

# Edward Farrar Utility District Waterworks Property Landscape Inventory & Assessment



**Spring 2026**

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# Acknowledgements

Many people graciously shared their time, energy, expertise, and resources during the course of this Landscape Inventory and Assessment. First and foremost, we are grateful to the Edward Farrar Utility District Commissioners for sponsoring our work and for their curiosity about, and care for, this special landscape. Thank you to Walter Poleman for seeking out a meaningful place-based educational experience and laying the groundwork for this project. Bill “Woody” Woodruff, Waterbury Public Works staff, and the Waterbury Conservation Commission provided invaluable early feedback on our process and guided our approach—Josh Lincoln, in particular, supported this project from start to finish and spent many hours on site with us. Prudence Doherty, Sam Ford, Steve Hagenbuch, Jens Hawkins-Hilke, Dave Moroney, Dan Sweet, Stephen Wright, and Bob Zaino joined us in the classroom and in the field and gave us tools that greatly enhanced our exploration of the parcel. We are deeply appreciative. Thank you to our instructors, Sophie Mazowita and Sonia DeYoung, for your leadership, feedback, and company.



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# Executive Summary

Graduate students in the Landscape Inventory and Assessment (LIA) class at the University of Vermont work as a consulting team to evaluate a specific land parcel on behalf of a sponsoring organization.

The 2026 LIA cohort spent the spring semester immersed in the geology, ecology, and human relationships of the Edward Farrar Utility District (EFUD) Municipal Watershed Lands (hereafter referred to as “the Waterworks”). EFUD sponsored this year’s LIA project to engage more deeply with their land holding and potentially inform future management decisions.

The twelve students in the class divided into four teams, each of which explored a different component of the parcel: **1) Human History**, **2) Enduring Features**, **3) Plants**, and **4) Wildlife**. This report details the findings that emerged from field work, spatial analysis, research, and consultation with experts and practitioners.

The **Human History Team** investigated how the land use of the Waterworks has changed over time, from post-European settlement to today. Archival research, LiDAR data, and consultation with historian Samantha Ford informed this section of the report. The parcel is, in some ways, a microcosm of Vermont’s overall land use history: lumbering, sheep farming, hill farms, mills, and intentional pine plantations are all part of the parcel’s past. Current use includes both drinking water infrastructure and recreation in a beautiful natural setting, reflecting values that many modern Vermonters prioritize: stewardship of natural resources and access to the outdoors.

The **Enduring Features Team** focused on topography, bedrock geology, soil, and surface water, researching how these features collectively influence the downslope movement of water from Hunger Mountain. The team identified patterns that contribute to erosion and flood risk and noted unmapped seeps and offshoot streams that may contribute to surface water volume in Thatcher, Tyler, and Merriam Brooks.

The **Plants Team** evaluated overall forest health and inventoried natural communities. They identified 121 species of vascular plants, 11 of which are non-native. Two of these, Morrow’s honeysuckle and Japanese barberry, are invasive species that may warrant management. Another invasive species, the emerald ash borer (EAB) beetle, poses an imminent threat to ash trees throughout the parcel.

The Plants Team’s updated map of the Waterworks delineates 12 natural community types, four of which are considered uncommon in Vermont: Hemlock-Balsam Fir-Black Ash Seepage Swamp, Lowland Spruce-Fir Forest, Montane Spruce-Fir Forest, and Montane Yellow Birch-Red Spruce Forest.

The **Wildlife Team** documented wildlife presence and habitat at the Waterworks. Priority habitats within the Waterworks include the beaver wetland complex, riparian corridors, and the Red Oak Northern Hardwood Forest. Trail-based recreation has the potential to negatively impact wildlife, with primary and secondary zones of influence that extend 100 and 500 meters. These distances can be used to buffer high priority wildlife areas.



The Wildlife Team also evaluated the parcel's role in regional wildlife connectivity. The undeveloped forest at the Waterworks allows wildlife to move between C.C. Putnam State Forest and Mt. Mansfield State Forest. This vital connection is part of the Shutesville Hill Wildlife Corridor—the sole remaining linkage between the Green Mountains and the Worcester Range.

This report's findings inform management recommendations that fall into four categories: **1) Trail Siting and Maintenance, 2) Public Outreach, 3) Forest Health and Habitat, and 4) Going Forward.**

## **Management Recommendations**

### **1. Trail Siting and Maintenance**

- Ameliorate erosion concerns through maintenance or rerouting.
- Consult a professional trail builder if mountain biking trails are a priority. If not, consider closing trails to mountain biking and focusing on pedestrian-friendly trail design for low erosion.
- Any future trails should avoid alluvial fans, streams, and seeps. Buffer wetlands and other sensitive wildlife areas.

### **2. Public Outreach**

- Consider engaging visitors with an interpretive trail that encourages positive recreation and describes the importance of the land use history, drinking water, and sensitive habitat on the parcel.
- Build partnerships with trail builders and mountain biking groups to approach recreation from a place of collaboration.

### **3. Forest Health and Habitat**

- Maintain early successional habitat by continuing to mow on a rotational schedule that avoids disruption to nesting ground birds.
- Retain standing dead trees to provide important bird habitat.
- Consider contracting the Vermont Youth Conservation Corps to manually remove honeysuckle and barberry and re-establish native species.
- Manage ash to retain potential EAB-tolerant genetics while minimizing hazards near roads, trails, and infrastructure. Avoid panic cutting to salvage timber value.

### **4. Going Forward**

- Hire a professional historian for any future deed research.
- Continue seasonal field visits to ensure that management remains responsive to emerging ecological conditions and supports long-term stewardship.
- Monitor the core beaver activity zone within the wetland complex. Do not remove beavers unless impacts are confirmed and alternatives have been evaluated.
- Develop a complete inventory of surface water features, including intermittent streams, seeps, vernal pools, and other unmapped hydrologic elements.

# Property Overview

The Waterworks is a 478.88-acre, mostly forested parcel located in the towns of Stowe and Waterbury, Vermont, and owned and managed by the Edward Farrar Utility District (EFUD). As its name suggests, the Waterworks is a public water system watershed that presently supplies drinking water to approximately 6,000 users in Waterbury, Waterbury Center, Duxbury, and Moretown. Surface waters provide a substantial amount of the water supply, and the property hosts multiple wells and surface water collection areas.

The Waterworks sits within the Northern Green Mountains biophysical region, an area of Vermont defined by its high peaks, cold winters, and short growing season. Glaciers shaped the landscape through which the brooks flow and deposited glacial till that weathered into soil. The property ranges from approximately 1,200 to 2,200 feet in elevation and includes a diverse assemblage of natural community types. Its position within the wider landscape makes it part of a crucial wildlife corridor that provides the only remaining linkage between the Green Mountains and the Worcester Range.

The Abenaki people are the traditional stewards of Vermont's forests and waters, and it is likely that human use of what is today the Waterworks dates back to the time after the last glacial retreat, approximately 12,000 years ago. However, readily-accessible written records of human history on the parcel begin in the period after European settlement.

Most of the property was cleared for agricultural purposes in the 1800s, though much of the forest has regenerated. Fewer than 10 acres remain open as regularly maintained meadows and a beaver wetland complex. This site also has a long history of logging, with at least 10 timber harvests documented since 1973. The most recent *Forest Resource Management Plan* was prepared in 2019 and will be updated in 2029.

In addition to water infrastructure and timber harvests, human activity continues to shape the landscape in other meaningful ways. Local residents have long cherished the natural beauty of the Waterworks as a site for outdoor recreation, though these activities have never been explicitly sanctioned. Erosion along access roads and trails is likely contributing to sedimentation of surface water sources that EFUD uses for the municipal water supply; all trails on site are currently closed as EFUD evaluates their impact.

**\*A note on brook names:** We have used the brook names as they appear in the *Forest Resource Management Plan* and as they tend to be used among people we've interacted with on this project. Throughout this report, the brooks are labelled from North to South as Thatcher, Tyler, and Merriam. This is in contrast to some official mapping sources, such as ESRI, which label the center brook as Thatcher.

# Human History

## Introduction

In order to understand the present-day ecology of the Waterworks, we began by looking at its past. We asked, how has land ownership changed over time? What were the past agricultural and industrial uses of the site? And in what ways are we still seeing this history present on the Waterworks today?

## Scope of Research

According to state archaeologist Jess Robinson, there are no known pre-colonial land use sites within the bounds of the present-day Waterworks (J. Robinson, personal communication, February 25, 2026). However, we know that Vermont is the ancestral land of the Abenaki people (*Research Guides*, n.d.), and that this land was likely stewarded by them in ways that we are currently unaware. For the purposes of this study, we focused on history after European settlement since those were the records we were able to access. It is also important to mention that we were only able to access records from the early- to mid-1800's, and that post-colonial use of the land began much earlier than we were able to research.

In order to piece together post-colonial land use on the site, we referenced the historic Beers Atlas maps and Walling County maps for both Lamoille and Washington Counties, visited the Stowe Town Clerk to look at deed records, accessed Special Collections at the University of Vermont to reference agricultural census data, utilized Newspapers.com's archives of digitized records to search for both names of known inhabitants and instances of the mention of the Waterworks, sourced LiDAR data to locate instances of cellar holes and stone walls on the Waterworks, searched historical photos and documents on the Waterbury Historical Society online collections, and consulted with research specialist Samantha Ford.

## 1859 Walling Map of Stowe with EFUD Boundary Overlaid



0 0.25 0.5 1 Miles



EFUD Boundary

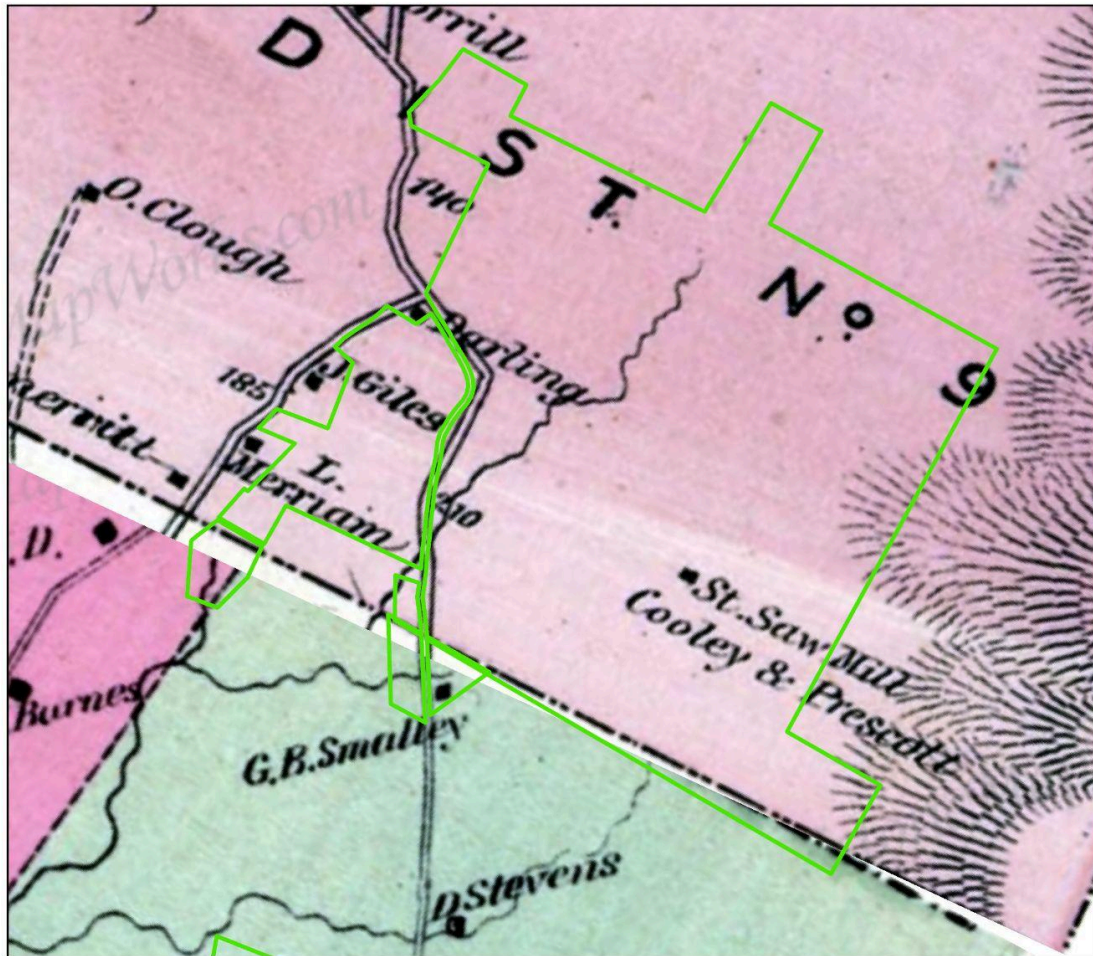
Created by: University of Vermont Field Naturalist Landscape  
Inventory and Assessment graduate students  
April 2026

Credits: Library of Congress Geography and  
Map Division

Figure 1: The 1859 Walling Atlas map, overlaid with the present-day Waterworks boundary (H.F. Walling, Map of the counties of Orleans, Lamoille, and Essex, Vermont, 1859).



## 1873 and 1878 Beers Atlas with EFUD Boundary Overlaid



0 0.25 0.5 1 Miles



EFUD Boundary

Created by: University of Vermont Field Naturalist Landscape  
Inventory and Assessment graduate students  
April 2026

Credits: Middlebury College  
Special Collections and Ward  
Maps LLC

Figure 2: The 1873 Beers Atlas map of Waterbury and the 1878 Beers Atlas map of Stowe, overlaid with the present-day Waterworks boundary (F.W. Beers & Co, Atlas of the Counties of Lamoille and Orleans, Vermont 1878 & F.W. Beers & Co, Atlas of Washington County, Vermont 1873).



0 0.25 0.5 1 Miles

  EFUD Boundary



Credits: Vermont Center for Geographic Information

10



## Early Residents and Land Ownership

The town of Stowe was chartered in 1763 and divided into plots (Stowe Historical Society, n.d.). What is now known as the Waterworks was once a collection of much smaller parcels of land. A Stowe lotting plan made in 1913 (Figures 3 and 4) shows the original parcels, which were labeled with numbers, and their proprietors (Dewart, 1913), which we used to trace the ownership and land use changes over time. We combined these lot numbers with Stowe town maps from the 1859 Walling County atlas and the 1878 Beers Atlas, which provided last names of parcel owners. Using both lot numbers and last names, we explored deed records at the office of the Stowe Town Clerk, which allowed us to track purchases, sales, and leases of land on these lots between 1835 and the sale of the site as a water source in 1896, beginning to provide us with a picture of land ownership and transfer.

An important component of understanding these deeds was that the spelling of names was inconsistent, and it was necessary to compile alternative spellings for certain landowners in order to get a clear picture of their presence on the Waterworks over time. For example, James “Demeritt” was alternately spelled as “Demerit,” and William “Lamphier” was alternately spelled as “Lamphere” or “Lampheer.” Without also researching these alternative spellings, we may have missed records relevant to the Waterworks’ past stewards.

The location of the current Waterworks lies on portions of what used to be 16 different parcels. Cross-referencing the 1913 map of the original lotting plan with a present-day map of the area, we found that lot numbers 57 through 62 fell within the bounds of the current-day Waterworks. Waterworks also lies on portions of what were plots 53, 54, and 62, smaller portions of plots 52, 55, 56, 57, and 58, a corner of plot 1, and one unlabelled plot underneath plot 55. These plots were differently sized in the original plan and some were also divided over time (Dewart, 1913). A small sliver of the Waterworks also lies in Waterbury, however, due to time constraints we were not able to investigate historic Waterbury parcel ownership.

The first proprietors of main lots where the Waterworks now sits are as follows:

- Plot 1: Propagation Society
- Plot 57: Hon. Richard Wibird Esq.
- Plot 58: Asa Browne
- Plot 59: Nathan Burdege
- Plot 60: Jacob Parrant
- Plot 61: Nathaniel Merritt
- Plot 62: School

Later divisions of land (specifically the fourth division) included the following proprietors:

- Plot 53: Abel Wicks
- Plot 54: Joshua Simmons (alternately spelled “Josiah Simonds”)
- Plot 62: Jonathan Church

Plots 1 in the first division of land and 62 in the fourth division of land were “glebe lots.” During early European settlement in Vermont, a land system was carried over from England that allotted parcels of land called glebe lots specifically for the funding of parishes and schools. The rental income from that land was used to pay for public schools, religious work, or other community needs. Until 2020, this system was still in place, and buyers of glebe lots had the right to use the land, but did not officially own it (Peet Law Group, n.d.). Plot 62 in the fourth division of Stowe (now a part of the Waterworks) was a school glebe lot, and plot 1 in the first division was a “Propagation Society” glebe lot, likely affiliated with a religious organization.

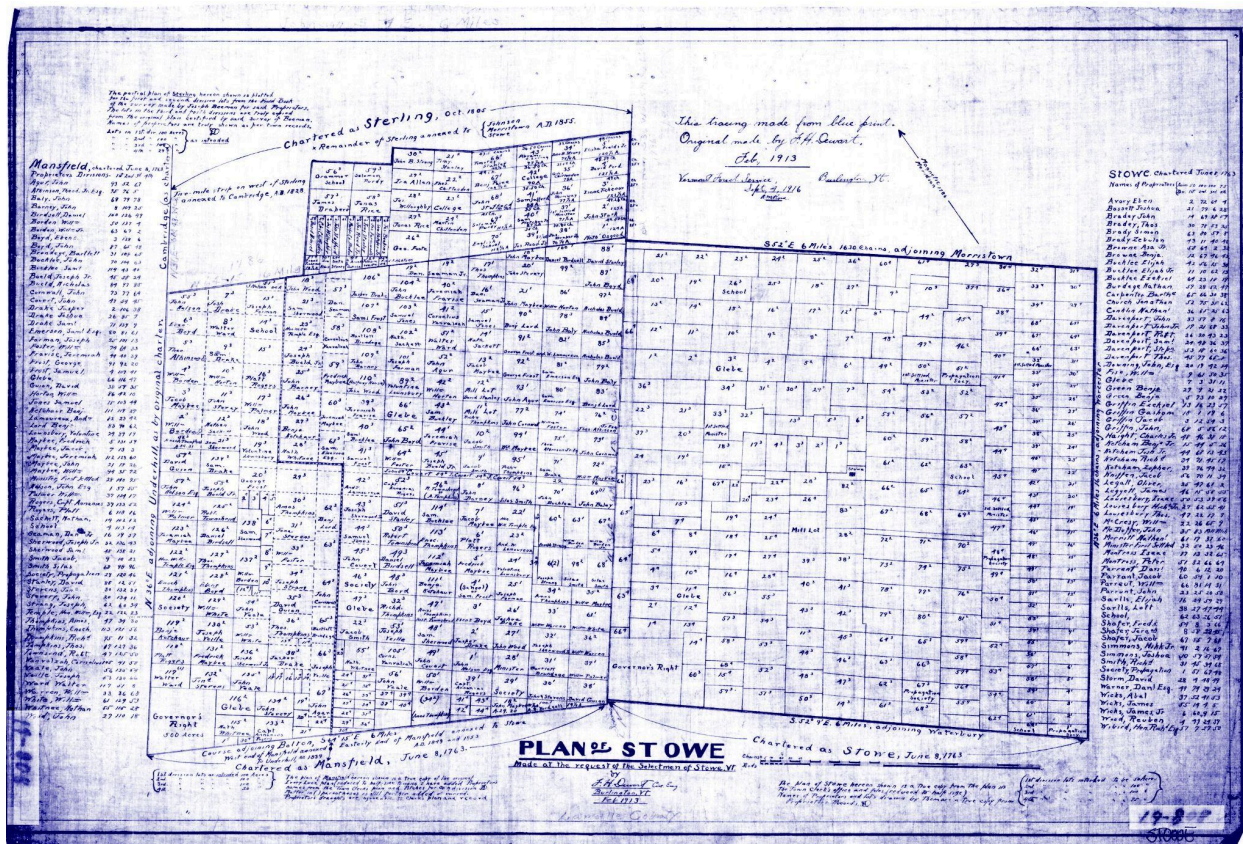


Figure 4: The 1913 lotting plan for the town of Stowe (Vermont Center for Geographic Information).

This information allowed us to access deed records at the Stowe Town Clerk. Most of the accessed land deeds provide details into parcel size. For example, a record of transfer from William Lamphier to James Demerritt in 1850, includes “the whole of the farm... supposed to contain about 200 acres” (*Deed Book 11*, 1850b). Others provide more specific details into past land use. For example, a record from 1850 transferring land from Benjamin Barrett to Luther Morse states, “I reserve the right of moving off the house and lumber located on said premises,” (*Deed Book 11*, 1850a) and one from W. H. Anderson to John Gibbs in 1890, which states:

“Reserving unto myself the right to draw the water from the spring that now supplies water to my steam mill – also the right of way across the said described farm or premises to my timber lands. And to draw logs and lumber thereon and the right also to pile logs thereon – and also the right in case I wish to build a steam mill in the pasture on said farm and draw the water to supply the same from the spring that now runs to the house...And I also sell in connection with this farm the sugar apparatus and the dairy apparatus, one mowing machine, one horse rake, one plow, one spike tooth harrow, one cultivator, one grindstone. All the hay that I may have on the farm March 1<sup>st</sup> next. Six cows, all of the sheep that I own on the farm, also a pair of Stags that Watts has now & is to keep til March 1<sup>st</sup> next” (*Deed Book 25*, 1890).

In 1896, when John and Annette N. Gibbs deeded land to W. H. Anderson, they stated, “All the hay and fodder now on these premises except what is on the scaffold in the south barn is hereby conveyed” (*Deed Book 25*, 1896a).

Other deed records describe less traditional forms of payment, such as a 1873 deed transferring land from O C. Clough to George W. Brown, which states:

“This land to be paid for to me said Clough by said Brown in a two-year dark bay Mare Colt two-years old part this deed is given and is expected by said Brown on this consideration that if the title to said Coult [sic] is not good in said Clough, then this deed to be void and of no effect but if said Clough’s title shall prove good then this deed to be good and valid” (*Deed Book 19*, 1873).

