating a more terrestrial topography (The Carboniferous). Temperatures grew mild during the Carboniferous, tree ferns, club mosses, great horsetails, and hundred-foot tall, seed-producing trees such as Cordaites, with its strap-like leaves and cones, grew in vast lowland swamp forests (Carboniferous Period). In these swamp forests, still seedless plants flourished. Throughout the span of the Pennsylvanian the land alternated between being terrestrial and marine. This was caused by changing seas levels driven by the melt and freeze cycles of vast polar glaciers. Plant material did not decay when the seas covered it, and this cycle formed the coal we use today.

Ferns and horsetails became more important during the later Carboniferous, and Cordaites, the earliest relative of the conifers, with long ribbonlike leaves, appeared. Ferns and horsetails still grow today under the tall conifers inside my study site. Many decedents of the horsetails of the Carboniferious, looking much the same now as then, can still be seen today in Vermont. Here are the species of horsetails that might be found inside my study site and surrounding areas: Equisetum arvense: Field Horsetail, Equisetum fluviatile: Water Horsetail, Equisetum hyemale ssp. Affine: Scouring Rush, Equisetum x mackaii: Shore Horsetail, Equisetum palustre: Marsh Horsetail, Equisetum pretense: Meadow Horsetail, Equisetum scirpoides: Dwarf Scouring Rush, Equisetum sylvaticum: Woodland Horsetail, Equisetum variegatum ssp. Variegatum: Variegated Scouring Rush. All of these grow in Windsor county and might be found inside my study site. Here is a photo of an Equisetum scirpoides I took out in the field.

During the Permian Period, the final period of the Paleozoic Era, the giant swamp forests of the Carboniferous began to dry up, their mossy plants slowly replaced by gymnosperms like today's conifers. The first modern trees were found in fossils from the Permian period, including conifers, ginkgos, and cycads (Permian). Large areas turned into deserts (Steur) but rich forests were present in many areas with a great amount of diversity within them (Permian). It was during this time period that Pangaea would form and the interior of the vast supercontinent would dry out. Fossils from the late Permian Period show huge conifer forests blanketing Pangaea at the time of the Permian-Triassic extinction event. The fossil strata above this layer shows few signs of vegetation but is filled with fossils of fungi which likely fed on the decay of these trees. The Great Dying mass extinction (also known as the Permian-Triassic extinction) closed the Paleozoic Era, an event resulting in more than 95% of marine animals and more than 70 percent of land animals going extinct.

In the Middle Triassic, Pangea began to break apart, forming Gondwana (South America, Africa, India, Antarctica, and Australia) and Laurasia (North America and Eurasia) (The Triassic). The land mass was relatively high and the sea was low, and the inland areas were arid. There were no polar ice caps, and the temperature probably didn't change much from the near polar regions to the equatorial regions. Pleuromeiales, close relatives of the Lepidodendrids, appear during the Triassic (Boyer). Modern ferns (Filicalean) begin to appear. The northern forests of this era were dominated by bennettitaleans, conifers, ginkgos, and cycads, but it is not known if these existed in the lands that would become Vermont.

Land plants abounded in the Jurassic. Dinosaurs fed on lush ferns and palm-like cycads and bennettitaleans. Ferns, ginkgoes, bennettitaleans, cycads and cycadeoids flourished in the Jurassic. Close relatives of modern redwoods, cypresses, pines, and yews developed. A new method of plant reproduction evolved. Gymnosperms, cone-bearing plants such as conifers, began to use wind for distribution of pollen and by the end of the Jurassic, the gymnosperms were widespread. Pangaea started to break up into the continents that we know today. Laurentia was splitting into landmasses that would eventually form North America and Eurasia (Jurassic Period). The minor Tithonian extinction marked the end of the Jurrasic.