Later deeds from 1896 provide details into planning around water-use infrastructure on the property. A deed from Horace Merriam to the Village of Waterbury states:

“And I hereby grant to said Village of Waterbury the right to take and divert water from the mountain brook that flows through my said pasture, for the use of said Village at such point on my said land as shall be most convenient. Also to construct and forever maintain a dam across said stream for the purpose of aforesaid and to lay aqueducts from the same and from the springs on the land above conveyed across and through my said farm by the most convenient route to convey said waters to said Village and to forever maintain the same; and by its servants and agents to enter at any and all times upon my said farm to construct relay or repair said dam and aqueducts doing as little damage to said premises as practical” (*Deed Book 27*, 1896b).

An 1896 deed from Willie M. Gibbs and George S. Gibbs to the Village of Waterbury describes existing infrastructure on the property, stating:

“But we reserve to ourselves so long as we shall operate our steam mill, two rights of way across said land to pass on foot or with teams. One from the highway across the northern boundary of the land hereby conveyed, to land lying on Thatcher’s Brook now owned by us; the other from the said highway across the southerly end of said piece of land near said mill to our mill yard lying easterly of said mill; also to maintain during the same period our elevated track across said land on which to bring logs to said mill as the same now stands...” (*Deed Book 25*, 1896c).

## Industry and Agriculture on the Waterworks

Agricultural census data from between 1850 and 1880 shows fairly consistent land use between parcels (*Vermont Agricultural Census*, 1850-80). Common crops included:

- Wheat
- Corn
- Hay
- Rye
- Oats
- Peas and beans
- Potatoes
- Grass seed
- Maple sugar

Livestock included:

- Pigs
- Oxen
- Sheep
- Milking cows
- Horses
- Cattle

Animal products included:

- Butter
- Cheese
- Wool

In the 1880 census, land use documentation expanded to include mention of:

- Timber products
- Barley
- Buckwheat
- Poultry



Newspaper records from this time fill in specifics about the agricultural use of the site. Reports in the Green Mountain Freeman from 1847 and 1849 reference Marvin Dutton as producing high-quality leather ("Mechanic Arts," 1847; 1849). The Lamoille Newsdealer reported in 1861, "Isaac Merriam, of Stowe, on Friday last, sent us a stock of corn, the longest leaves of which measured 5 feet 10 inches, and says this is a sample of an acre he has growing" ("Isaac Merriam, of Stowe...", 1861). In 1888, the Burlington Weekly Free Press reported that Walter Slayton and Lewis Raymond "have bought a tract of land and gone to lumbering" ("Stowe," 1888). Reports from 1889 and 1890 in various local papers continue to reference their business, citing sales of "cords of maple wood," a sale of their "teams" (likely in reference to horses), and the hauling of lumber in Waterbury ("Stowe Scribblings," 1889; 1890a; 1890b; "Stowe," 1890).

Newspaper records also fill in details on the industrial history of the Waterworks. In 1867, the Vermont Christian Messenger reported, "We have been shown a specimen of copper ore found on Isaac Merriam's farm in the south easterly part of Stowe. The vein is being worked by a Hyde Park company, and promises to be profitable" ("We Have Been Shown...", 1867). In 1874, the Vermont Watchman reported, "Cooley & Prescott are putting up a forty-horse power engine on their land, near Isaac Merriam's hill farm, for sawing shingle" ("Waterbury Center," 1874).



Figure 5: The Merriam family circa 1900 (Waterbury Historical Society).

There is much evidence of this land use still on the Waterworks today. Near the main entrance, there are the remains of the cellar of an English-style house constructed with stacked stones, likely from the late 1800's or early 1900's. In the nearby stream, a square structure still stands, made of cement which indicates it was constructed less than 100 years ago. Along the road and between existing structures we still see evidence of stone walls, some of which are quite extensive. One stone wall still contains three rows of wire, both with and without barbs, indicating the presence of sheep, which would have required barbless wire to prevent their wool getting entangled (Samantha Ford, personal communication, April 6, 2026).



Figure 6: Barbless wire, one of three wires found within a stone wall on the Waterworks.

A second cellar hole, made of smaller stones, is likely somewhat older than the first, possibly from the mid-1800's. It is thought to have been Isaac Merriam's home with his wife, Mary, and their eleven children (Samantha Ford, personal communication, April 6, 2026).

In the brook at the corner of the pasture, there was likely a steam mill. The largest cellar remains consist of a foundation including large stones, mortar, and handmade bricks. This foundation was likely not that of a home, and would probably date to circa 1860.

However, the exact use of this structure is not known (Samantha Ford, personal communication, April 6, 2026).

Lastly, a stone wall up the stream suggests the possible presence of a steam mill (Samantha Ford, personal communication, April 6, 2026).





Figure 7: View of Waterworks Road, adjacent to the potential site of the Merriam homestead.

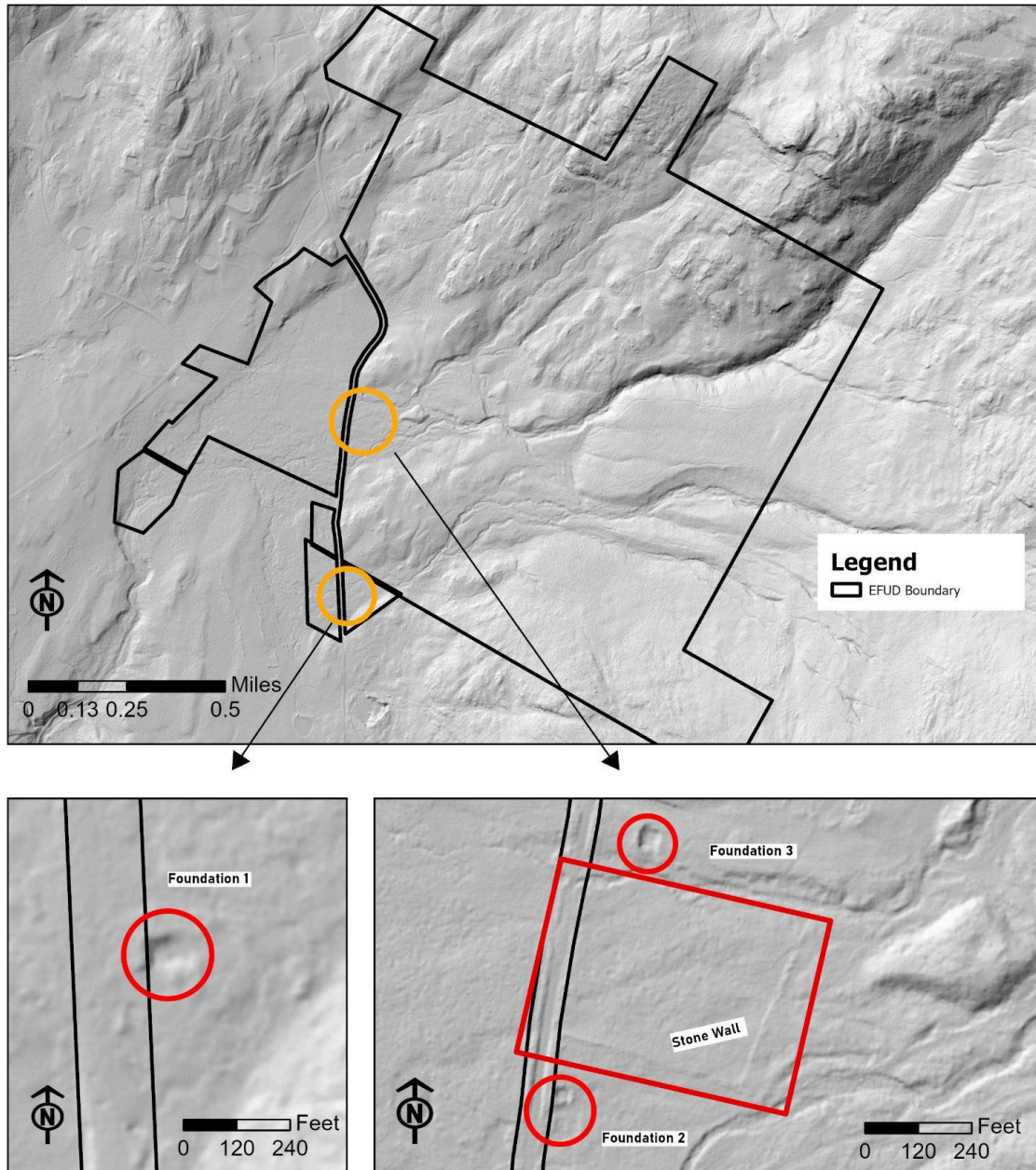




Figure 8: Evidence of historic mill infrastructure on Thatcher Brook.



## Historic Features on EFUD Property Visible with Lidar



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Inventory and Assessment graduate students  
April 2026

Credits: VCGI, Sources: Esri, Vantor, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community, Esri, NASA, NGA, USGS, FEMA, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community

Figure 9: Historic structures visible with LiDAR (Credit: Vermont Center for Geographic Information)





Figure 10:  
Foundation 1,  
referenced in  
Figure 9  
above.



Figure 11:  
Foundation 2,  
referenced in  
Figure 9  
above.



In 1926, a Vermont newspaper reported on a vote to greenlight the purchase of “not less than 10,000 Norway Spruce trees to be set out this coming year on ground adaptable to them on the Village watershed, situated on the Stowe Hollow Road on land owned by the village which at this time is not being utilized except as pasture land.” Subsequent reports from 1931 cited both an order for the purchase of 5,000 Norway spruce and the order having been canceled by the Waterbury Waterworks. In 1932, papers reported Waterbury Village as having placed an additional order for Norway spruce (“Will Have Municipal Forest,” 1926; “Trees Ordered for Spring,” 1931; (“We Commend the Judgement...,” 1931; “370,000 Trees Are Ordered For Spring,” 1931).



Figure 12: Foundation 3, referenced in Figure 9 above.





Figure 13: Stone walls, referenced in Figure 9 above.



## Life on the Waterworks

In “A History of Waterbury,” written by Ward Knapp, husband of Eva Merriam, and published in 1987, a clear picture of life on this landscape comes into view. In a chapter called “Loomis Hill Road,” Knapp describes some of the properties we know to have existed on what is now Waterbury Waterworks. While Loomis Hill Road does not run through the bounds of the Waterworks currently, the information in the chapter is accurate to what we know occurred on the site, and it seems commonly understood that the names of these roads have been changed over time.

In the beginning of the chapter, Knapp writes, “There was a little Settlement here once, on the Stowe side of the line. The Gibb Sawmill was located here, and a Creamery, and a few houses. The people who lived here shopped in Waterbury, and felt that they were more a part of Waterbury than Stowe. The “Cary Mary” copper mine was up the hill near here. It had two shafts, and I’m not sure if they have filled in by now or not. The mine never amounted to anything, and they later called it fool’s gold” (Knapp, 1987, pp. 51).

Knapp also describes a George Smalley having sold a “big farm” to Will Tyler. “When he died his wife tried to keep it on with a hired hand. Will’s wife had to sell the farm, and since most of the land was in Waterbury she sold it to the town of Waterbury for the water rights. The big red barn was bought by Warner, who moved it to the old Wheeler farm near the Center” (Knapp, 1987, pp. 51).

Knapp speaks on his wife’s family history, saying, “This farm was the Merriam farm, where my wife Eva grew up. Eva’s father built a large henhouse and raised two hundred Rhode Island reds. He had an egg route in Waterbury, and the money from the eggs was used to send Eva’s sister to college” (Knapp, 1987, pp. 53).

Another section contains information on a stone quarry “back in the woods” which was “blasted for the base of the new highway, Interstate 89.” He also describes a “Cold Spring Farm,” with a springhouse in their barnyard (Knapp, 1987, pp. 51-53).

## Transfer to the Village of Waterbury

In September of 1895, the Waterbury Record first reported, in an article titled “The Water Supply Situation,” on the need for a water supply to be established for the town of Waterbury. “The only drawbacks [sic] seems to be the somewhat doubtful sources of supply, but if those can be shown to be ample, there is no difficulty in having a water service in Waterbury within a year” (“The Water Supply Situation,” 1895). On the same page, another article reports, “a special meeting of the voters of Waterbury was called to hear the report of a committee elected some two and a half years ago to investigate as to the best sources of a water supply for the village of Waterbury for domestic use, fire protection, or any other purpose that may be thought necessary.” The report goes on to detail the water capacity of nearby water sources and the feasibility of their use as the town’s water source (“Tuesday’s Village Meeting Brought Forth Some Watery Talks,” 1895). Two months later, in November of 1895, the same newspaper



reported that “The committee have accepted the plans and specifications to secure water from Gibbs’ mill...it is thought by far the best place to secure water for the village” (“The Committee Appointed...,” 1895). One month later, in early December, the paper reports on having held a village vote on the acquisition of the Gibbs property (“Waterbury,” 1895).

A few days later, the Waterbury Record published an article entitled, “Special Village Meeting: A Clean Sweep for the Friends of the Water Supply.” In it they wrote, “After the most careful consideration of the whole subject we are clearly of the opinion that it is advisable for the Village to seek its water supply from springs situated in the northerly part of Waterbury and just beyond the town line in Stowe, and we have therefore taken the precaution to obtain from the owners of such springs, viz; Messrs. Charles Stevens, Horace Merriam, John Gibbs, and A. E. Gibbs option contracts in writing for the conveyance of such springs to the village at reasonable prices.” The article goes on to detail proposed infrastructure and an estimated overall cost (“Special Village Meeting,” 1895). A few days later the paper reported, “The Gibbs’ spring has long been known as one of the finest in this section, and the village of Waterbury is to be congratulated on its possession” (“Stowe Journal,” 1895).

Almost a year later, in September of 1896, the Waterbury Record reported, “Waterbury can now boast of one of the best water systems in the state. Pure mountain spring water and abundance of it, constitutes the new water works.” The article also includes, in detail, the costs, infrastructure, and labor contracts pertaining to the installation of the water system (“Waterbury Can Now Boast...,” 1896).

In a letter housed at Special Collections at the University of Vermont, addressed to “Contractors” and dated January 6, 1896, proposals were solicited for furnishing and laying water pipes, furnishing and setting valves and hydrants, and building, receiving and distributing reservoirs.” This letter also lists John Gibbs, E. A. Gibbs, Horace Merriam and Charles Stevens as having sold their springs to the Village of Waterbury (W. P. Dillingham et al., January 6, 1896).

## Current Land Use

The most significant use of the Waterworks today is by EFUD as the water source for the town of Waterbury, including timber harvest and maintenance of water infrastructure. Known public recreation on the site includes use by mountain bikers, birders, walkers and runners (some of whom bring dogs), hunters, skiers, snow shoers, and foragers. The presence of recreation on this site combined with research about the history of the Waterworks suggests the potential for place-based education on the site, including interpretive trails with corresponding signage.

The Waterworks also hosts a network of “rogue” mountain biking trails created without permission (Figure 14). Locals have reported an increase in use and creation of these trails in recent years (Front Porch Forum, 2026). Online trail tracking platforms such as Strava show an extensive network of these unauthorized trails on the site (Strava, n.d.). The trails on the Waterworks are used far less frequently than nearby official trails such as Perry Hill and Little River State Park (Strava, n.d.). Due to the continued use and development of these trails, EFUD

closed the property to the public in September 2025. Local public forums showed a variety of reactions of locals to the closure. Many were disappointed that the Waterworks had been closed without more opportunity for public engagement (Front Porch Forum, 2026). In December 2025, EFUD hosted a series of public forums to discuss the use of the Waterworks and concerns about how recreation may affect the safety of the water supply (Front Porch Forum, 2026).



## Unauthorized Trails in The Waterworks

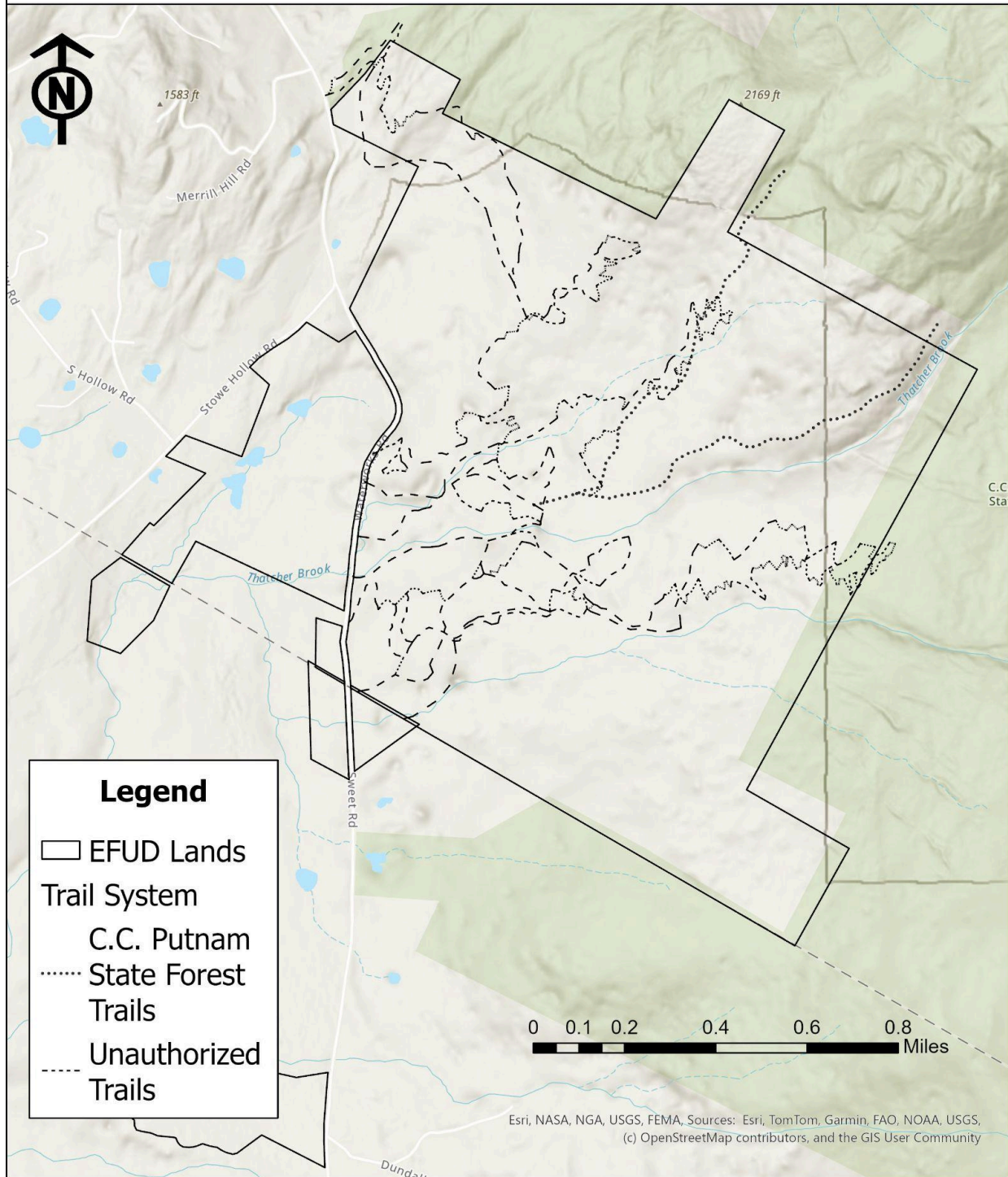


Figure 14: This map shows the current network of unauthorized trails on EFUD land.

Below is a link to an ArcGIS StoryMap created by Clara Chaisson that includes a more in-depth timeline of events that led to the closure of the Waterworks, an evaluation of mountain biking in the region as a whole, and a look at public commentary on Front Porch Forum about the closure of the site.

<https://storymaps.arcgis.com/stories/9440590a43bb41cbb5db142a9c21ee6a>

## Context within Vermont

The land use history of the Waterbury Waterworks closely mirrors that of Vermont's overall land use history. Lumbering, sheep farming, small-scale hill farms, mills, intentional pine plantations, and glebe lots were once extremely common across the state (*War & Industry: Vermont's Changing Landscape* — Vermont Historical Society, n.d.; *History of Forestry in Vermont* | Department of Forests, Parks and Recreation, n.d.; *Glebe Land and Perpetual Lease Land in Vermont*, 2023). The current use of the land both for recreation and as a source of water also mirror Vermont's culture today. Many Vermonters value the state's beautiful natural areas, habitat for wildlife, and access to clean water. Outdoor recreation also plays a large part in Vermont's culture from cross country skiing to birdwatching. The Waterworks has all of these elements and is an important piece of land as a natural area, water collection site, and somewhere where people have historically and continue to appreciate the land.

## Conclusion

In order to continue understanding the history of human land use on the site, we recommend a few next steps. First, we were not able to visit the Stowe Historical Society, and their records are not digitized. Second, there were quite a few historic parcels on the present-day Waterworks site, including some parcels in Stowe and all parcels of the Waterbury portion of the Waterworks, that we were not able to research. A professional historian could do an appropriately thorough deep-dive into these and other deed records from this area. We also only visited the Stowe Town Clerk, and the Waterbury Town Clerk may have deed records relevant to the southernmost area of the Waterworks. Last, we recommend an extensive, on-site survey to comb for any undiscovered foundations and stone walls, and to analyze the known traces of human habitation on the site.



## 1963 Aerial with EFUD Boundary Overlaid

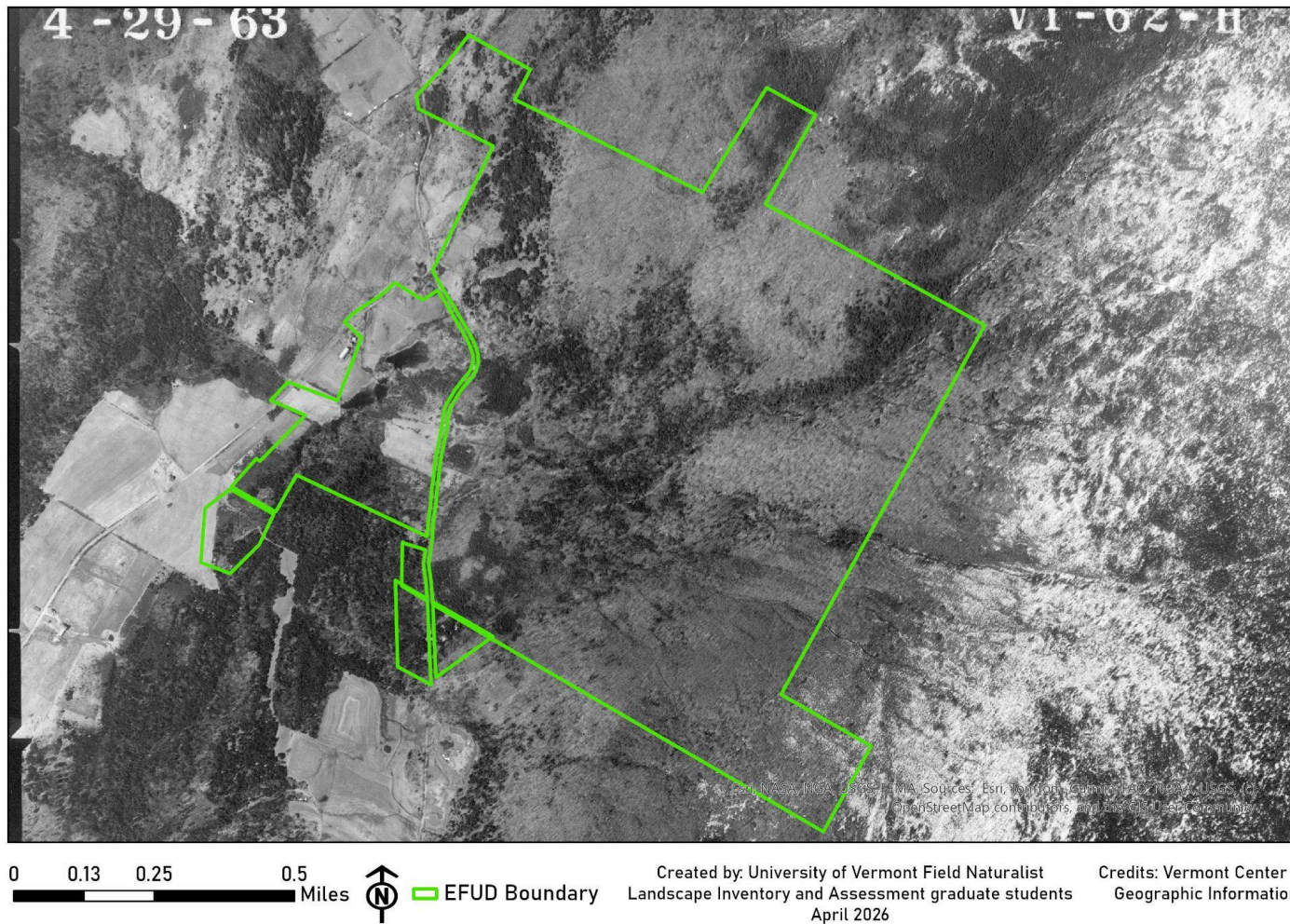
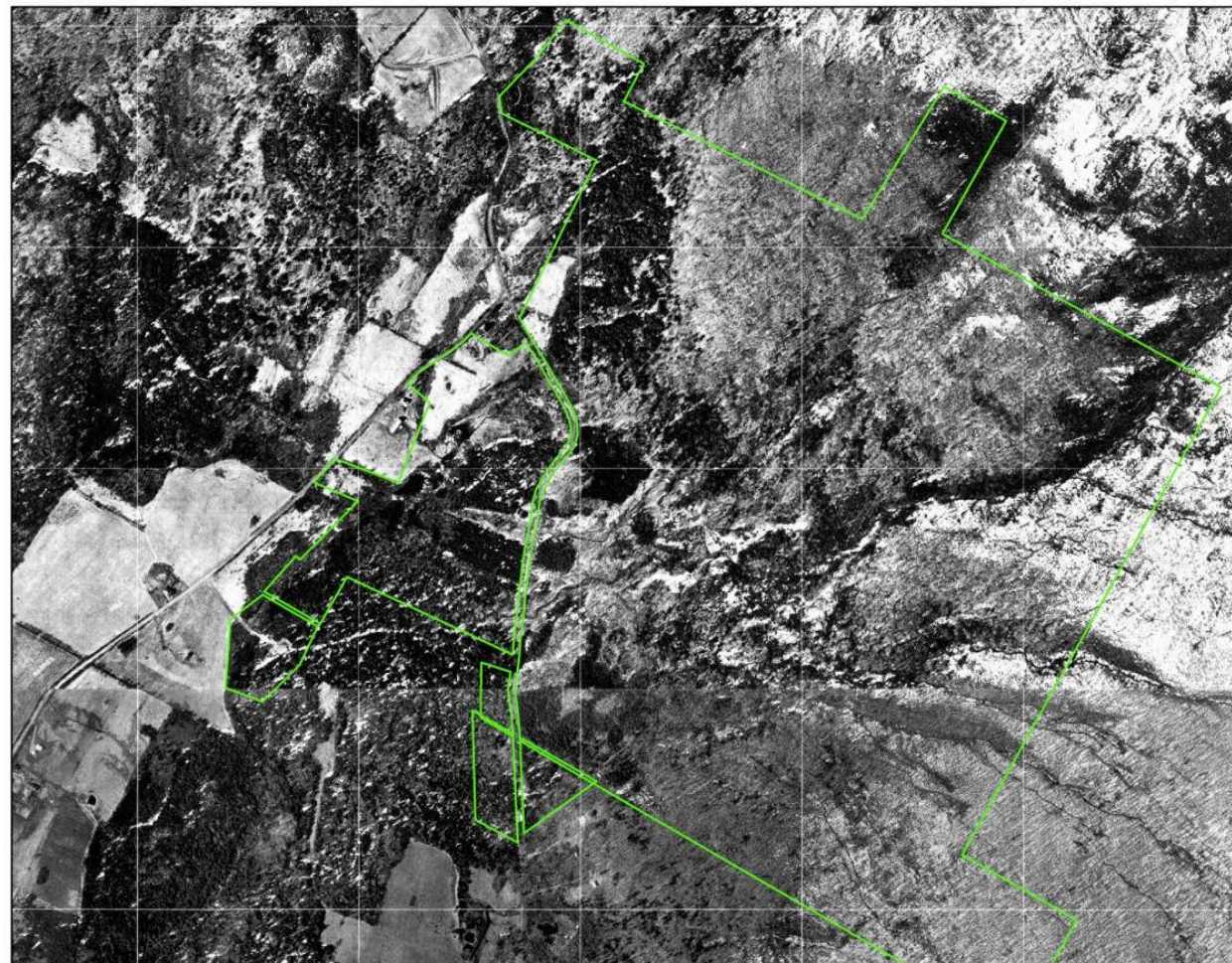


Figure 15: 1963 Aerial Imagery (Black & White, Leaf Off)



## 1979 Aerial with EFUD Boundary Overlaid



0 0.13 0.25 0.5 Miles



EFUD Boundary

Created by: University of Vermont  
Field Naturalist Landscape  
Inventory and Assessment  
graduate students  
April 2026

Credits: Vermont Center  
for Geographic  
Information

Figure 16: 1979 Aerial Imagery (Black & White, Leaf Off)



## 1996 Aerial with EFUD Boundary Overlaid

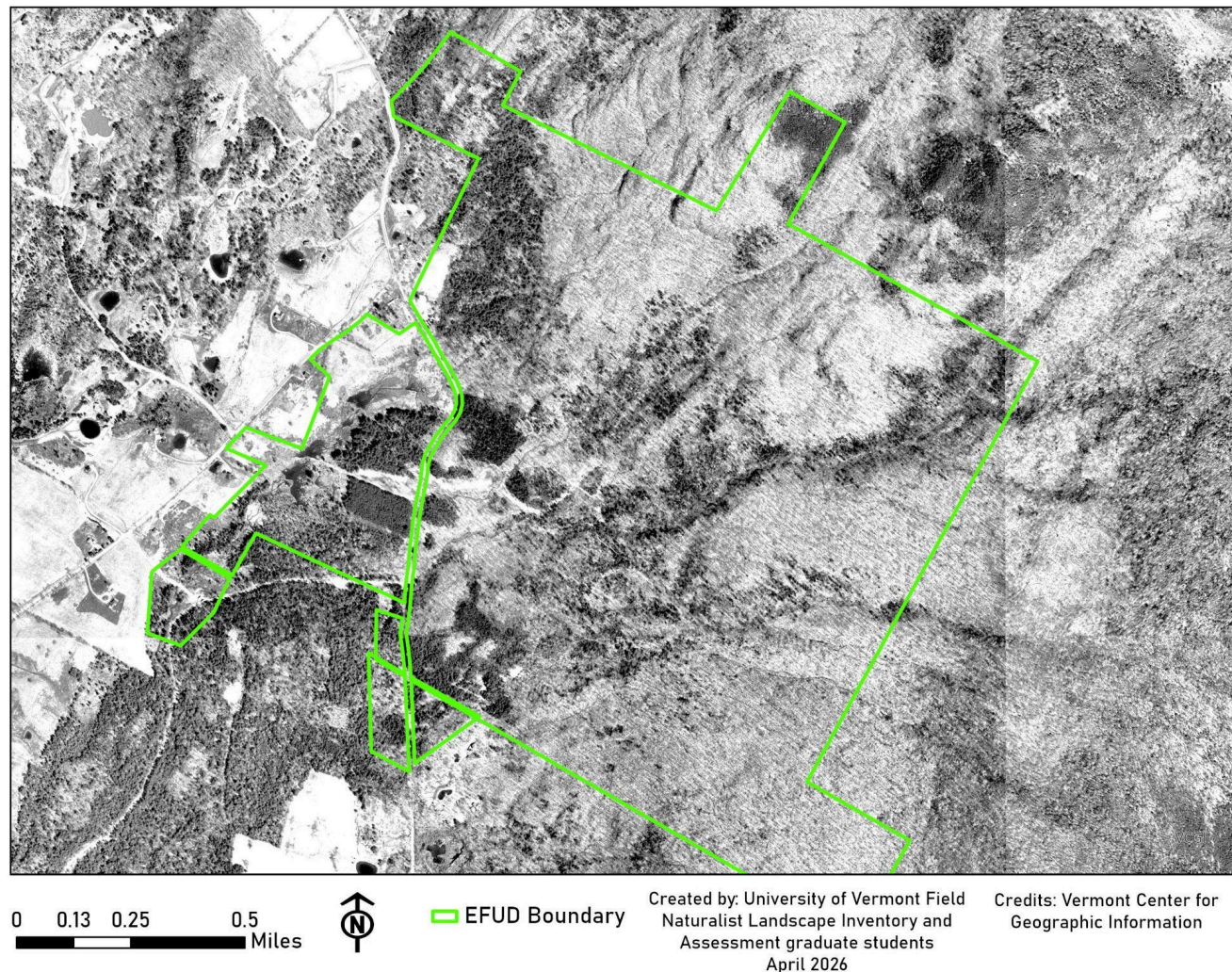
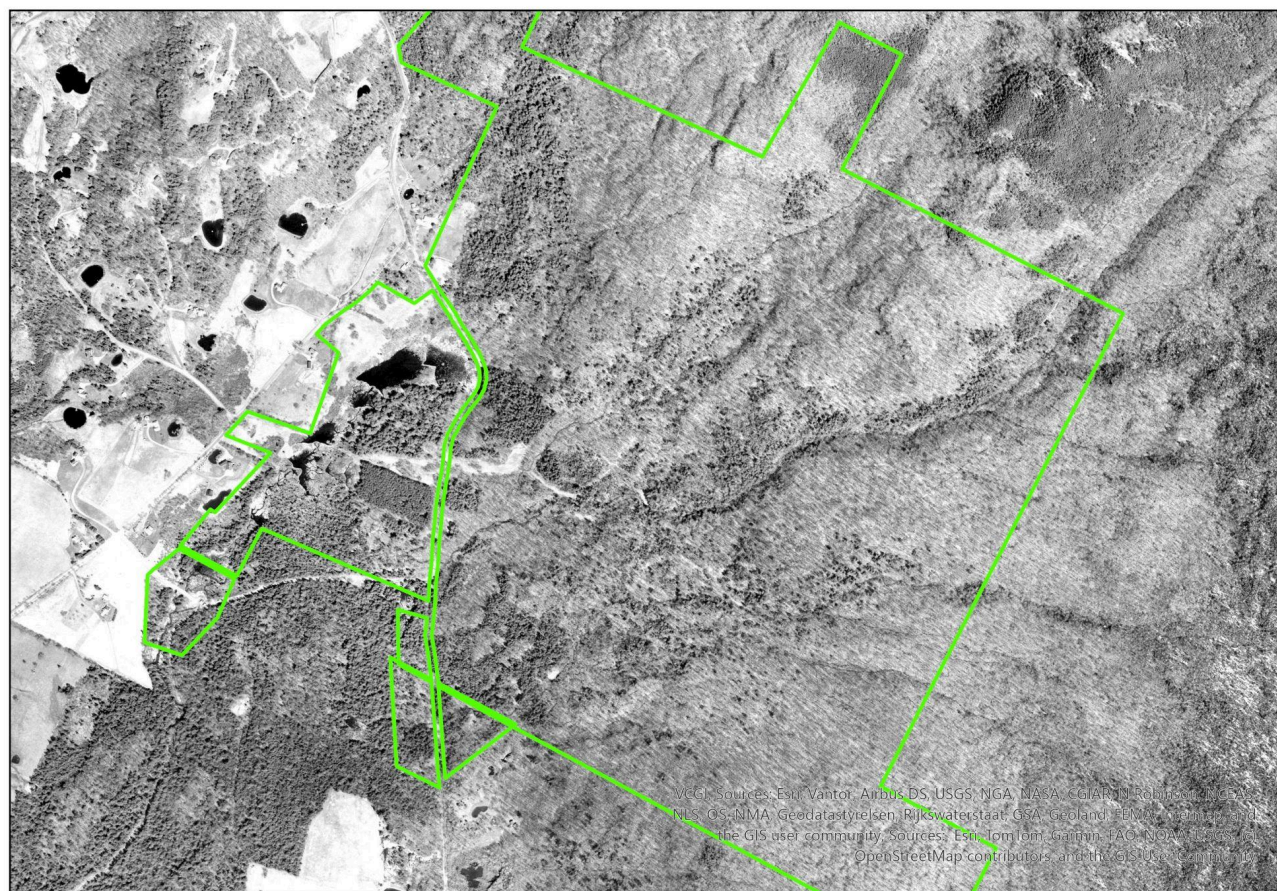


Figure 17: 1996 Aerial Imagery (Black & White, Leaf Off)



## 2007 Aerial with EFUD Boundary Overlaid



0 0.13 0.25 0.5 Miles



EFUD Boundary

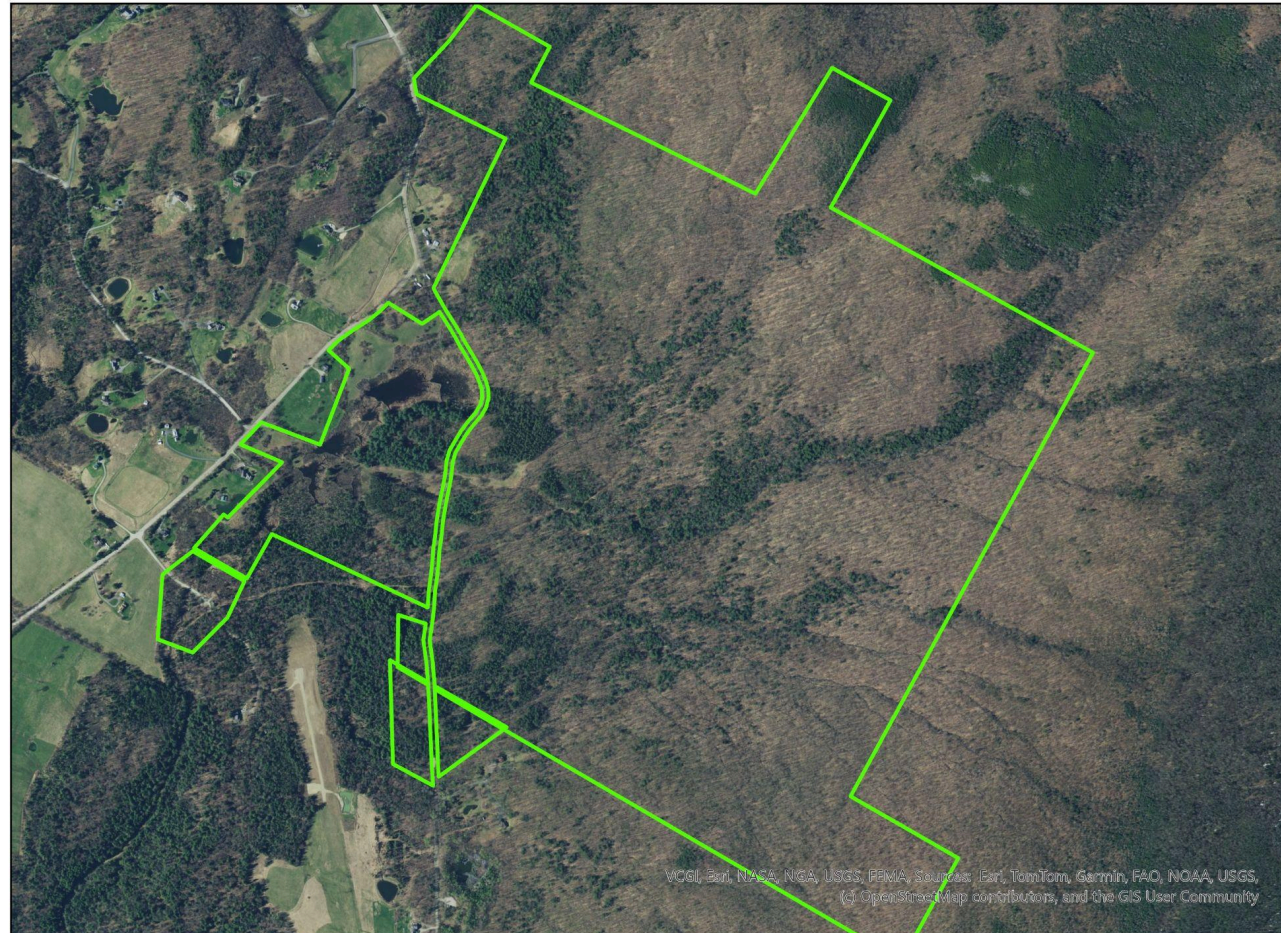
Created by: University of Vermont Field  
Naturalist Landscape Inventory and  
Assessment graduate students  
April 2026

Credits: Vermont Center  
for Geographic  
Information

Figure 18: 2007 Aerial Imagery (Black & White, Leaf Off)



## 2018 Aerial with EFUD Boundary Overlaid



0 0.13 0.25 0.5  
Miles



EFUD Boundary

Created by: University of Vermont Field  
Naturalist Landscape Inventory and  
Assessment graduate students  
April 2026

Credits: Vermont Center for  
Geographic Information

Figure 19: 2018 Aerial Imagery (Color, Leaf Off)



# Softwood Plantation in Field 1963-2018

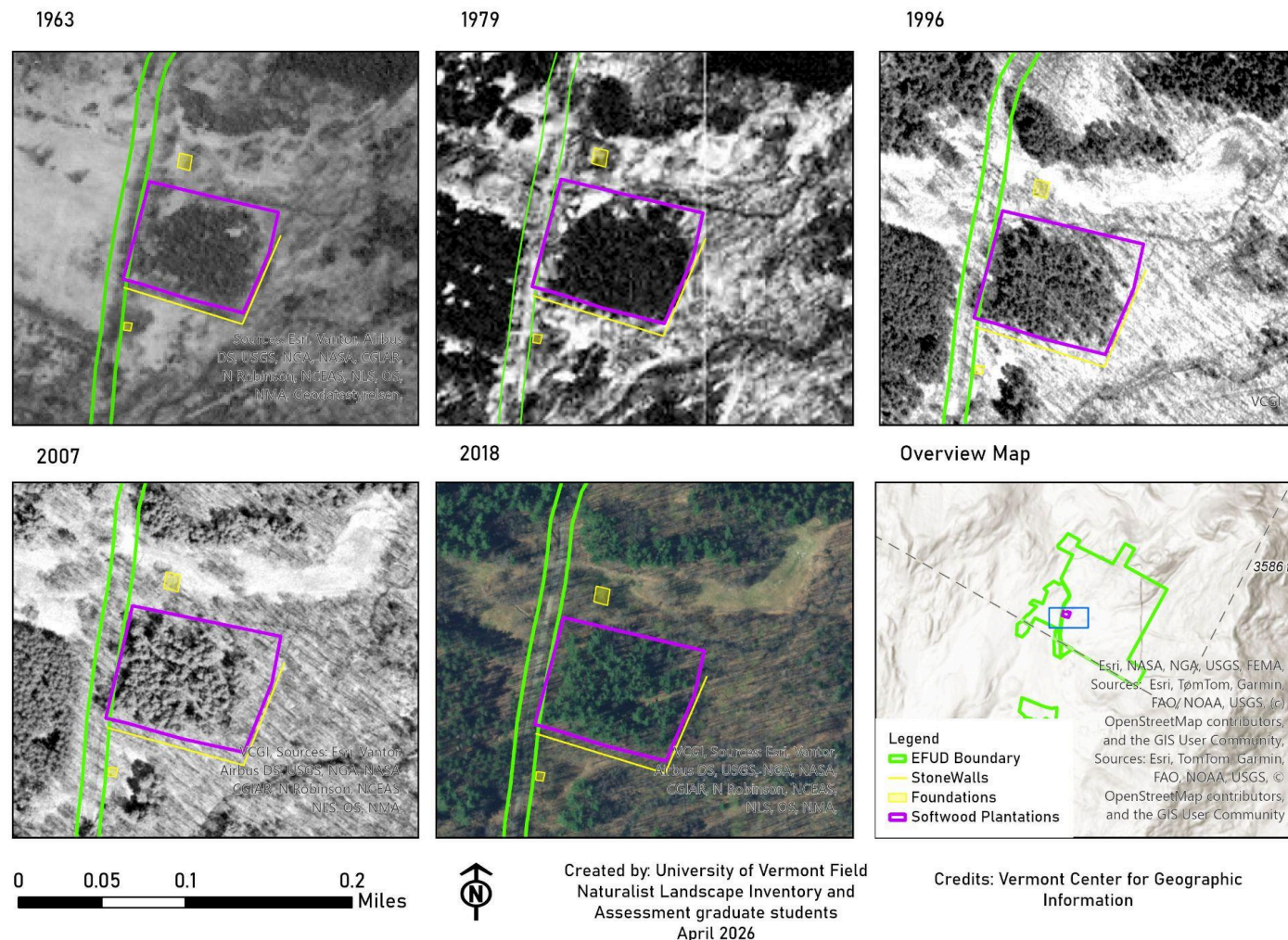


Figure 20: Comparison over time of softwood plantation inside potential former Merriam family pasture area.