In the early Cretaceous, sections of Pangaea were drifting apart. In the middle Cretaceous, ocean levels were much higher and most of the landmass was underwater. The poles were cooler than equatorial latitudes, but overall, it was a warmer period. Most importantly, the first true flowering plants (Angiosperms) evolved in the Cretaceous. The rapid success and diversification of the flowering plants may have been driven by their need to attract insects. Flower forms changed to attract insects, which then adapted different ways of collection pollen and nectar, the beginnings of intricate co-evolutionary systems we have today (Bagley). The Central Atlantic had opened up in the late Jurassic Period, and by the end of the period the continents were close to modern configuration other than a small segment of Laurasia still being bridged. The K-Pg extinction event (also known as the Cretaceous-Tertiary extinction event), which is believed to have been meteor or volcanically driven, marks the boundary between the Cretaceous and Paleogene periods. This event likely blocked the sun's ray for an extended period. Without enough sunlight, plants died. Any herbivores that had survived likely starved. Reduced sunlight lowered global temperatures.

We have finally arrived at our current era! The early Cenozoic was much warmer than our world is today, and the climate was generally consistent from poles to equator (Zimmermann). Almost all of today's plants developed in the Cenozoic Era. This tropical period was called the Paleogene Period. Palm trees appeared, and cacti may have appeared at this time. Thick tropical, sub-tropical, and deciduous forests covered the land (Boyer). A massive global warming event called the Paleocene–Eocene Thermal Maximum (also called the Initial Eocene Thermal Maximum), took place of 55.8 million years ago, marking the end of the Paleocene.

In the early Eocene, the world was mostly ice-free, and precipitation prevailed (The Eocene). This period had the highest mean annual temperatures of the Cenozoic Era, about 86 degrees. To put that into perspective, the average mean annual temperature for the 20th century was 57 degrees. The interval was characterized by the highest global temperatures of the Cenozoic Era, sea surface and continental air temperatures increased by more than 9 degrees during the transition into the PETM. The rapid onset, occurring over just a few thousand years, resulted in huge ecological consequences. Widespread extinctions were present in both marine and terrestrial ecosystems. In the middle Eocene, Antarctica and Australia separated, creating a deep water passage which lead to the formation of the circum-Antarctic Current. This new current changed oceanic circulation patterns and global heat transport, which resulted in a global cooling event closing the Eocene.

The Oligocene marks the end of the Paleogene. During this time ice began to cover the Earth, lowering sea levels globally, tropical and sub-tropical forests were replaced with temperate deciduous forests (Boyer). The first open grassland plains formed – their first time existing outside of the margins of a river. These plains led to the increase of grazing animals like deer. Omnivorous bears appeared, taking advantage of the wide range food sources available. Primitive beavers first appeared, although not anywhere near the lands that would become Vermont. North America was covered in a mix of temperate and subtropical trees such as cashews, lychee, beech, and pines. Legumes such as beans and peas were common and the expansion of flowering plants Angiosperms continued. Many researchers believe it is during this time from which Vermont's first fossil record of vegetation originated. The Brandon lignite contains diverse Cenozoic pollen floras and exhibits the northernmost fossilized flora of Cenozoic angiosperms in northeastern North America. Exact dating is still hotly contested, but the general consensus is that it is from anywhere between early Oligocene to early Miocene. This positively identifies the first record of land-based vegetation existing in the land we now know as Vermont. In this sample, we see evidence of flora of algal remains, wood, seeds, fruits and palynomorphs (Traverse).

The Neogene Period was a time of global cooling, although it was still much warmer than it is today (The Pliocene). In the first part of this era, the Miocene, deciduous hardwood forests that were widespread in Laurasia began to decline as the climate become cooler and drier. It is possible that Vermont was a holdout for these late forests, which we know persisted in other parts of the Appalachian Mountains. $C0_2$ levels dropped (Boyer). Grasses became tougher due to increased silica content, and grazing animal flourished. Importantly, the Indian and Eurasian Plates would collide during the Miocene, forming the Himalayan Mountains, which would eventually block tropical airflow. The Panama Isthmus, today's Central America, forms, cutting off the Atlantic from the Pacific Oceans. These events combined resulted in the onset of cooling in the northern hemisphere. Mastodons first appeared during this time, which brings us to the remains found in Vermont, which was either a mammoth, indicating open tundra grasslands, or more likely, a mastodon, indicating scrubby spruce-fir forests (Johnson). The further study of this fossil may tell us more about the vegetation of our state at an earlier time. In the later part of the Neogene, called the Pliocene, Coniferous forests and tundra cover north hemisphere (Boyer). It is during the Pliocene that the formation of large polar ice caps began (The Pliocene).