# Enduring Features: Bedrock, Streams & Soils

## Introduction

This section explores landscape features that typically endure for many years, such as topography, bedrock, surface water, and soils. We'll discuss the **glacial history** of the Waterworks, how the land shapes and soils formed, and why water moves across the landscape the way that it does. We'll also discuss **erosion** on the landscape, and note areas where sediment seems likely to be entering the surface water sources that EFUD utilizes for the municipal water supply. We make recommendations regarding **trail and road repair and maintenance, trail design, and siting considerations** for any future trails or reroutes that may be developed.



Figure 21: Two streams merging upland on Merriam Brook, neither of which shows up on existing maps.

## Fieldwork

In order to align our survey approach with the core purpose of the Waterworks – to provide clean drinking water – we focused our survey on the major brooks that host water infrastructure, walking Merriam and Tyler brooks along their full length within the site. Throughout these walks, we photographed erosion along the brooks, noted any roads or trails that came near to the brooks and drained water into them, and noted other features as needed. We also noticed many streams that were not on the map, and walked some of these as well. We spent additional time in the lowland parts of the Waterworks, around the road and the wetlands, in order to deepen our understanding of the most accessible parts of the site where we expect recreation to be the most concentrated.

## Topography, Bedrock, & Glacial History

The present-day landscape of the Waterworks is the result of its topography, bedrock geology, and glacial history, which together influence the movement of water downslope from Hunger Mountain. Similar to other mountains with streams in the Worcester Range, the Waterworks has high bedrock (shallow soils) which pushes groundwater toward the surface and limits infiltration (the extent to which water can soak down into the ground), contributing to a higher volume of water remaining in the streams. Streams moving down Hunger Mountain pick up speed and carry sandy sediment, which is deposited at the base of the mountain. While the Worcester Mountain Range was formed 300-500 million years ago when ancient continents collided and forced bedrock upwards, the landscape of this region was shaped more recently by glaciers that deposited sediment, scoured bedrock, and defined valleys (Stuhl, n.d.).

### Topography

Topography is an important defining characteristic of the Waterworks, with steep mountain slopes allowing streams to channelize (create deep banks over time). Channelized streams with rocky banks shift less over time, which makes them reliable sources for drinking water. The steep slopes, which make the site desirable for recreational activities such as hiking and mountain biking, also increase flash flood and erosion risks along Merriam, Tyler, and Thatcher Brooks. The Waterworks is flattest in the southwest corner near the road entrance and becomes steeper in both northern and eastern directions.

There is over 950 feet of elevation gain across the Waterworks, with slopes increasing substantially near Well #1 on Tyler Brook. The steeper half of the Waterworks is defined by slopes exceeding 20-30% grade, denser clay soils, areas of exposed bedrock, and rocky stream channels which are straighter to enable faster flow of water moving downstream. Tyler Brook runs through a deeper channel with rocky ledges reaching over 100 feet above the stream as the slopes become steeper in the northeast section of the Waterworks.

From Well #1 to the southern boundary of the Waterworks, only ~200 feet of elevation gain defines a more gradual slope for the southwestern quadrant. This gentler slope allows Tyler and Thatcher Brooks to widen, deposit sediment, and merge near Waterworks Road. All of the



streams contribute sandy sediment at the base of the mountain. This sandy soil is more prone to erosion and will allow streams to shift, widen, and meander over time.



Figure 22: View down to Tyler Brook in the steeper northeastern section of the Waterworks.

## Bedrock

The bedrock of a site influences groundwater flow as well as soil development. Bedrock is visible in many areas within the Waterworks. Notably, a boulder outcropping likely still connected to bedrock buried under soil can be seen north of Waterworks Road along Tyler Brook. The large boulder has moss and ferns growing along its surface. Enough of the rock is exposed to see different sediment layers and joints of the rock. These joins reveal a glimpse into how water may travel through bedrock underground.

The three key bedrock types on the Waterworks are: **amphibolite**, **schist** with quartzite, and **greenstone** (VT Agency of Natural Resources, n. d.)

**Amphibolite** is the most common bedrock type, and is common generally in the Worcester Range. Amphibolite underlies Merriam, Thatcher, and Tyler Brooks and is characterized by a dark-green to black color that may have speckled or mottled streaks. Amphibolite rocks are medium-to-coarse-grained, meaning the individual mineral crystals of the rock fragments are easily seen by the human eye, and the rock likely formed through slow cooling. The rock type is described as “massive,” a geologic term meaning that amphibolite is often homogeneous, uniform in texture, and lacking internal structures such as layering and cleavage (splitting along planes of weakness in the crystal structure). This bedrock type commonly presents as a solid, large unit rather than a series of thin stacked rock layers. This solidity allows amphibolite to act as a relatively impermeable layer under the soil, through which water, for the most part, does not pass. Water is only able to pass through this bedrock type when there are fractures in the rock face (Coish et al., 2012).

**Schist** is another prominent bedrock type present on the Waterworks. It has layers of hard quartzite, likely formed by intense heat and pressure acting on older sedimentary rocks. This bedrock is dark in color and flaky with more fractures that may allow for water movement. Mineral bands of mica, quartz, and garnet may be present throughout the schist.

**Greenstone** bedrock is also present on the Waterworks. Greenstone may include some layers of quartzite, but is more grayish-green in color with rusty hues showing after weathering. Greenstone is denser than schist and less likely to have as many fractures to allow for water movement.





Figure 23: Exposed bedrock near Tyler Brook north of Waterworks Road with visible fractures revealing how water may move through rock layers underground.



# Bedrock Geology

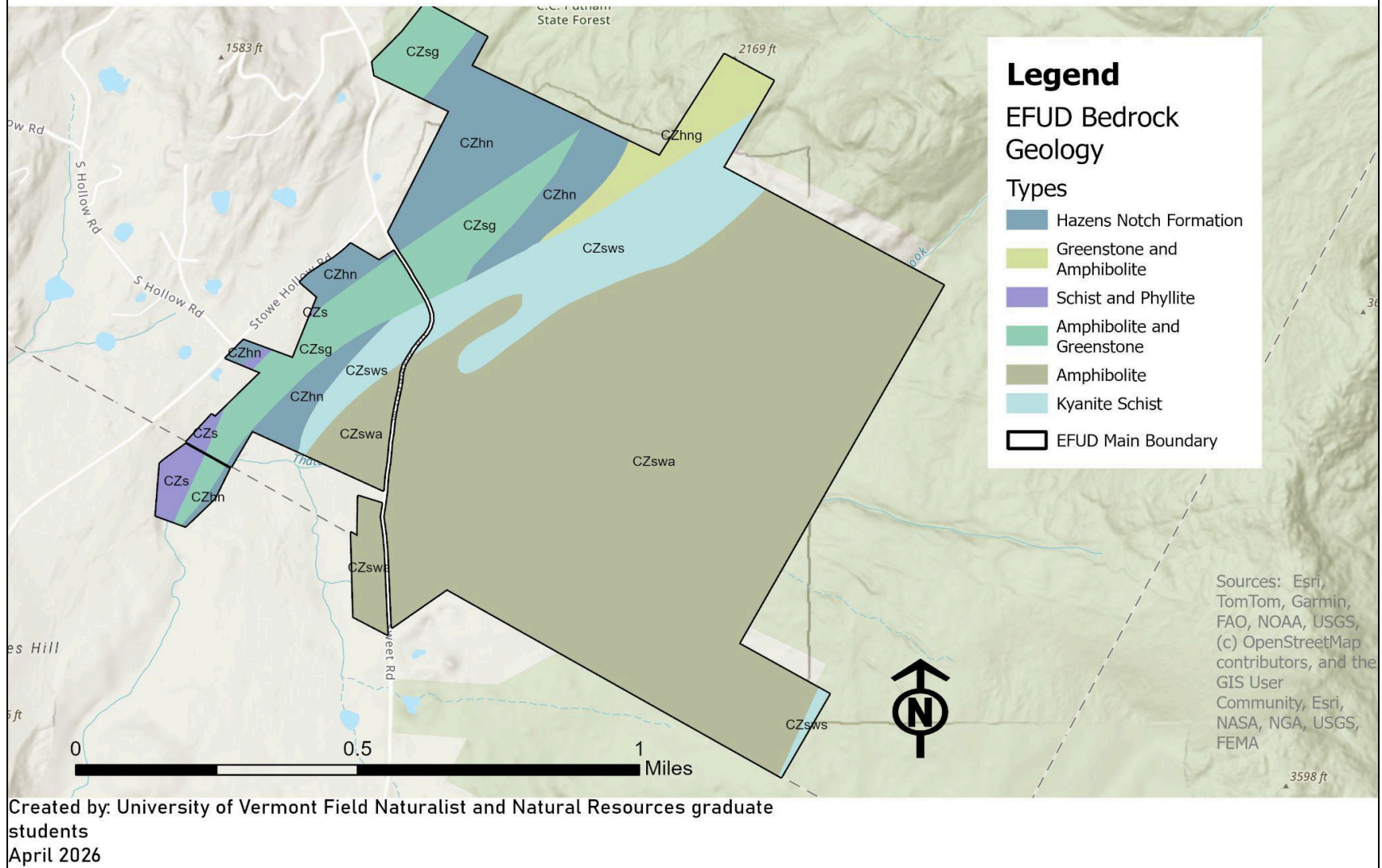


Figure 24: A map of the bedrock geology of the Waterworks, showing that greenstone, amphibolite, and schist are the predominant bedrock types on the landscape.



## Glacial History

The Worcester Range in Vermont formed roughly 300-500 million years ago during the same tectonic events that built the Appalachian Mountains (NPS Geologic Resources Division & American Geosciences Institute, 2020). These mountains eroded over time before being reshaped more recently by the Laurentide Ice Sheet and accompanying glaciers during the Pleistocene Epoch (2.6 million to 11,700 years ago). During the time that all of Vermont was covered by the Laurentide Ice Sheet, glaciers eroded mountain summits, widened valleys, and deposited sediment, ice, and rock. Glaciers moving through the Worcester Range would have scraped across the bedrock, clearing away soil and depositing glacial till: an unsorted mixture of clay, silt, sand, gravel, and boulders. Soil on the Waterworks today is softened glacial till that has been weathered since the glaciers began melting in Vermont (Thomspon et al., 2019).

Glacial activity on the Waterworks can be seen on scratched or scoured bedrock where scratches are all running in the same direction and indicate the movement of a glacier. While it is likely that streams flowing down Hunger Mountain pre-dated the glaciers, glacial activity across the Waterworks probably shifted stream flows by moving massive quantities of soil. Stephen Wright, former geologist and lecturer at the University of Vermont, noted that there is little evidence of extremely scratched or scoured rocks along the main streams, meaning the topography of the stream channel most likely pre-dated glacial activity (Wright, 2026).

Some soil deposited by the glaciers was gradually eroded away by Tyler, Thatcher, and Merriam Brooks. This soil flowing downstream is deposited as each stream hits a flatter slope and widens out. Over time, this soil deposition creates a characteristic wedge or fan shape at the bottom of each stream, where newly deposited sediment keeps pushing out previously deposited sediment. These deposits, called alluvial fans, are defined by water flow and made up of moderately erodible soil. They are dynamic landforms where *water flow patterns and soil locations may change over the long-term (decades to centuries) with major floods having the capacity to cause more immediate changes.*



Figure 25 & 26: [Photo of alluvial fan](#) from Google Earth (left) and topography lines from the parcel showing the characteristic cone-shape of an alluvial fan (right).



# Main Brooks of the EFUD parcel

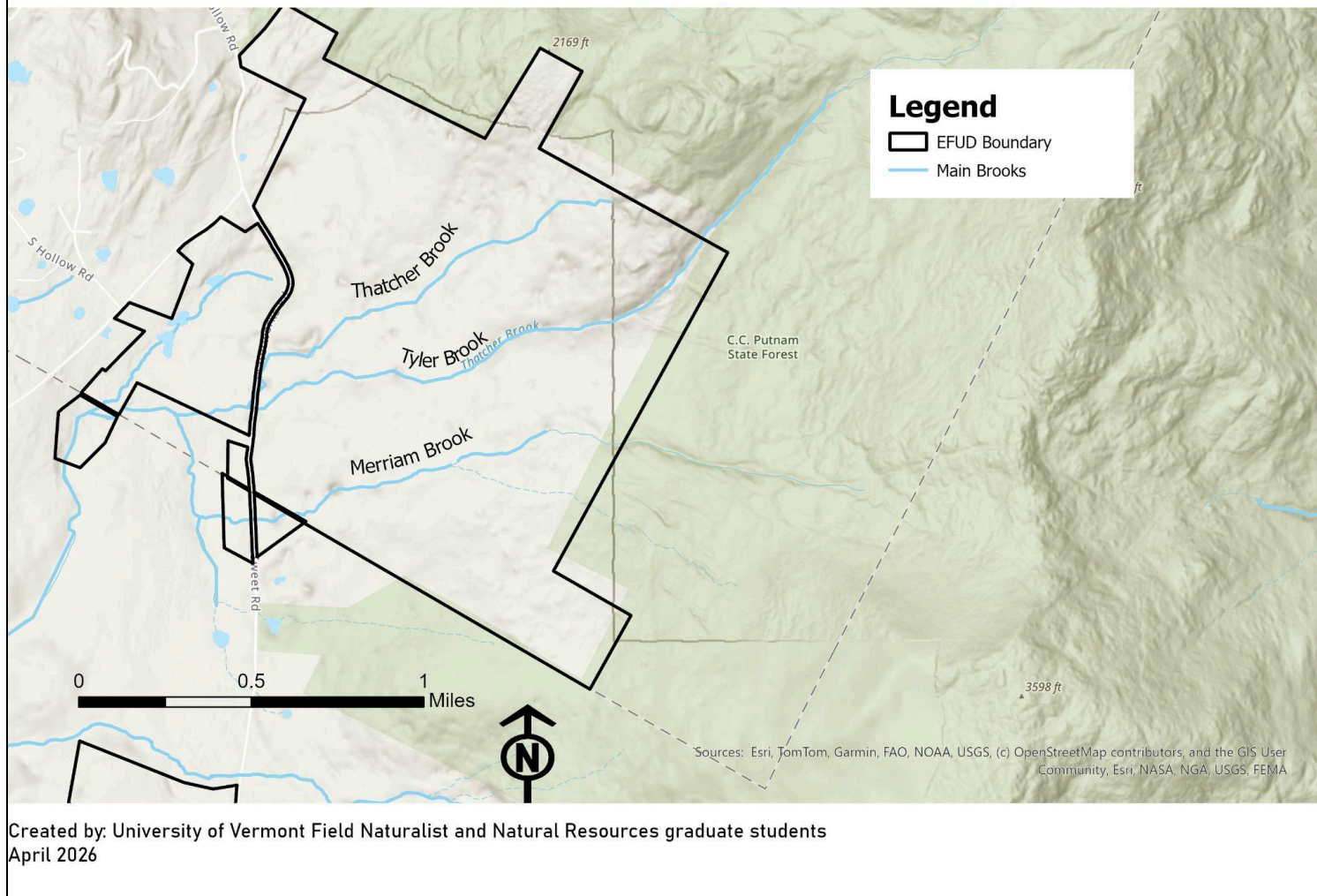


Figure 27, above: Map of the main brooks on the EFUD parcel.

## Surface Water: Streams, Springs, Seeps, Wetlands, and Flooding

The Waterworks has several streams, including Thatcher, Merriam, and Tyler Brooks, and others not shown on most maps, which flow down the southwestern face of Hunger Mountain. The brooks merge along the southern edge of the Waterworks and eventually drain into the Winooski River. With several brooks running through the Waterworks, a lot of surface water and groundwater is concentrated within the Waterworks boundary. There are wetlands running parallel to Stowe Hollow Road. While there have been no major/standing water floods impacting the Waterworks, Merriam, Thatcher, and Tyler Brooks are susceptible to flash floods, particularly where their banks are lower near the bottom of the Waterworks.

Figure 28, below: EFUD infrastructure along Tyler Brook.



### Main Streams

The streams of the Waterworks are part of the Winooski River Watershed, the largest watershed in Vermont. This watershed is mostly forested and drains into the Winooski River before eventually flowing into Lake Champlain. Hunger Mountain, part of the Worcester Range, includes many streams that feed into the headwaters of the Winooski River. Thatcher, Merriam, and Tyler Brooks are steep, rocky, and fed by high-elevation snowmelt and rain originating from Hunger Mountain. The steepness of each stream channel increases with slope and there is an overall elevation gain of over 950 feet across the parcel. Along Tyler Brook, 100-foot steep rock walls separate forests from the brook below.

As the climate changes, less snowfall is predicted for Vermont, including in high-elevation areas like Hunger Mountain. Over time, there might be less water feeding into Thatcher, Tyler, and Merriam Brooks. The brooks experience high water levels during snowmelt and during



increased rainfall in the spring, and may see sharp increases in water volume throughout the season following major rains.

Thatcher Brook just north of Waterworks Road transitions into a losing stream (also called influent stream), which is a stream that disappears into the groundwater system and seems to stop flowing. Losing streams connect with groundwater flow through permeable spaces created by sandier soils and/or fractures in the underlying bedrock.

EFUD has collected water turbidity data from the main streams as well as recorded on which days water needed to be pulled from wells instead of surface water due to high turbidity. Water quality turbidity data measures the cloudiness or haziness of water caused by suspended particles like silt, clay, and organic materials. The data have been collected monthly since 1992, with only a few gaps, such as a missing month here and there and no data for 2006. EFUD has analyzed the data to show an increase in water turbidity over time. Yearly spikes in 1995, 2005, and 2023 likely correspond with significant storms in the summer of 1995, remnants of Tropical Storm Tammy in 2005, and rain that caused the flood in July 2023 (Figure 29).

We used data collected by EFUD to create a boxplot, which shows the range of values and medians as bolded center lines, for the turbidity range for each month since 1992 to determine if there are seasonal fluctuations (Figure 30). There was a moderate increase in average turbidity in April and May, which likely reflects spring rains and snowmelt. Spring storms lead to more runoff and sediment washes into waterways. Additionally, trees are not fully leafed out in spring and are thus unable to intercept as much rainfall. There is another moderate increase in water turbidity in October, which may relate to seasonal bursts of rainfall. Additional analysis of local rainfall data compared to turbidity trends is required to understand this relationship. Local rainfall data are available through National Weather Service rain gauges. Waterbury Reservoir gauge (WRSV1) and Ranch Camp gauge (RCHV1) are the closest to the parcel (*National Weather Service*, n.d.).

Although predictions cannot be made solely from the data collected, trends revealed by the data—that turbidity is increasing over time and seasonal turbidity is slightly higher in April, May, and October—may continue in the future, especially as Vermont is projected to receive higher rainfall with climate change.

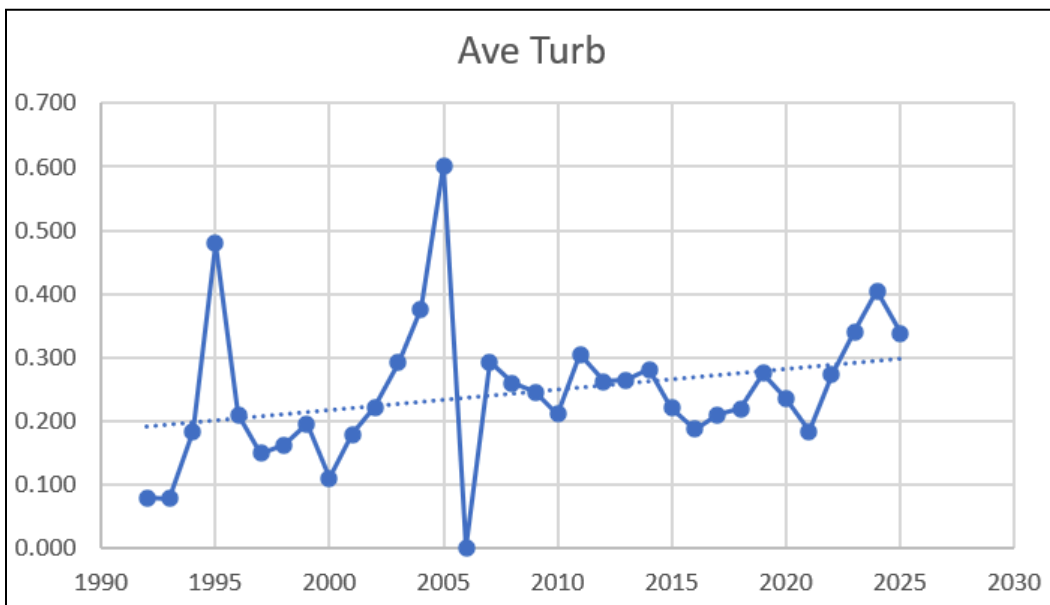


Figure 29: EFUD graph showing yearly average water turbidity from 1992 to 2025.

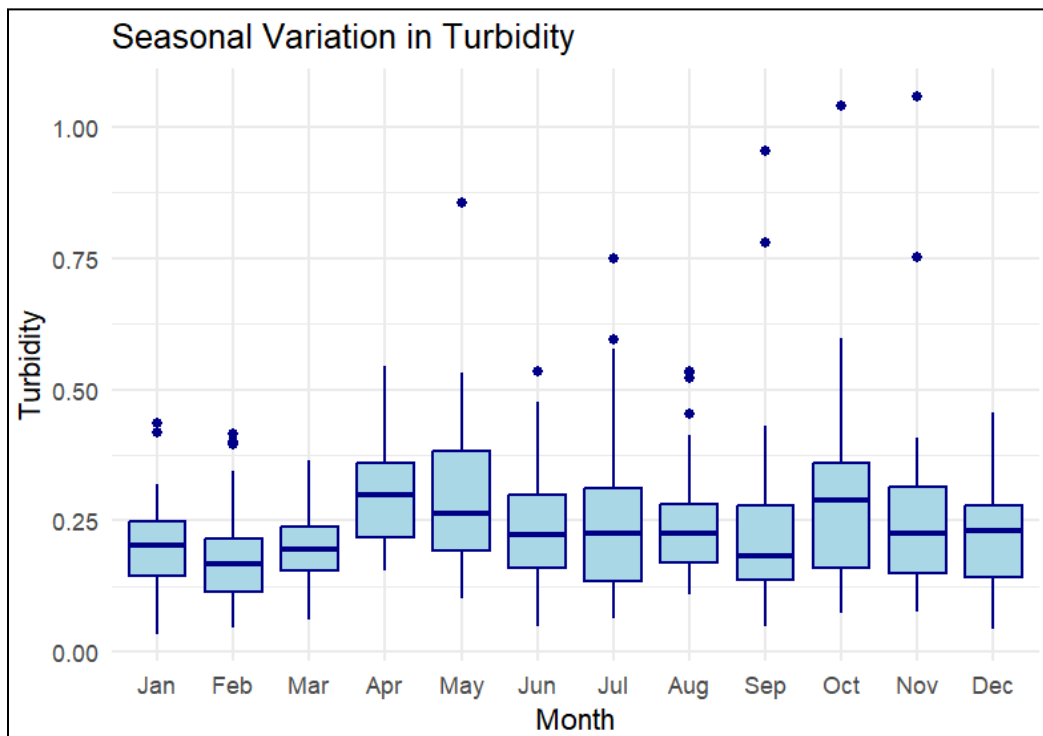


Figure 30: Boxplot created in R Studio showing seasonal variation in turbidity over 33 years (from 1992-2025). Each blue box represents the middle 50% of turbidity range for that month. Lines are the upper and lower 25% of data, respectively. Blue points outside boxes represent outlier data points. There are moderate increases in median turbidity for the months of April, May, and October. Turbidity units are NTU (Nephelometric Turbidity Unit).





Figure 31: North of Waterworks Road, Thatcher Brook transitions into a losing stream (a stream that disappears into the groundwater system and seems to stop flowing).



## Springs, Seeps, and Un-Mapped Streams

Springs and seeps are plentiful on the Waterworks. Springs originate from a specific concentrated point where water flow is driven by consistent pressure, while seeps (Figure 32) flow more slowly, discharging groundwater over a broad and non-channelized area (*Springs and Seeps*, n.d.). Both springs and seeps have the potential to serve as crucial water sources and help maintain perennial flow in larger brooks. Exploration of the Waterworks parcel revealed the presence of **many stream offshoots and groundwater seeps that do not show up on published maps** like the Vermont ANR Atlas or Vermont GeoData Portal layers. There is also a spring located just East of the parking lot—the water from the spring currently passes through a culvert under the road, into a wetland area, and eventually feeds into Merriam Brook near the west edge of the Waterworks. Mapping offshoot streams and groundwater seeps would be important to inform future management of the Waterworks, as these streams and seeps have the potential to feed into existing water collection infrastructure.



Figure 32: Small, unmapped groundwater seep in the northeastern section of the Waterworks near Tyler Brook



# Unmapped Hydrologic Features

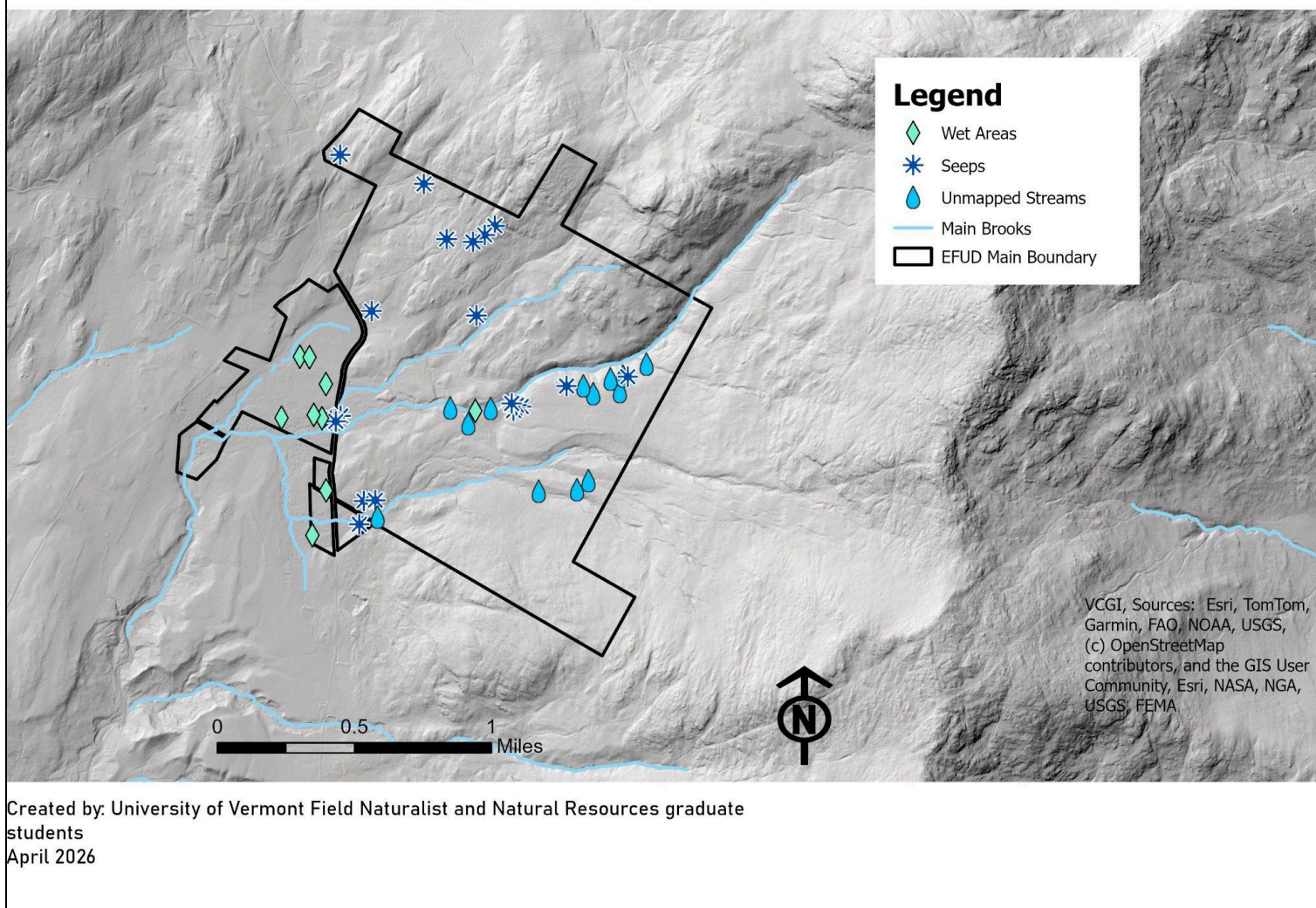


Figure 33: Areas where previously unmapped small streams or groundwater seeps were noted on the Waterworks Parcel.



## Wetlands

Wetlands, characterized by saturated soils and standing water, are sensitive ecosystems providing rich habitats for fish and wildlife (VT Department of Environmental Conservation, n.d.). Wetlands can act as important buffers during flooding, helping filter out pollutants, including sediment, which might get washed into the streams. On the Waterworks parcel, wetlands are located in the southwest corner. Though this area has sandier soils, high groundwater makes it prone to saturation. It is difficult to install and maintain infrastructure in and around wetlands. Boundaries of wetlands are fluid over time which may also make trail maintenance more challenging.



Figure 34: Wetlands along the western edge of the Waterworks Parcel



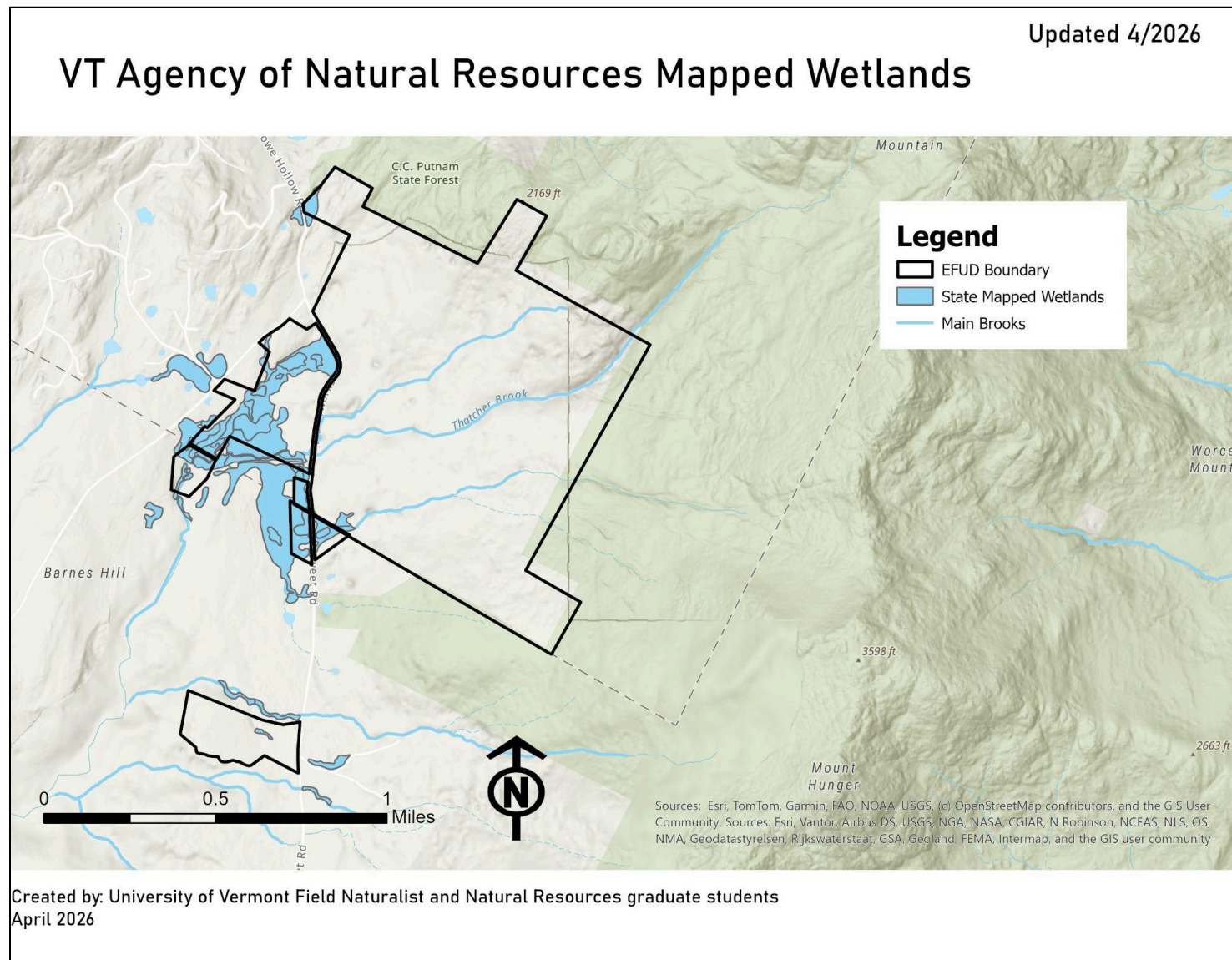


Figure 35: Mapped wetlands along western edge of the Waterworks Parcel.





Figure 36: Part of a large wet area not currently mapped as a wetland in ANR Atlas.

### Flooding

The Waterworks does not fall within a Special Flood Hazard Area (SFHA) as mapped by FEMA, meaning the Waterworks is at low risk for inundation flooding. Nearby areas, including the Town of Waterbury, have been affected in the past by historic flooding, such as the Great Flood of 1927, which caused serious destruction after three days of heavy rain in November. Neither this flood, nor other inundation floods EFUD is aware of, have impacted the Waterworks, due to its high elevation above the Winooski River. Tyler, Thatcher, and Merriam Brooks do, however, carry flash flood risk, because they flow down steep slopes and can reach capacity during heavy rains. Flash floods move loose boulders and fallen trees downstream and could impact EFUD infrastructure. Tessa Yip, a Community Support Floodplain Manager with DEC's Rivers Program, also noted that Tyler Brook has a mapped river corridor that is highlighted on the ANR Atlas. River corridors are designated zones of land adjacent to a river that represent the spatial extent a river needs to meander and shift naturally. Unlike fixed setbacks, these buffers are mapped to reflect the dynamic nature of rivers, providing insight on how river channels may shift or erode over time. River channel fluctuation may be exacerbated by flash-flood events, especially if these events include undercutting of stream banks. Mapped wetlands to the north may provide an important flood buffer for the downstream river corridor.



# Flood Hazard Risk

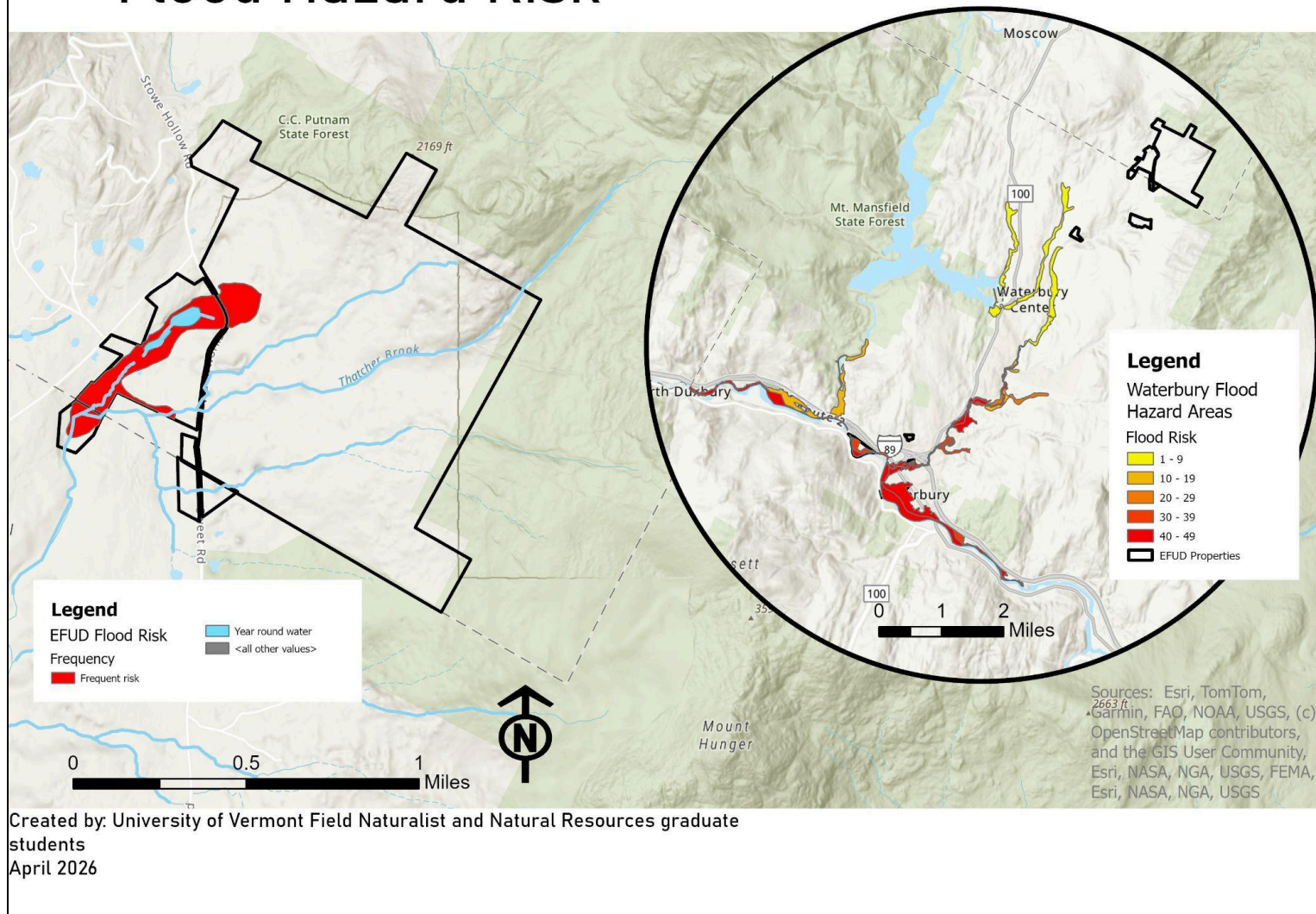


Figure 37: Flood hazard map showing hazards in and around the property.

## Soils & Erosion

The EFUD Commissioners are concerned about the potential for existing trails to cause soil erosion and more sediment in the surface water supply. Accordingly, they have closed some trails and may choose to keep some or all of these trails closed permanently. If EFUD allows for some trails to remain open or for the construction of new trails in the future (e.g. to reroute problematic sections or replace closed trails), these would need to be strategically designed, sited, and maintained to minimize surface water turbidity, by reducing erosion potential during rains and thaws, especially near streams.

This section will describe the existing soils as well as soil characteristics that may influence road and trail suitability, and will also briefly discuss Design & Maintenance. Broadly, the considerations about trails also apply to roads on the Waterworks, including existing roads used to access water infrastructure and remnants of old logging roads. We draw from an evaluation by Dave Moroney of existing trail sites, past experience maintaining trails by certain authors of this report, and input from a professional trail builder (Moroney, 2026; M. Partridge, personal communication, 2026).

In order to determine whether an area is suitable for a trail, it is necessary to visit in person, ideally during a heavy rain event—to see how wet the soil is and whether there are small, temporary streams that could carry sediment into the surface water. Our maps can be used to guide these future on-the-ground assessments.

### Soil Types

This site contains a wide variety of rocky and sandy or silty loams (See Figure 39 below), notably the Colton-Duxbury complex near the road and the various complexes involving the Tunbridge soil series throughout the site. The Tunbridge Soil Series is the Vermont State Soil—it formed during the melting of the glaciers and occurs commonly in most counties in the state (Villars, n.d.). The full range of soils is shown in Figure 39 below. Many areas have shallow soil, often with only 10-40” before hitting bedrock, which contributes to the prevalence of seeps and springs (NRCS, n.d.). The soils in the flatter, western part of the site tend to be sandier. Based on our observations, the sandier soils further north are generally drier than those to the south, which are largely saturated with water.

A 50-foot buffer zone around major streams is shown on the maps in this section, to match the buffer for timber harvesting equipment specified in the Forest Management report (Hunger Mountain Forestry, 2019). Other studies on sediment control have found that at least 30 feet of buffer is often needed, and up to a few hundred feet in places where there are very steep slopes and highly erodible soils (Hawes, 2005). **We recommend that when siting trails a case-by-case approach be used, rather than a uniform buffer.**





Figure 38: A trail just above Tyler Brook that likely contributes sediment into the stream.



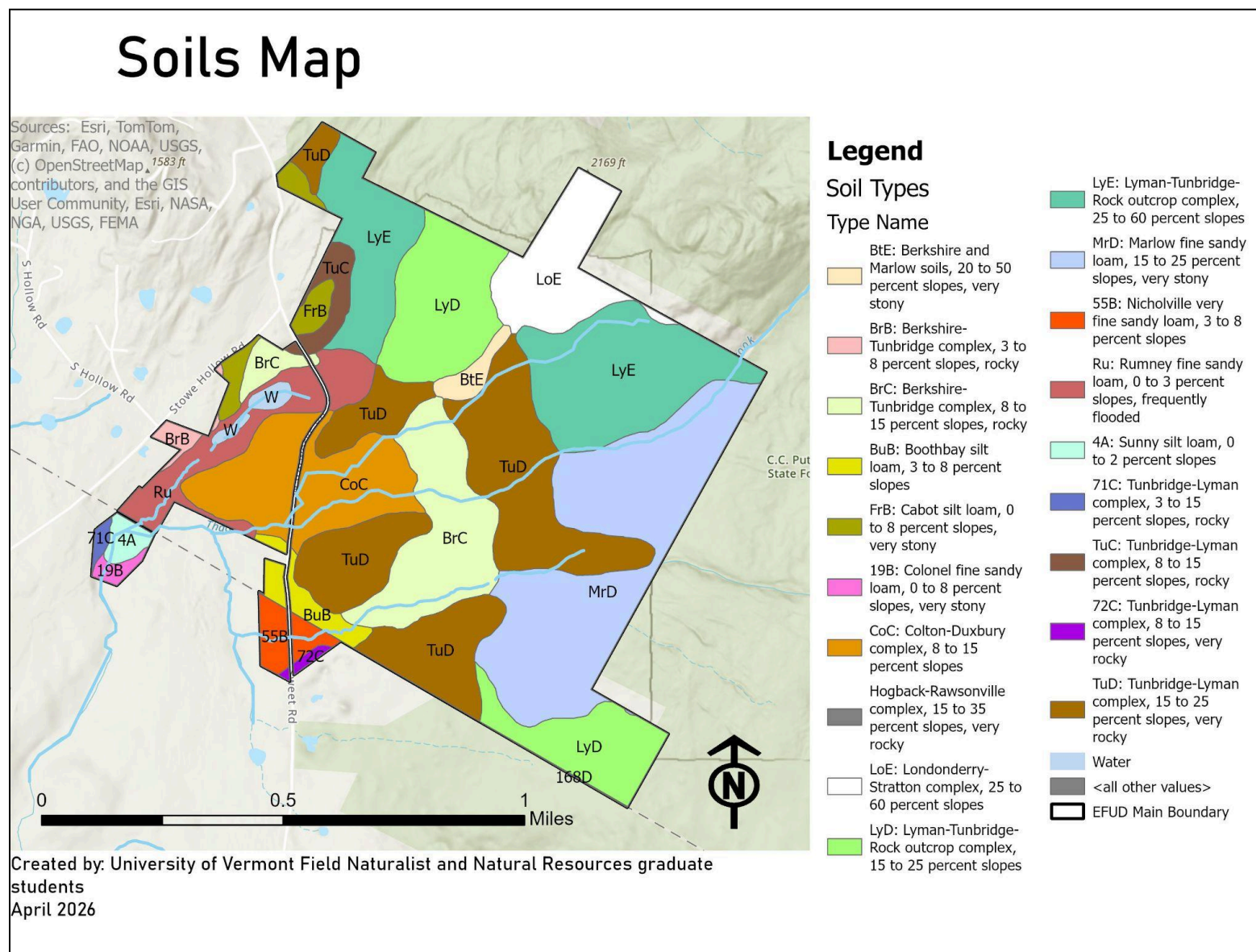


Figure 39: Soils map, including Colton-Duxbury complex near the road and the various complexes involving the Tunbridge soil series.