The ice age begins. This was a time of great dying in what is now North America, where large mammals suffered extinction (The Pleistocene). During the Pleistocene, vast glaciers - flowing sheets of ice - covered much of the northern portion of the world. These areas were alternately covered with glacial ice and uncovered again during interglacial periods. This period lasted from about 3 million to 10,000 years ago. During this time, so much of the world's water was tied up into these vast glaciers that the sea levels fell 475 feet. At the beginning of the Pleistocene the Laurentide Ice Sheet formed, thickened and moved southward from modern-day Greenland. About 1.5 million years ago the land of Vermont, along with much of the Northern Hemisphere, was covered by glaciers. The glaciers advanced and retreated at least four times. During the last advance, about 13,000 years ago, the land of Vermont was covered by glaciers a mile thick. The severe climatic changes during the ice age had major impacts on the fauna and flora (Pleistocene). Plants and animals retreated southward to escape the glaciers. Vegetation in the lands of Vermont likely had slowly become more tundra-like as the temperatures dropped before all remnants of it were scoured off the land by the grating force of the glaciers movement, which was powerful enough to round off mountain tops, leaving barren bedrock behind. Preceding advancement of the glacier, before the ice encroached completely, grew cold-resistant coniferous trees such as spruce and fir, species that would later become our Boreal forest (Johnson). After the glacier's final retreat, the tundra slowly advanced back north, and then came the conifers, finally, deciduous trees returned.

This is the period in which humanoids were first believed to have been present in what is now North America, these predecessors would later have significant impact of the vegetation of Vermont in the form of white settlers.

From the Ice Age to today spans the Holocene. The Earth warmed, and the Laurentide Ice Sheet retreated. The vast glacial tundra gave way to new forests as succession took place in the new, warming environment. In the land of Vermont, the remnants of the glacial period, the glacial till clogged our glacially carved valleys, resulting in a vast landscape of postglacial lakes. Approximately 14000 years ago, during the late Pleistocene, Glacial Lake Hitchcock filled the eastern side of Vermont in the current Connecticut River valley until around 13500 years ago when the moraine dam located at modern-day Rocky Hill Connecticut broke and caused the drainage of the primary southern basin (Bigl). This vast lake most likely once covered the area in which Hartness Park resides. In *Geology and Hydrogeology of the Town of Weathersfield*, Stephen Wright writes, "The extent of glacial lake deposits in the area indicates that Glacial Lake Hitchcock lay at an elevation of ~600 feet (~182 m) at the latitude of Vermont State Route 131. Fluvial sediments in these valleys suggest that much of the North Branch and Black River valleys were filled with a delta system that rapidly filled the lake as the delta prograded southward towards North Springfield". Similarly, Charles Johnson says, in his book, *The Nature of Vermont*, "Lake Hitchcock reached as far west as Randolph". Thus, as we enter the Holocene, for the sake of this paper proceeds under the presumption that the land of Hartness Park was part of the Glacial Lake Hitchcock basin. This means that until the valley emptied of water sometime near 13500 years ago, there may have been little land vegetation. After Glacial Lake Hitchcock drained, the area became known as the Connecticut River Valley, with the Connecticut River passing southward along the eastern border of Vermont. Much of the research about the vegetation of Vermont has concentrated on the northern half of the state, making finding reliable data about the exact historical composition of our Southern Vermont locales difficult. Today one can see a significant difference between the Northeast Kingdom, the Lake Champlain area, and my little corner of Southeastern Vermont. It is with that grain of salt that I shall proceed into the supposed post-glacial paleoenvironment potentially existing within Hartness Park. Much of this data comes from a fantastic paper by Peter A. Thomas titled, A Perspective on Vermont's Prehistoric Past. In it, Thomas notes, "A spruce-fir woodland was well established in Vermont's lowlands by 10200 B.P. Larcg and alder were present in low percentages in the wet lowlands, and beech, oak, ash, and maple began to appear on the better drained bottomloand areas and low hills in the Champlain and Connecticut River valleys". It is upon one of the low hills of the Connecticut River valley in the Southern Vermont Piedmont that Hartness Park stands. The dominating white pine forests that dominated Vermont when the first white settlers arrived can be confirmed to have been in place by 9000 year ago through pollen profiles which show white pine, hemlock, oak, elm, ash had become well established. Native Americans, if present in the areas, lived in balance with the natural habitat. As the climate warmed, and dry summers became the norm, white pines dominated the forest. 8000 years ago, forests of oak, beech, birch, maple, elm, and ash mixed with hemlock and white pine in deciduous-coniferous lowland forests. These are the same forests we see in Hartness Park today, where upon the ridgeline sits a long narrow band of Hemlock Northern Hardwood Forest. On the steep westerly facing hillside one can find hemlocks mixed primarily with maples, beech, ash, and oak. Beech and maple are the predominate understory trees. The easterly-facing slope is dominated by a Sugar Maple-White Ash-Jack-in-the-pulpit Northern Hardwood Forest. At ground level, one can find ferns, horsetail, jack-in-the-pulpit, clubmoss, witchhazel, and in one part of the park where the canopy has been artificially cleared, grass. Most of the forest floor has been invaded by earthworms, resulting in a primarily barren landscape of litter, lichens, and the occasional fern. On the far easterly border there exists a large invasion of japanese barberry, likely planted intentionally as the area appears to have been near a long forgotten homestead. Historical photographs from the early 1900s show that most of the hillsides in Springfield were clearcut, only a few conifers appear to remain on the ridgelines. Some of the hemlocks on the ridgeline in Hartness park today may originate prior to 1900, but it is likely that the rest of the forest is successional and dates 1920 or later. Early on, white settlers of Springfield began to make significant changes to the natural landscape of the area.