## Drainage

Soils listed as “excessively drained” allow lots of water to soak in (infiltrate), rather than run off. Soils that do the opposite are considered “poorly drained,” while those in the middle are considered “well drained.” Counterintuitively, while sandier soils closer to the wetlands might be expected to have better drainage, the groundwater is very high in some of these areas. (Wetland boundaries are not always crisply defined or correct in existing maps, because they can shift often.) *High groundwater, independent of soil texture, can prevent water from fully draining, making these maps a sometimes misleading representation of how wet or dry the real soils are.*

Soil Drainage data comes from the [Natural Resources Conservation Service \(NRCS\) Web Soil Survey](#).

# Soil Drainage Class

**Legend**

- Poorly Drained
- Somewhat Poorly Drained
- Well Drained
- Moderately Well Drained
- Somewhat Excessively Drained

Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community, Esri, NASA, NGA, USGS, FEMA

Created by: University of Vermont Field Naturalist and Natural Resources graduate students  
April 2026

Figure 40: More poorly drained soils are shown in darker purples and pinks and the well drained soils are in light blue. Well drained soils are in dark blue.



## Erosion

During our survey walks along the brooks, we noted areas of concern where roads or trails were eroding into streams. These were typically locations where they came near to or crossed streams, or where clear water drainage pathways traveled from a trail or road to the stream.

Overall, we noticed more areas of erosion concern along roads (some of which were infrastructure access roads) than along trails, although both were present. Roads can cause more severe erosion because of their larger size and, in some cases, greater tendency to intercept water running downslope. As climate change increases the frequency and severity of heavy rains in New England, erosion challenges on roads and trails are likely to worsen.



Figure 41: An access road eroding into Merriam Brook, near the parking lot (below the dam).

The NRCS publishes a calculated soil erosion factor “K” (see the map below), which is based on particle size, organic matter, structure class, and permeability class. It’s also important to note that this data is based on broad soil data, not site-specific assessment. For example, it does not consider slope - on the Waterworks parcel, slope varies substantially and is a key factor in understanding how easily an area may erode — shallow slopes are generally less prone to erosion, because water will not run over them as quickly. Steeper slopes require more switchbacks, and are still more susceptible to damage from water flowing directly downhill, across the trail. The southwest quadrant, near the road, is the flattest, while the rest of the site is steeper.



Our on-the-ground assessment showed that even the flatter area, which NRCS labels as having lower erosion potential, has some susceptibility to erosion: we saw clear erosion along some of the stream banks in that zone.



Figure 42: Streambank erosion with exposed tree roots along Tyler Brook just south of Waterworks Road (sandier soil section of parcel).





Figure 43: Streambank erosion and road-edge cave-in along Tyler Brook just north of Waterworks Road (sandier soil section of parcel).



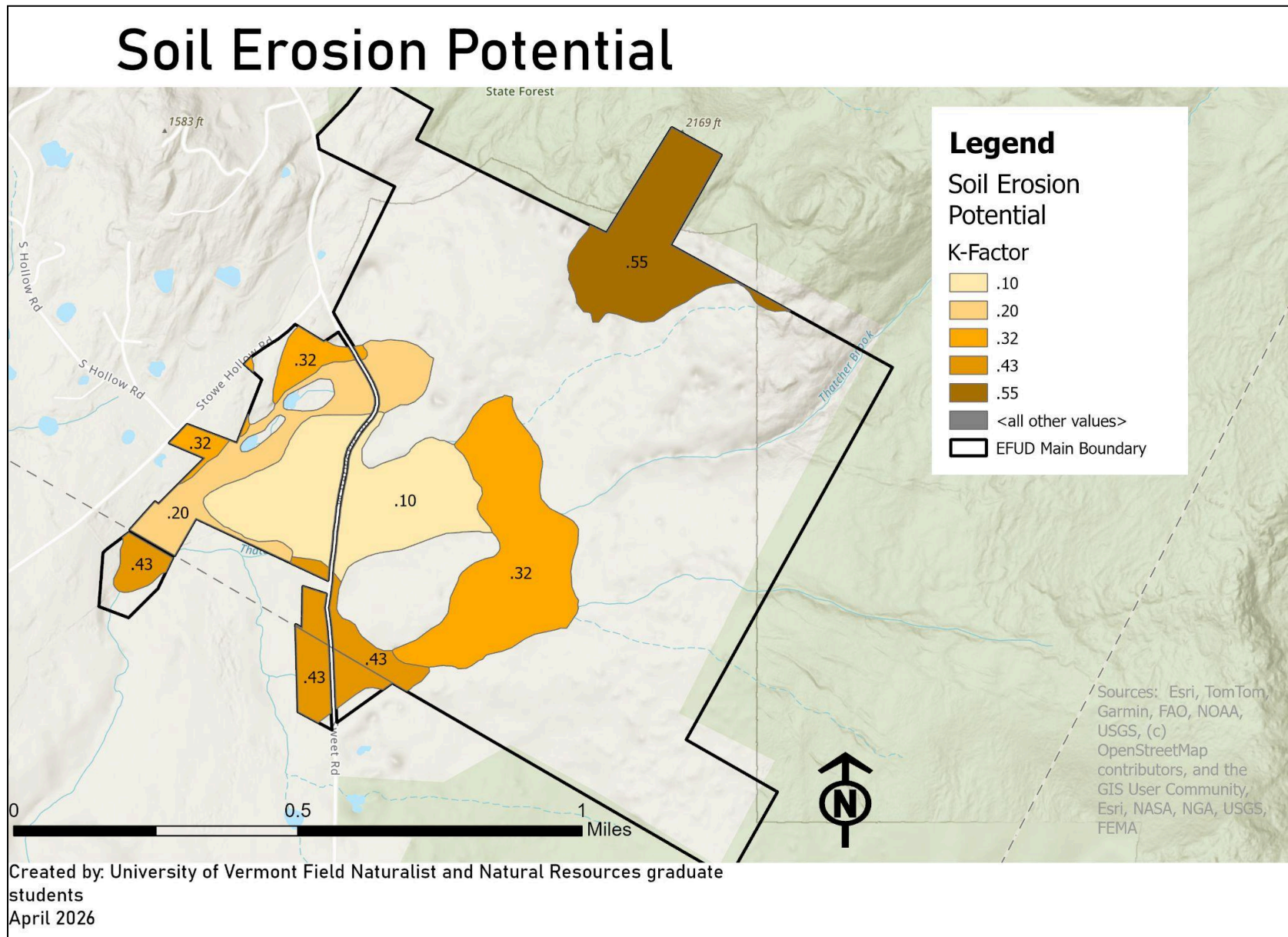


Figure 44: Worse Erosion Hazard areas are shown in various shades of orange/brown. The darker colored areas have higher erosion potential.



## Trail Design

### Trail Design

Effective trail design can substantially reduce erosion potential. Staircases, switchbacks, [waterbars](#), and drainages can prevent water from running directly down trails and from picking up speed and sediment. That said, mountain bikers cannot easily traverse stairs or waterbars and often prefer steeper slopes (fewer switchbacks) and smoother rides (fewer drainages). If EFUD wants to allow mountain biking, even greater care will need to be taken with trail siting and design. **We recommend seeking advice from a professional specializing in mountain bike trails.** If EFUD chooses not to design only for biking use, then the potential area for trails is larger, and thoughtful design in that area can do more to prevent erosion. An experienced designer of foot trails could still be brought in to advise.

### Trail Maintenance

**Any trail or access road (existing or new) will require regular maintenance in order to reduce erosion potential.** If an assessment of the erosion potential of existing trails and roads has not already been conducted, we recommend one in order to determine which sections should be permanently closed and revegetated, and which sections need to stay open but have problem areas that will need ongoing maintenance to prevent further erosion (e.g., clogged drainages, ineffective waterbars). Any trails or roads that are allowed to remain open should have a maintenance plan in place. **If trails are sited, designed, and maintained correctly, we believe that they will have a negligible impact on surface water turbidity.**

# Identified Areas of Stream Erosion Concern

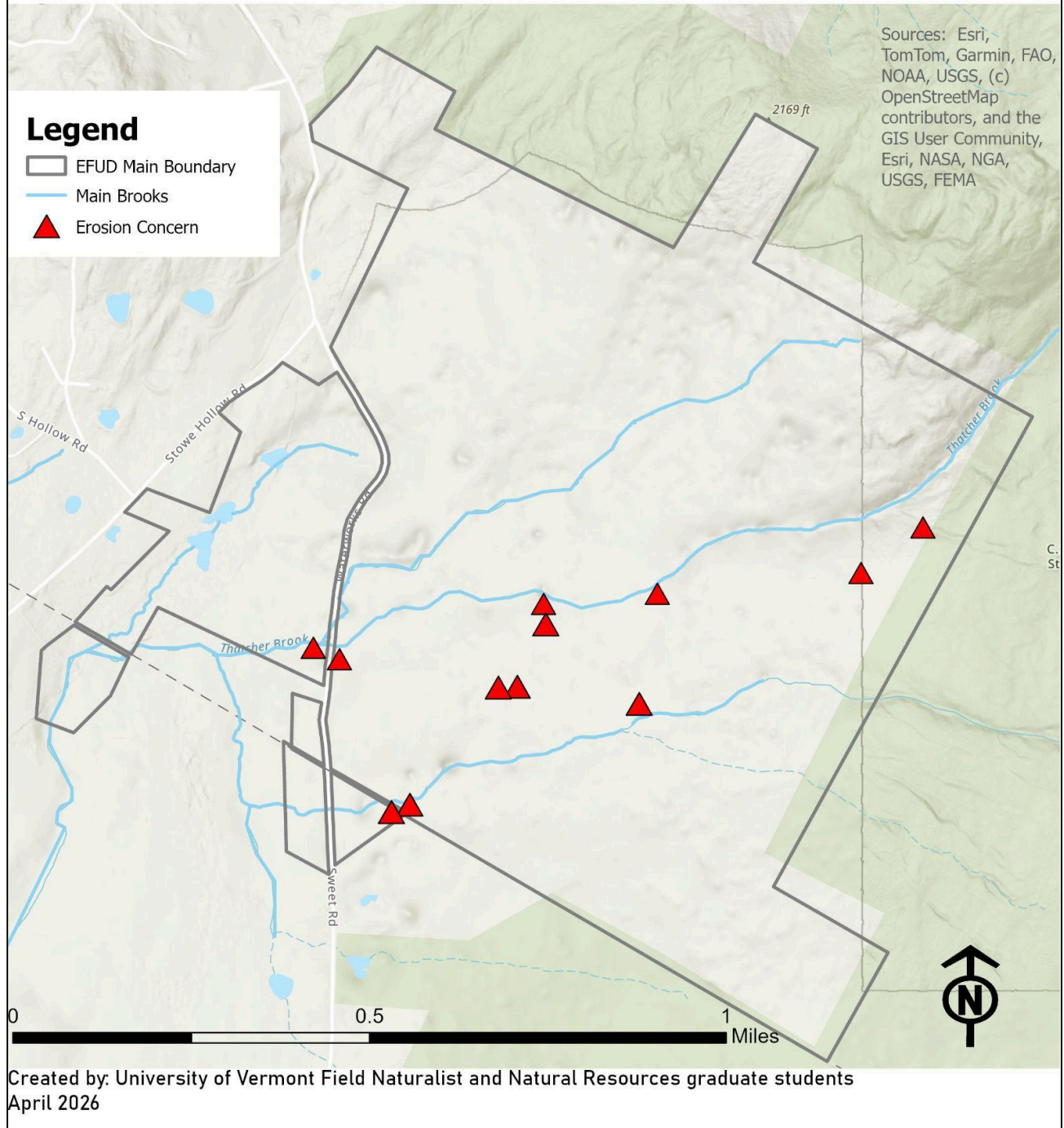


Figure 45: Areas of erosion concern along access roads and trails.





Figure 46: A trail closure sign.

## Plants

### Plant Inventory & Natural Community Delineations

#### Introduction and Methods

Natural communities are interacting assemblages of plants, other organisms, and their physical environment (soil, water, geology) that occur under similar conditions across the landscape (Thompson et al., 2019). From wetlands on the western side to montane areas on the high-elevation slopes, a diverse range of natural communities exists across the Waterworks. From mid-March to late-April in 2026, we inventoried plants and characterized natural communities throughout the property.

In total, we identified 121 species of vascular plants (see Plant Species List in the Appendix). This includes 41 tree species, 16 shrub species, 52 herb species, and 12 fern and fern-ally species. While we consider this a solid representation of the site's vegetation, especially given our fieldwork timing ahead of the growing season, there is still more to discover on this property. Guided by *Wetland, Woodland, Wildland* (Thompson et al., 2019), we identified and mapped 12 distinct natural community types—six upland and six wetland—based on plant species composition, topography, aspect, soils, hydrology, and land-use history (see Figure 37).

#### Anthropogenic Habitat

Although not an official natural community type, we mapped habitat created and maintained by human activity, particularly the open meadows along the western edge of the property and other

mowed areas. Vegetation in these areas includes reed canary grass (*Phalaris arundinacea*), sensitive fern (*Onoclea sensibilis*), and common dandelion (*Taraxacum officinale*), as well as the occasional apple tree (*Malus domestica*). We also observed Morrow's honeysuckle (*Lonicera morowii*) and raspberry (*Rubus* spp.) throughout hedgerows and along the edges of openings.

#### Plant Composition Summary

- **Abundant:** Reed canary grass, Morrow's honeysuckle
- **Common:** Sensitive fern, common dandelion, raspberry
- **Occasional:** Apple

## Upland Natural Communities

### Montane Spruce-Fir Forest

Located within the northernmost part of the property and above 2,000 feet in elevation, Montane Spruce-Fir Forest is one of four uncommon (S3)<sup>1</sup> montane natural communities observed during our field survey. While the Vermont Department of Fish and Wildlife mapped this zone as a Red Spruce-Heath Rocky Ridge community, we observed no heath family plants. Red spruce (*Picea rubens*) heavily dominates this area, though we also identified a few scattered balsam fir (*Abies balsamea*), paper birch (*Betula papyrifera*), and red maple (*Acer rubrum*). The understory is relatively sparse, but dense patches of multiple moss species are present at ground level. Perhaps better described as a Montane Spruce Forest due to the minimal balsam fir component, this zone might require further study to help refine its identity.

#### Plant Composition Summary

- **Abundant:** Red spruce
- **Common:** Mosses
- **Occasional:** Balsam fir, paper birch, red maple

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<sup>1</sup> The Vermont Department of Fish & Wildlife ranks natural communities as follows: S1 (very rare), S2 (rare), S3 (uncommon), S4 (common) and S5 (very common) (Thompson et al., 2019).





Figure 47: Montane Spruce-Fir Forest

### Montane Yellow Birch–Red Spruce Forest

Montane Yellow Birch–Red Spruce Forest is another uncommon (S3) natural community located on the upper slopes of the Waterworks. This community type covers large areas within Vermont's higher elevations and often occurs on thin soils (Thompson et al., 2019). While characterized by red spruce and yellow birch (*Betula alleghaniensis*), we also identified paper birch throughout this community. In the shrub layer, we observed Pin cherry (*Prunus pensylvanica*), striped maple (*Acer pensylvanicum*), mountain maple (*Acer spicatum*), red elderberry (*Sambucus racemosa*), and bristly black currant (*Ribes lacustre*). Though the ground was snow-covered on the day we investigated this forest, intermediate wood ferns (*Dryopteris intermedia*) were poking through, and we noted smooth rock tripe (*Umbilicaria mammulata*), a large leafy lichen, on several boulders and rock outcrops.

### Plant Composition Summary

- **Abundant:** Red spruce, yellow birch, paper birch
- **Common:** Pin cherry, striped maple, mountain maple, bristly black currant, intermediate wood fern
- **Occasional:** Red elderberry





Figure 48: Transition from Northern Hardwood Forest to Montane Yellow Birch–Red Spruce Forest.

### Northern Hardwood Forest

Northern Hardwood Forest forms the matrix community type across much of Vermont and most of the property. At the Waterworks, abundant tree species include sugar maple (*Acer saccharum*), red maple, white ash (*Fraxinus americana*), and yellow birch with American beech (*Fagus grandifolia*) as a common component. Scattered eastern white pine (*Pinus strobus*), black cherry (*Prunus serotina*), striped maple, and hobblebush (*Viburnum lantanoides*) populate some areas. Herbaceous plants include intermediate wood fern, Christmas fern (*Polystichum acrostichoides*), eastern hay-scented fern (*Dennstaedtia punctilobula*), and American trout lily (*Erythronium americanum*).

While not extensive enough to map as individual Rich Northern Hardwood Forest communities, several pockets within the larger Northern Hardwood Forest showed signs of nutrient enrichment. We documented indicators of rich, moist soils in these patches, including American basswood (*Tilia americana*), maidenhair fern (*Adiantum pedatum*), wild leeks (*Allium tricoccum*), Dutchman's breeches (*Dicentra cucullaria*), bloodroot (*Sanguinaria canadensis*), blue cohosh (*Caulophyllum thalictroides*), and sharp-lobed hepatica (*Anemone acutiloba*).

We mapped areas occupied by softwood plantations as Northern Hardwood Forest, or variants thereof, based on regenerating tree species and understory vegetation that will one day become



the dominant species. The Norway spruce (*Picea abies*), red pine (*Pinus resinosa*), and eastern white pine plantations are not technically considered natural communities and will likely revert to a Northern Hardwood Forest type over time.

#### Plant Composition Summary (planted trees excluded)

- **Abundant:** Sugar maple, red maple, white ash, yellow birch, intermediate wood fern, American trout lily
- **Common:** American beech, Christmas fern, wild leeks
- **Occasional:** Eastern white pine, black cherry, striped maple, hobblebush, eastern hay-scented fern, American basswood, maidenhair fern, Dutchman's breeches, bloodroot, blue cohosh, sharp-lobed hepatica



Figure 49: Dutchman's breeches in the Northern Hardwood Forest.  
Photo courtesy of Lauren Sopher.

#### Hemlock-Northern Hardwood Forest

A Northern Hardwood Forest variant, Hemlock-Northern Hardwood Forest, is common throughout the eastern portion of the property. This community includes eastern hemlock (*Tsuga canadensis*) as a significant canopy component, while yellow birch, paper birch, sugar maple, red maple, American beech, and red spruce appear less frequently. Striped maple is occasionally found within this natural community at the Waterworks. Our field surveys identified

common clubmoss (*Lycopodium clavatum*), plantain-leaf sedge (*Carex plantaginea*), intermediate wood fern, and Christmas fern, in the herb layer.

#### Plant Composition Summary

- **Abundant:** Eastern hemlock
- **Common:** Yellow birch, paper birch, sugar maple, red maple, American beech, red spruce, common clubmoss, intermediate wood fern, Christmas fern
- **Occasional:** Striped maple, plantain-leaf sedge

#### Red Oak-Northern Hardwood Forest

A relatively small Red Oak Northern Hardwood Forest community covers a hillside near the property's northwestern corner. As its name suggests, this area is dominated by northern red oak (*Quercus rubra*). Less abundant tree species include sugar maple, red maple, eastern hemlock, and yellow birch. The shrub layer is sparse, but American trout lily, Carolina spring beauty (*Claytonia carolinia*), and common clubmoss are present on the forest floor.

#### Plant Composition Summary

- **Abundant:** Red Oak
- **Common:** Sugar maple, red maple, eastern hemlock, yellow birch, American trout lily
- **Occasional:** Carolina spring beauty, common clubmoss

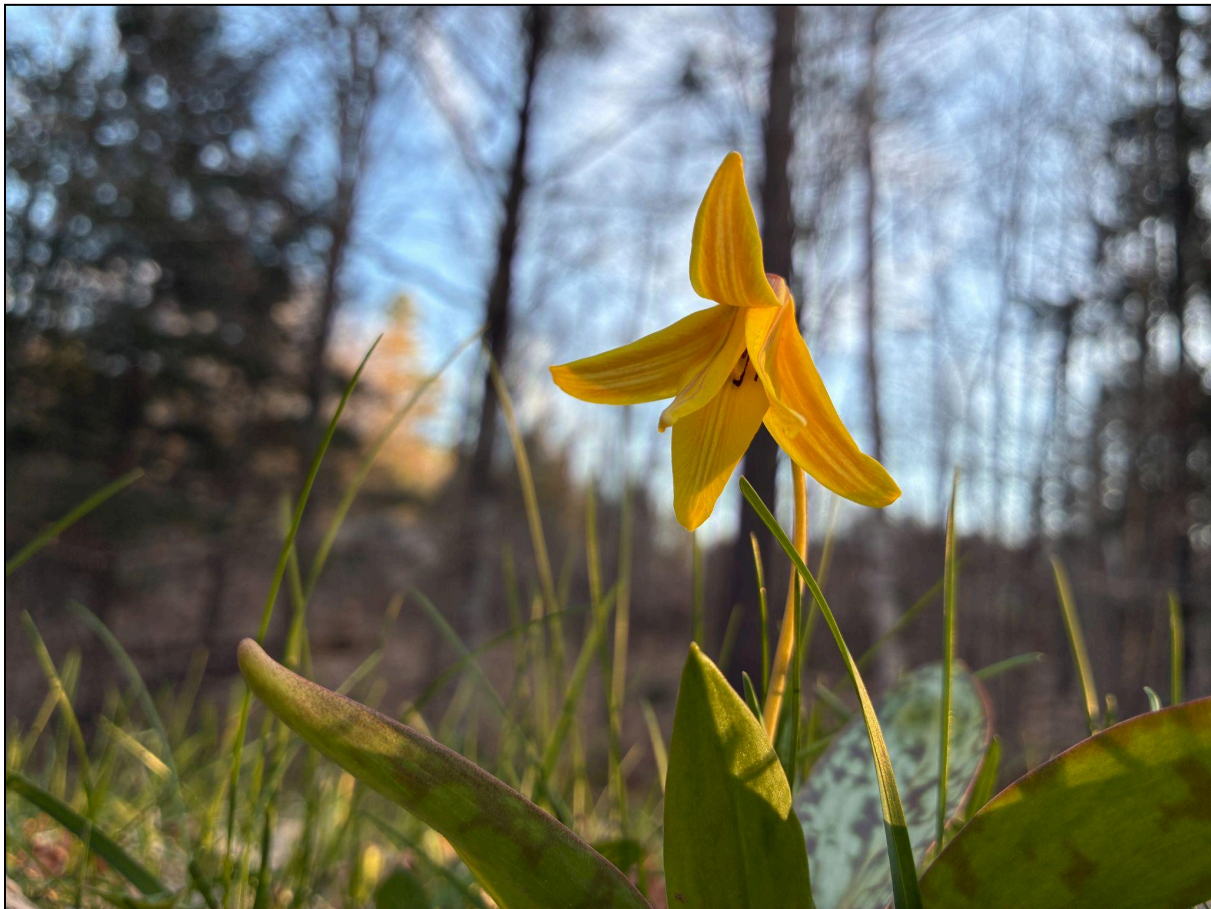


Figure 50: Trout lily. Photo courtesy of Lauren Sopher.



## Red Spruce-Northern Hardwood Forest

Another Northern Hardwood Forest variant, Red Spruce-Northern Hardwood Forest is found in several locations on the eastern side of the property. The largest patch is situated on a plateau between Merriam Brook and Tyler Brook, while other examples near the upper extents of the property create a transition zone between hardwood and montane communities. Like other northern hardwood variants, this forest type is defined by the prevalence of its namesake, in this case, red spruce. Other tree species include sugar maple, red maple, American beech, yellow birch, and eastern hemlock. We also observed hobblebush and striped maple in the shrub layer, with intermediate wood fern and American trout lily in the herb stratum.

### Plant Composition Summary

- **Abundant:** Red spruce, sugar maple, red maple, yellow birch
- **Common:** American beech, eastern hemlock, intermediate wood fern, American trout lily
- **Occasional:** Hobblebush, striped maple

## Wetland Natural Communities

### Alder Swamp

We identified several areas of Alder Swamp near the margins of the beaver wetland complex in the western portion of the property. Alder Swamps are dominated by speckled alder (*Alnus incana*), with willow (*Salix* spp.) and dogwood (*Cornus* spp.) as common components. We also observed red maple, tussock sedge (*Carex stricta*), Canada mannagrass (*Glyceria canadensis*), aster (*Aster* spp.), cinnamon fern (*Osmundastrum cinnamomeum*), sensitive fern, and spotted Joe-Pye weed (*Eutrochium maculatum*), as well as several species of moss (*Sphagnum* spp.) and sedge (*Carex* spp.). In addition, we noted red spruce, which is not a frequent Alder Swamp associate.

### Plant Composition Summary

- **Abundant:** Speckled alder
- **Common:** Willow, dogwood, sensitive fern, cinnamon fern, mosses, sedges
- **Occasional:** Red maple, Canada mannagrass, aster, spotted Joe-Pye weed, red spruce

### Hemlock-Balsam Fir-Black Ash Seepage Swamp

We observed an interesting Hemlock-Balsam Fir-Black Ash Seepage Swamp west of Sweet Road near the southern boundary of the property. An uncommon (S3) community type in Vermont, Hemlock-Balsam Fir-Black Ash Seepage Swamps act as biodiversity hotspots driven by groundwater seepage and often form headwater streams (Thompson et al., 2019). At the Waterworks, this area is dominated by eastern hemlock, with yellow birch as the most common associate. While not abundant, balsam fir and black ash (*Fraxinus nigra*) are present. We identified black cherry growing on upland hummocks. We also noted foamflower (*Tiarella cordifolia*) in the herb stratum, along with royal fern (*Osmunda regalis*), sensitive fern, and several bryophyte species.

### Plant Composition Summary

- **Abundant:** Eastern hemlock
- **Common:** Yellow birch, sensitive fern, bryophytes
- **Occasional:** Balsam fir, black ash, black cherry, foamflower, royal fern



Figure 51: Hemlock-Balsam Fir-Black Ash Seepage Swamp

### Lowland Spruce-Fir Forest/Spruce-Fir Seepage Forest

Present in the western portion of the property, this uncommon (S3) community type is dominated by red spruce and balsam fir. While associated with moist soils (Thompson et al., 2019), some areas of Lowland Spruce-Fir Forest at the Waterworks are very wet, appear to be influenced by groundwater, and resemble a Northern White Cedar Seepage Forest (minus the cedar component). Though described as a variable community by Thompson et al. (2019), further investigation may clarify whether the Waterworks sites may be better described as a seepage forest variant. In addition to spruce and fir, we identified yellow birch, red maple, eastern hemlock, cinnamon fern, and foamflower. Like the Hemlock-Balsam Fir-Black Ash Seepage Swamp, we also documented several bryophyte species within this community type.

### Plant Composition Summary

- **Abundant:** Red spruce, balsam fir
- **Common:** Yellow birch, red maple, bryophytes
- **Occasional:** Eastern hemlock, cinnamon fern, foamflower





Figure 52: Lowland Spruce-Fir Forest

### Northern Hardwood Seepage Forest

We observed a Northern Hardwood Seepage Forest, bisected by Sweet Road, near the southern property boundary. Described by Thompson et al. (2019) as predominantly wetland, with some upland features, these groundwater-influenced communities contribute to headwater streams. At the Waterworks, associated tree species include sugar maple, yellow birch, red maple, and eastern hemlock. Other vegetation includes water avens (*Geum rivale*), sensitive fern, and foamflower in moist spots, with intermediate wood fern on upland hummocks.

### Plant Composition Summary

- **Abundant:** Yellow birch
- **Common:** Sugar maple, red maple, eastern hemlock, sensitive fern
- **Occasional:** Water avens, foamflower, intermediate wood fern

### Shallow Emergent Marsh

Several examples of Shallow Emergent Marsh occupy the beaver wetland complex in the western portion of the property, especially adjacent to open water. Grasses, sedges, and herbs dominate these communities. Field surveys identified herbaceous plants such as bur-reed (*Sparganium* spp.), tussock sedge, Canada mannagrass, spotted Joe-Pye weed, and water avens. Observed shrubs, though less abundant, included meadowsweet (*Spiraea alba*),



steeplesh ( *Spiraea tomentosa* ), Bebb's willow ( *Salix bebbiana* ), and speckled alder. The introduced, non-native reed canary grass is also present.

#### Plant Composition Summary

- **Abundant:** Bur-reed, tussock sedge, Canada mannagrass
- **Common:** Spotted Joe-Pye weed, water avens
- **Occasional:** Meadowsweet, steeplesh, Bebb's willow, speckled alder, reed canary grass

#### Woodland Seep

Woodland Seeps are defined as small wetlands surrounded by upland forests shaped by a constant flow of groundwater (Thompson et al. 2019). Given the area's reputation as a water source, it is not surprising that multiple woodland seeps were identified across the Waterworks. Like the larger seepage forest communities, Woodland Seeps are also biodiversity hotspots and provide important wildlife habitat. Due to their broad distribution across the property, and occurrence within a variety of larger communities, we documented a diverse array of vegetation within these areas. Frequently noted species include yellow birch, sensitive fern, foamflower, and water avens.

#### Plant Composition Summary

**Common:** Yellow birch, sensitive fern, foamflower, water avens

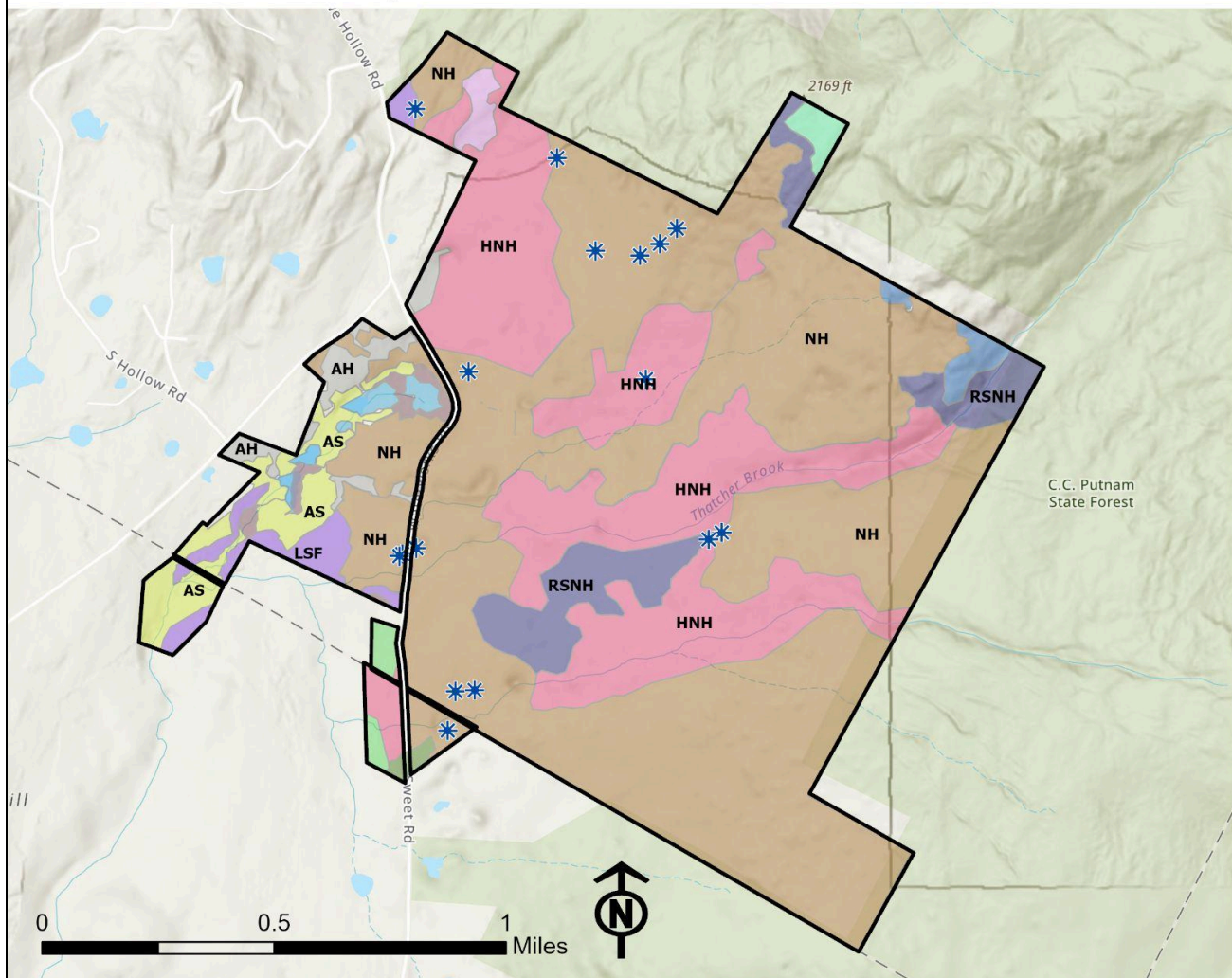


Figure 53: Woodland Seep



# Natural Communities

Natural Community delineations within the Edward Farrar Utility District Waterworks parcel



## Legend

\* Seeps

### Natural Community Type

Anthropogenic Habitat  
Alder Swamp  
Hemlock Northern Hardwood

Lowland Spruce Fir  
Montane Spruce-Fir Forest  
Northern Hardwood  
Northern Hardwood Seepage Forest

Red Oak-Northern Hardwood Forest  
Red Spruce Northern Hardwood  
Shallow Emergent Marsh  
Spruce Fir Seepage Swamp

Woodland Seep  
Open Water  
Montane Yellow Birch-Red Spruce Forest  
Hemlock-Balsam Fir-Black Ash Seepage Swamp

Created by: University of Vermont Field Naturalist and Natural Resources graduate students  
April 2026

Figure 54: Natural Community map

## Rare, Threatened, Endangered Plants & Natural Communities

We identified no rare, threatened, or endangered plant species during our field survey. We reviewed geospatial data from the Vermont Department of Fish and Wildlife and the nearest uncommon plant species is mapped near the summit of Mount Hunger, approximately 0.75 miles away. While not considered rare and not legally protected in Vermont, a robust population of pink lady's slipper (*Cypripedium acaule*) has been described at the Waterworks. Known for their large, showy flowers, these members of the orchid family generate excitement among plant enthusiasts. Despite the prevalence of pink lady's slipper, they are very sensitive to disturbance and care should be taken to prevent damage from human activities.

As noted above, four of the identified natural communities have an S3 status, meaning that they are considered uncommon, that they are restricted in distribution, or that many examples have been severely altered in Vermont. These uncommon communities are:

- Hemlock-Balsam Fir-Black Ash Seepage Swamp
- Lowland Spruce-Fir Forest
- Montane Spruce-Fir Forest
- Montane Yellow Birch-Red Spruce Forest

S3 natural communities are prioritized for conservation, and significant examples may be protected by the State of Vermont. Care should be taken to prevent impacts. Infrastructure and trails should avoid these areas, and any activities that may alter the native species composition should be discouraged. **It is important to note that recreational trails or evidence of trail construction was observed in each of these community types at the Waterworks.**

## Forest Health

### Introduction

A multifaceted approach was employed to assess the overall forest condition and vulnerability to disturbances (e.g., extreme weather, non-native plants, insects). First, we performed a forest structure analysis to assess horizontal (tree diameter) and vertical (tree height) diversity, and forest canopy uniformity, providing a baseline for understanding ecosystem resilience. We then documented the presence of non-native plants and developed computer-based habitat suitability models to identify areas at elevated risk of invasion by Morrow's honeysuckle and European buckthorn (*Rhamnus cathartica*). We also conducted a targeted survey for emerald ash borer. These methods combined perspectives that may support management decisions aimed at maintaining forest function and mitigating disturbance impacts.

### Forest Structure Analysis

Diverse forests with a mix of tree ages and complex canopies are more resilient to disturbance than uniform, even-aged forests (D'Amato et al., 2023; Kosiba, 2024). Evaluating forest



structure is therefore a common component of assessing forest vulnerability and health (Duveneck & Scheller, 2016; D'Amato et al., 2023).

To better understand the structural complexity and resilience of forests at the Waterworks, we evaluated tree size data provided in the *Forest Resource Management Plan* (Sweet & Sweet, 2019) and charted tree size distributions for each forest stand. Publicly available Normalized Digital Surface Model (nDSM) data were downloaded and visualized with ArcGIS Pro to assess tree height and canopy dynamics. To obtain quantitative data, we calculated the average and standard deviation of tree height ranges for the forested portions of the property. These figures were then compared to those of a highly diverse old-growth forest at Lord's Hill Natural Area in Marshfield, Vermont.

The tree size distribution charts show that the Waterworks forest is dominated by small trees, with relatively few large trees found in nearly every stand (see Figure 39). 17 of 21 stands lack basal area<sup>2</sup> in the 24+” size class, while 9 of 21 stands lack basal area in the 18–22” size class. The nDSM visualization depicting tree heights shows a relatively closed-canopy forest with uniform tree heights, especially east of Waterworks Road (see Figure 40). Our statistical analyses show an average tree height range of 8.7m, and a standard deviation of 1.5m. The Lord's Hill old-growth forest, by comparison, exhibits a tree height range 3 times higher, and a standard deviation 3.9 times greater than those of the Waterworks forest, highlighting the lower structural complexity at the Waterworks.

Because forests with low levels of structural diversity can be more susceptible to single, forest-wide disturbance events, uniform trunk diameters, an even distribution of tree heights, and uniform canopies indicate lower levels of resilience. A lack of structural variation means that a single threat, such as a specialized pest or specific wind speed, can impact numerous trees simultaneously, rather than being buffered by a mix of tree sizes, ages and spacing.



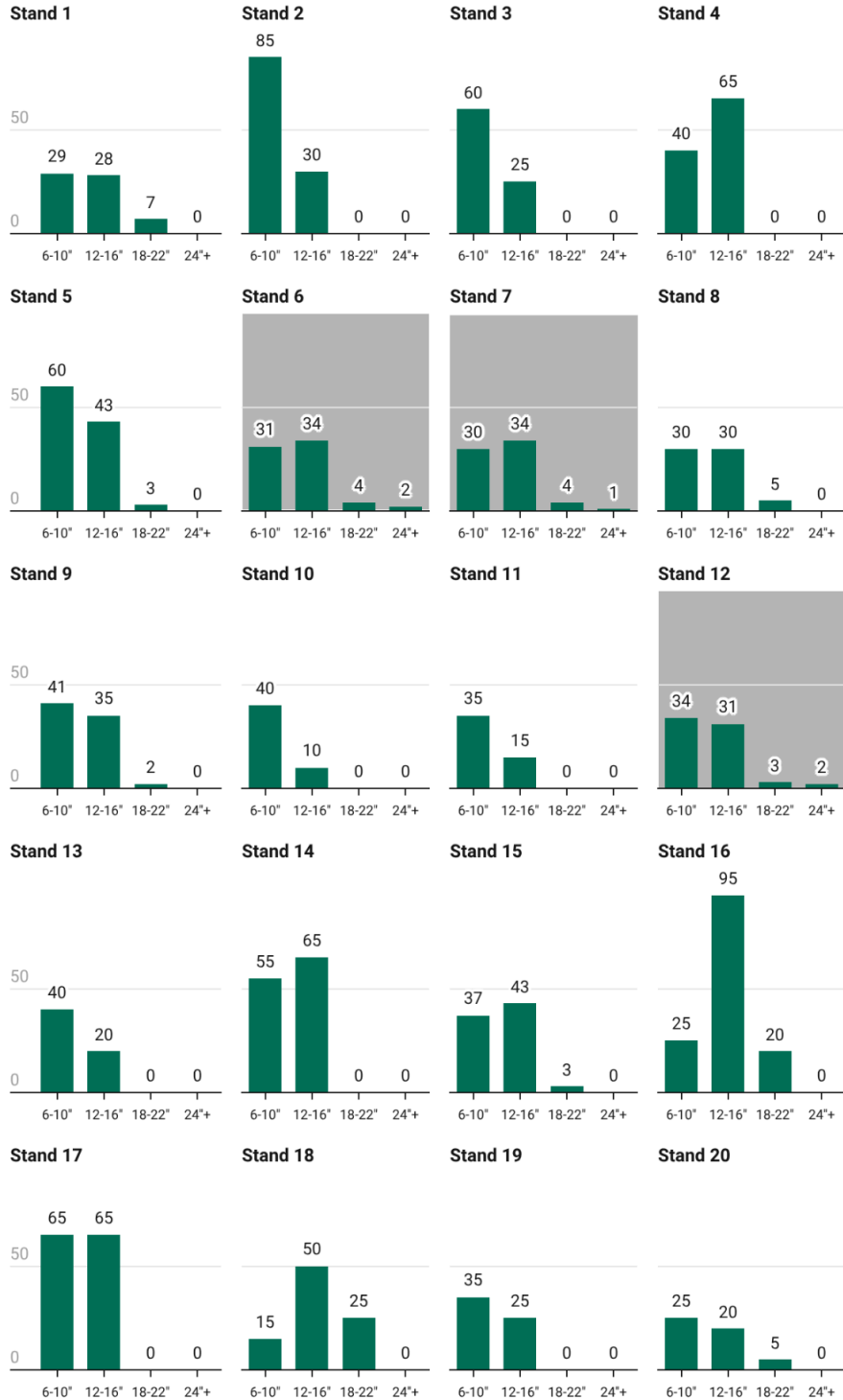
Figure 55: Norway Spruce plantation exhibiting low structural diversity.

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<sup>2</sup> Basal area measures the space occupied by tree trunks and is defined as the cross-sectional area of a tree at breast height (usually 4.5 feet above the ground).

## EFUD Waterworks Tree Size Distributions

Basal Area (ft<sup>2</sup>/ac) by Size Class. Stands with large diameter trees are highlighted.



Stand 21 (Montane Spruce-Fir) not included.