In one archive can be found the following quotes, which sum up the fate of most of the standing timber. From the proceedings of the Ministerial Committee: “Voted aud Grauted [sic] Twenty Acres of the Land now Undivided in the Towuship.of [sic] Springfield to any person, who shall build a Sawt-Mill [sic] in said Township, to the Acceptance of a Committee which shall be appointed by the proprietors for that purpose, in such place as the said committee to be appointed shall consent to: To be to him and his Heirs forever; together with the Use of the said Mill-Place so long as he shall keep the said Mill in good Repair. And also the Use of one Set of Irons for the said Mill; provided he shall maintain and keep in Repair the said Mill and Irons for the Terra of Fifteen years next after this Day, and then return the said Irons to the proprietors." July 19, 1762, and then in June 26th, 1789, “A tax of one hundred and fifty pounds to be paid in timber, material, or produce by the first of May next was voted.” Rapid deforestation ensued. At the time, the dense old growth forest must have seemed an inexhaustible resource, but when you can pay your taxes with the “free trees” on your land – well, it didn’t take long to clear the new fields settlers needed to farm, and once the fields were clear, it didn’t take much longer to clear the hillsides. It was a stark landscape, erosion washed the depleted soils into streams and rivers. The landscape was a wasteland, barren hillsides no longer held their fragile soils, rivers churned with mud. Habitat destruction such as the destruction of this time period may be pushing in the next mass extinction event - it is estimated that as many as 30% of plant and animal species on Earth may face extinction within the next 100 years (Bagley). In Charles Johnson’s book, *The Nature of Vermont*, he notes that “More than 75% of the region had been cleared of trees, and sheep and dairy farming predominated.” Eventually a turning point was made, around the mid 1800s Vermont settlers had depleted the soils of Vermont, and many fled the region seeking richer soils for their farms. This time period moves into one of succession, where white pine forests established themselves in previously open fields across vast swaths of Vermont. By 1910 the white pines had reached a marketable age and once again, the land was clearcut by the settlers that remained (Johnson). In the absence of the large pines, now a mixed hardwood forest began to grow across Vermont. Not long after, awareness of the impacts of clearcutting became commonly known, and thus ended the barbaric destruction of Vermont’s forests. The some of the mixed hardwood forests that filled in by the 1930s still exists today.

Wildlife

With the coming of white men to the upper regains of Vermont came a surge of trapping. European fur companies had made deals with Native Americans for vast quantities of pelts (Johnson). Lynx, beaver, martin, fisher, and bears were systematically killed for their skins. By the time white settlers moved into the area and began hunting and trapping themselves, many of the furbearing mammals had been almost hunted to extinction. The last confirmed cougar in Vermont was killed by a white man in 1881, although there are some recent hopeful signs that they may be able to come back. Wolves once roamed the Vermont countryside, today the Vermont Wildlife Action Plan lists the wolf as a "Species of Greatest Conservation Need" in Vermont, though it was thought to be extinct in the state by 1900 (Bodin). It is not known to what extent these large furbearing animals existing in Windsor County, however, it is known that both grey and red foxes and bobcat pass through the park today, as are deer, skunk, raccoon, squirrels, chipmunks and more. The Vermont Agency of Natural Resources lists the northwestern border of the park as a Riparian Wildlife Connectivity corridor and lists a small segment of it as a Highest Priority Wildlife Crossing area (Biofinder). Much of the park is a Physical Landscape Diversity Block conservation area, conserving biological diversity and providing stewardship for the diversity of enduring features which in turn helps protect the diversity of natural communities and species (Sorenson et al). The BioFinder tool lists an area of the park as Riparian Area. A band of riparian habitat lies adjacent to all rivers, streams, lakes, and ponds or to the valley bottom. Riparian habitat provides vital habitat for a rich assemblage of aquatic species, including fish, amphibians, reptiles, invertebrates, and plants. Newts, salamanders, mudpuppies, frogs and toads, as well as water-breeding insects such as mosquitoes and black flies might be found in the park due to its riparian habitat. The park's many trees in varying states of living, dying, and decomposing provide a rich source of food for many insects and woodpecking birds. Other forest birds including songbirds like vireos, warblers, and chickadees, ground birds like turkeys, soaring vultures, predatory birds like owls, hawks, and bald eagles all have been seen in or above Hartness Park.

Food Webs

The trophic level of an organism is the position it occupies in a food chain of an ecosystem. The trophic interactions of organisms within an ecosystem is called the food web. All living organisms are part of this cycle. The three food web roles are producers, consumers, and decomposers. Producers generate food through photosynthesis (plants, algae), consumers eat producers or one another (broken down into carnivorous, herbivorous, and omnivorous with carnivores and omnivores further divided as primary, secondary, or tertiary consumers), and decomposers eat dead tissue and return nutrients and energy to other parts of the cycle. Primary producers in the park are covered under "Vegetation", and many of the significant consumers are found in the "Wildlife" section. An important decomposer in Hartness Park the Porcellio scaber, commonly called "woodlice". Another decomposer in the park is Collembola, the "springtail" (see "Soils" for more on springtails and decomposition). Yet another decomposer with a significant impact in Hartness Park is the Amynthas agrestis earthworm. This invasive earthworm disrupts natural habitats, harming forest ecologies. It is difficult to say how the forest of Hartness Park may have looked before earthworms invaded, but it is assumed there would be a much richer understory, and a diverse and dense scrub level. Nevertheless, it is now a major part of the food web in the park.

Species that have a disproportionate impact on other species in an ecosystem are called keystone species. Keystone animal species that might be found in Hartness park are: Earthworms, Bees, Bats, Beavers, Coyotes, Yellow-Bellied Sapsuckers, Pileated Woodpeckers, and Humans.

Indicator species are species whose presence or absence indicates an environmental change. Indictor species that might be found in Hartness Park are: Blackpoll Warblers, Salamanders.

Summary

Timeline wrap-up and closing thoughts on moving forward: Overview of site over several time periods, referencing geology, forest growth, deforestation, conservation, wildlife and wildlife corridor, watershed/cycle, and issues moving forward from today.

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