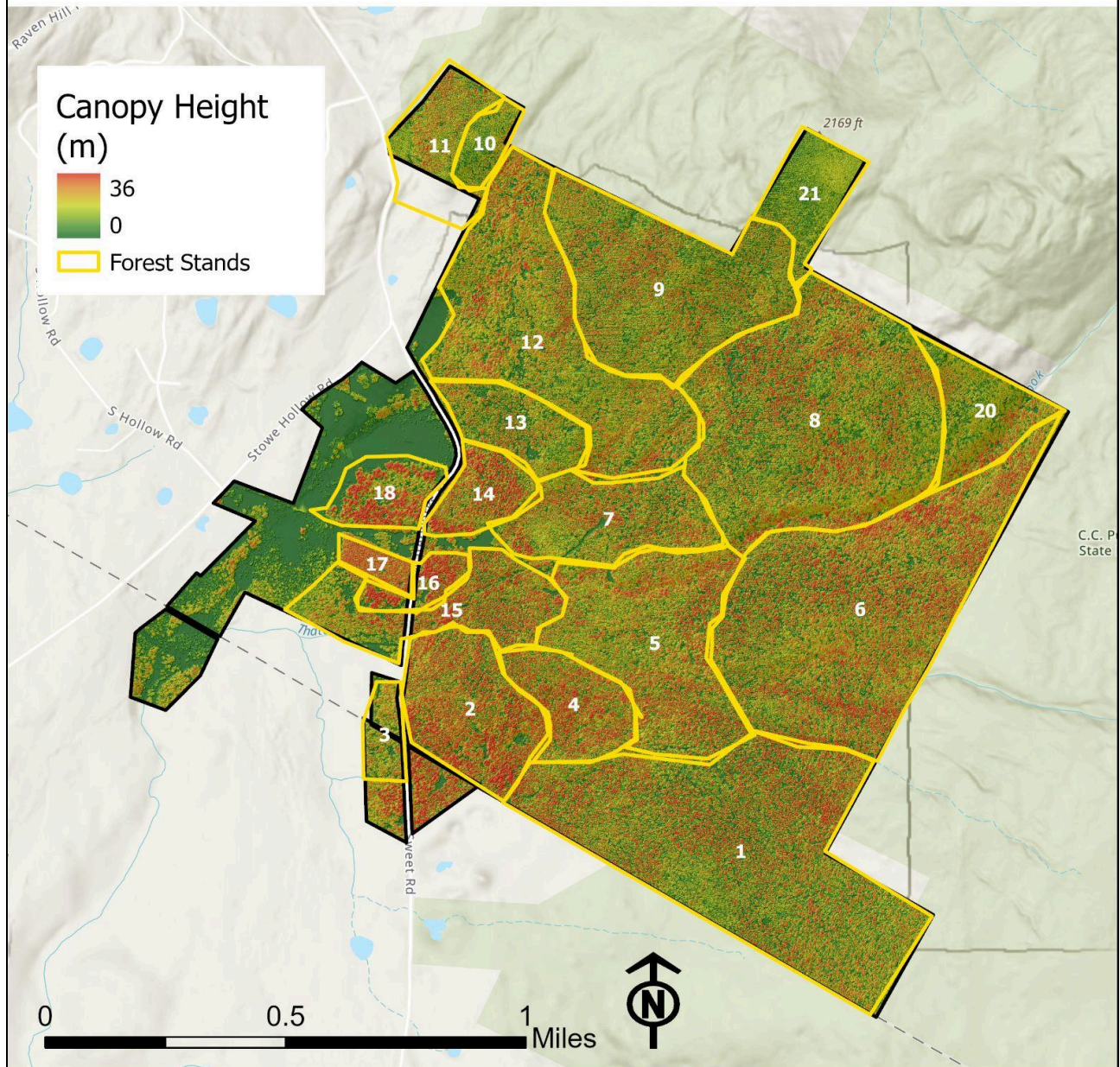
Chart: Nick Sibley • Created with Datawrapper

Figure 56: Tree size distribution charts for each forest stand.



# Forest Structure

## Waterworks Forest Structure Visualization via Normalized Digital Surface Model



Created by: University of Vermont Field Naturalist and Natural Resources graduate students  
April 2026

Figure 57: nDSM showing canopy height across the property. Height is depicted as a gradient from green to red (0 - 36 meters).

## Emerald Ash Borer Survey

Emerald ash borer (EAB) is an invasive beetle first reported in the United States in 2002. EAB is known to infect every species of ash (*Fraxinus spp.*), including the three species native to Vermont (black ash, green ash, and white ash). The beetle larvae feed on the tree's phloem, ultimately girdling the tree. The estimated mortality rate of ash trees infected with EAB is about 90% within 5 years of initial infection (Flower et al., 2013). A combination of a high mortality rate and difficulty in early detection makes EAB a major concern for forest health and management. In Vermont, EAB was first reported in Orange in 2018, then in Stowe in 2024 and Waterbury in 2025. Because the detection of EAB typically occurs years after initial invasion, reports of EAB in an area can mean that extensive die-off of ash trees in that area is imminent.

At the Waterworks, white ash is common, encompassing up to 25% of the basal area in some stands (Sweet & Sweet, 2019). The 2019 *Forest Resource Management Plan* was completed before EAB was detected in Stowe or Waterbury and therefore does not report any concern regarding this pest. To assess the health of the ash trees at the Waterworks, we visually inspected ash trees within three stands that contain over 10% ash cover by basal area.

Ash trees within forest stands 1, 2, and 11 (see Figure 39 for stand locations) were visually assessed. Select trees were evaluated for signs and symptoms of EAB, including “blonding” of bark via woodpecker flecking<sup>3</sup>, sloughing bark, dieback of the tree's crown, S-shaped beetle galleries (tunnels), and D-shaped larval exit holes. Due to limitations on timing, these ash health assessments were performed outside of the growing season. Therefore, determination of dead/alive status does not reflect the same level of certainty as would a leaf-on assessment (i.e. newly dead trees may be difficult to differentiate from living trees during leaf-off seasons). Deep snow during the initial assessment period limited access to individual trees, resulting in a total of 31 trees assessed in detail, most of which were close to trails.

Within the 3 sampled stands, health status was inconsistent, but signs of EAB infection (crown dieback, woodpecker flecking) were common. One instance of S-shaped galleries was identified outside of the stands included in this assessment (see Fig 41(a)). The health status of the 31 selected trees are as follows:

- Appear alive and healthy: 12
- Appear alive, but unhealthy (exhibiting symptoms of EAB infection): 9
- Appear dead or will be dead soon (i.e. extensive dieback, sloughing bark): 6
- Long dead (snags): 4

Although no definitive signs of EAB (undeniably D-shaped holes or distinctive S-shaped galleries) were detected during the initial assessment, symptoms of pest infection were common. A significant number of trees (including those not part of the 31 assessed in detail)

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<sup>3</sup> Woodpecker flecking occurs when woodpeckers remove the outer layer of tree bark while feeding on EAB larvae, revealing the lighter layer beneath.



showed crown dieback and extensive woodpecker foraging activity, in the form of “blonding” or flecking bark. Some trees also showed other signs of stress, including other beetle holes, epicormic branching,<sup>4</sup> or fully detached bark.



Figure 58: Signs and symptoms of EAB present in the Waterworks parcel: (a) S-shaped beetle galleries on a dead tree, (b) woodpecker flecking causing “blonding” of bark, (c) detached, “sloughing” bark.

After the formal ash assessment was completed, one white ash with possible D-shaped larval exit holes (see Figure 42) was observed near the upper property boundary approximately 850 feet northwest of Thatcher Brook. Photos of this tree were shared with staff at [Vermont Invasives](#), but positive identification was not possible due to woodpecker damage around the exit holes. Given the recent detection of EAB within Stowe and Waterbury, as well as the high percentage of visibly stressed ash trees on the property, it is likely that EAB has already infested this area. This suggests a high potential for mass die-off of ash trees, potentially causing significant canopy loss in some locations. Some stands could lose over 25% of their total canopy area within the next decade. Such compounding impacts—ash species loss, living biomass loss, and decreased canopy cover—will have significant ecological and practical consequences.

<sup>4</sup> Epicormic branches are shoots that sprout from the trunk of a tree and are often triggered by stress.



Figure 59: Potential EAB larvae exit holes on a white ash. Note the more recognizable D-shaped exit hole in the upper right corner of the photo.

## Introduced Non-native Plant Survey

While conducting our plant inventory, we also documented any introduced non-native species. We observed a total of 11 non-native plant species at the Waterworks (see Plant Species List in the Appendix). Of these, Morrow's honeysuckle (*Lonicera morrowii*) and Japanese barberry (*Berberis thunbergii*) are among the most concerning. The honeysuckle infestation is quite severe in some areas, especially around the beaver wetland complex and mowed fields in the western portion of the property. This species was also occasionally noted east of Waterworks Road, with several isolated populations in the upper portions of the property. We noted several populations of barberry north of Tyler Brook and east of Waterworks Road. Both species are



known to outcompete native vegetation, hinder forest regeneration, and otherwise negatively impact ecosystem functioning.

### Habitat Suitability Modeling

To better understand the risk of non-native plant invasion and evaluate how climate change might increase future risk, we developed computer models to predict habitat suitability for two common invasive species, Morrow's honeysuckle and European buckthorn. We used real-world location data, climate information (i.e. temperature and rainfall), and random locations where these species are not present to train the model to identify suitable habitat. We then employed statistical methods to estimate where these species could survive now and in the future under a moderate climate change scenario. The results showed that the Waterworks is currently suitable for both species and is expected to remain suitable in the future, with predicted conditions above the minimum levels needed for each species to establish and survive. For a more detailed and technical description of how this analysis was conducted, please see Appendix 4.



Figure 60: Japanese barberry

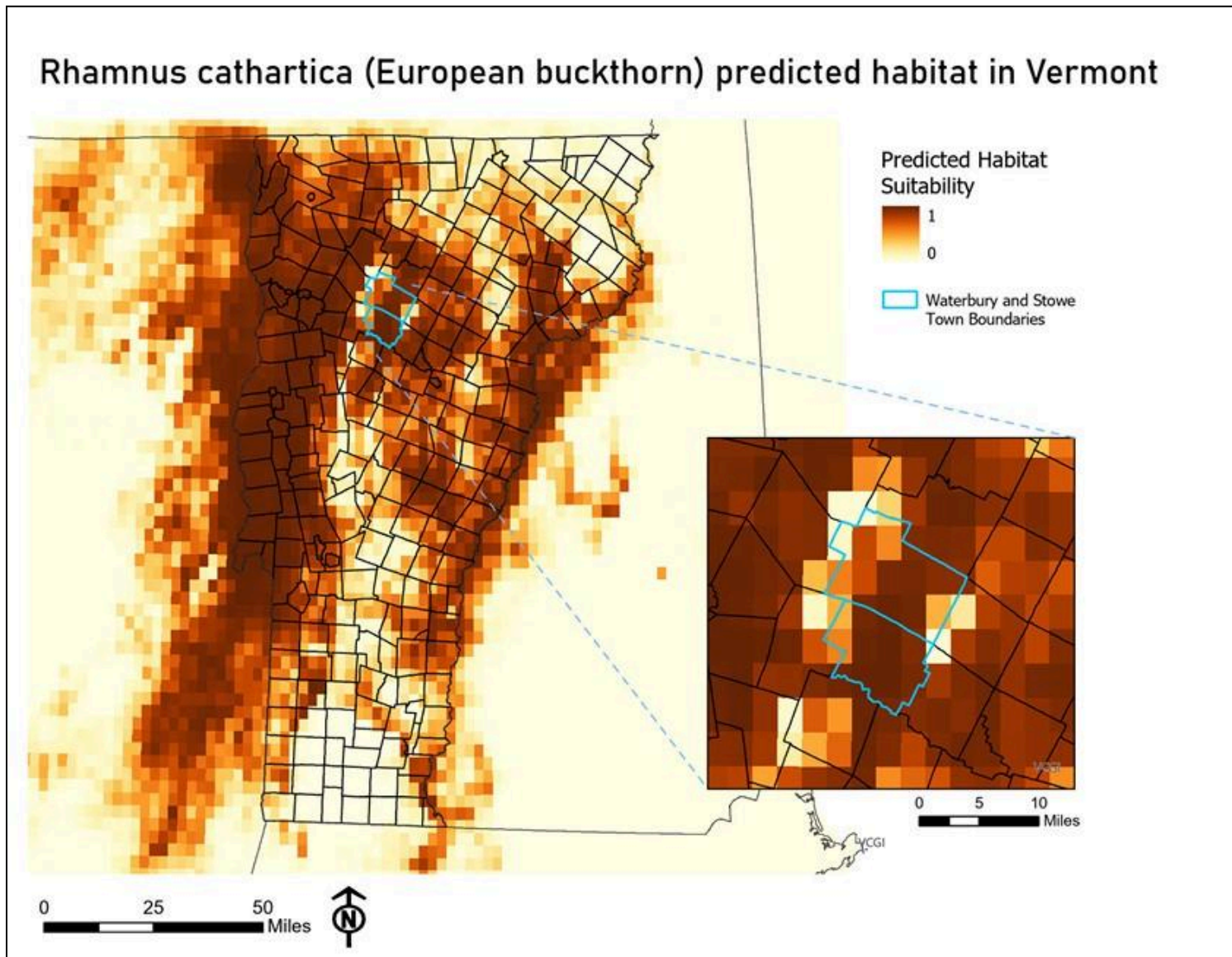


Figure 61: The predicted distribution of European buckthorn under future climatic conditions, showing the Waterworks as a suitable habitat for species establishment.



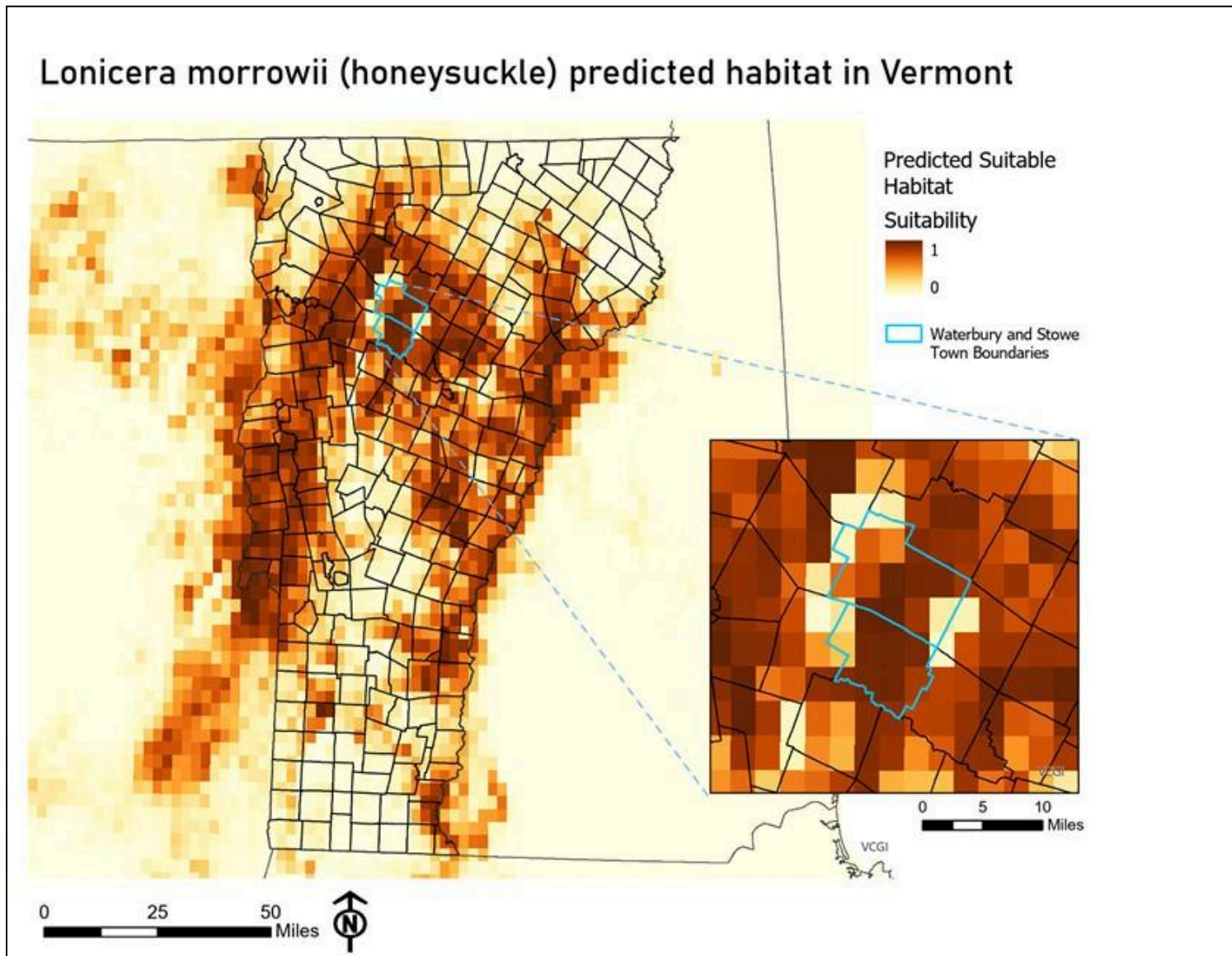


Fig 62: The predicted distribution of Morrow's honeysuckle under future climatic conditions, showing the Waterworks as a suitable habitat for species establishment.

## Forest Health & Habitat Recommendations

### Maintain and Promote Wildlife Habitat

Across the entire property, less than 10 acres of early successional habitat—such as young forests, shrublands, and grasslands—is estimated to exist. These areas are important to wildlife because they provide shelter, cover, and abundant food sources (fruits, seeds, insects), add structural diversity to the landscape, and serve as critical nesting or breeding grounds for many birds. Temporary in nature, these areas will naturally revert to forest if left undisturbed, reducing their ecological value.

Given the arrival of EAB and the anticipated loss of most ash trees, we expect an increase in early successional habitat as these trees die and create canopy gaps. Nevertheless, we recommend continued mowing to maintain areas of grassland. To increase diversity and improve ecological functioning, mowing should be done in a rotation, managing only a third or half of each meadow in a given year. Mowing should occur in late summer (after August 15th) to avoid destroying nests and killing fledglings of ground-nesting birds such as bobolinks (*Dolichonyx oryzivorus*). Furthermore, edge habitat can be improved by creating a gradual transition in vegetation height, moving from open areas into the forest. This can be accomplished by removing large trees within the transition zone and retaining shrubs and saplings to create a “feathered” effect. The *Forest Bird Habitat Assessment for the Waterbury Municipal Watershed Lands* (Hagenbuch, 2013) provides additional context for softening edge habitat, including a diagram illustrating this concept.

In addition, we recommend maintaining snags (standing dead trees). Snags provide essential nesting, roosting, and foraging opportunities for many bird species. Again, EAB will certainly increase the presence of snags across the landscape, but these features should be retained unless they pose a safety hazard. Hagenbuch (2013) recommends retaining more than six snags per acre to support forest bird habitat. Trees over 12 inches in diameter and cavity trees should be prioritized for retention.

### Introduced Non-native Plant Management

With respect to controlling non-native invasive plants, we recommend exploring the possibility of contracting the Vermont Youth Conservation Corps (VYCC) to manually remove honeysuckle and barberry, while simultaneously re-establishing native species with similar functional trait profiles.<sup>5</sup> Replacing the honeysuckle and buckthorn with appropriate native plants is important to help maintain community function and resist reinvasion (Drenovsky et al., 2012; Lambert et al., 2023). Without intervention, introduced non-native plants may impact native tree regeneration, leading to long-term changes in forest structure and negative effects on forest health.

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<sup>5</sup> Plants with comparable functional traits respond to environmental factors (e.g. drought, nutrients) in a similar way and have similar effects on ecosystem processes.



## Ash Management

To encourage critical decision-making and provide points for consideration, the following ash management methods are proposed. We acknowledge the technical aspects of these suggestions and recommend they be discussed with a licensed forester.

- At least 25–50% of ash trees, especially large and healthy individuals, should be retained in any given stand.
- Ash is dioecious<sup>6</sup> with male and female individuals. Females can be identified by the presence of dangling clusters of winged seeds (samaras), while male trees remain seedless. Maintaining a ratio of 5:1 female to male is recommended to ensure adequate seed production.
- Where ash regeneration is to be established and/or released, ensuring sufficient sunlight will enable saplings to fully develop over the coming decades. Young ash stems require partial to full release within approximately 10–20 years of establishment.<sup>7</sup>
- Consider ash as a “ghost tree” when determining desired post-harvest stocking<sup>8</sup> levels to ensure adequate stocking remains if the ash stems die.
- Evaluate the potential hazard of dead ash near roads, trails, and infrastructure and remove trees as needed.
- **Management practices that eliminate ash could be a greater threat than EAB itself. Survival of ash species depends on retaining EAB-tolerant genetics, seedlings, and/or a fresh seedbank to populate a new generation. Harvesting ash in accordance with silvicultural principles may be warranted, but panic cutting should be avoided.**

## Wildlife

### Introduction

The undeveloped forest and abundant surface waters that contribute to EFUD’s clean drinking water objectives also make the Waterworks attractive for a diversity of native wildlife.

The Waterworks sits at the heart of the Northern Green Mountains biophysical region. The high-elevation forests, substantial number of permanently conserved, privately owned properties, and large tracts of publicly owned land in the Northern Green Mountains—including Camel’s Hump State Park, C.C. Putnam State Forest, and Mt. Mansfield State Forest—provide extensive habitat for many species of mammals and birds (Thompson et al., 2019).

Vermont Conservation Design (VCD), the state’s vision for maintaining an ecologically functional landscape, underscores the important role that the Waterworks plays in providing wildlife habitat

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<sup>6</sup> Dioecious means that ash trees are either male (producing only pollen) or female (producing only seeds).

<sup>7</sup> Establishment refers to the point at which young trees have successfully survived and adapted to their site.

<sup>8</sup> Post-harvest stocking levels refer to the density of trees remaining in a forest stand immediately after timber harvest.

and connectivity within the wider region. According to VCD, the Waterworks lies within a highest priority interior forest block, connectivity block, and geological diversity block. Collectively, a statewide network of these prioritized lands allows wide-ranging mammals, such as black bear and bobcat, to move across their ranges and connect with other populations; provide the interior forest conditions that many native species, such as scarlet tanager, ovenbird, and wood thrush depend on; and maintain biodiversity as the climate changes (Hagenbuch, 2013; Vermont Fish & Wildlife Department).

Within the Waterworks, the varied topography, upland forest made up of hardwood, softwood, and mixed wood stands, and dynamic wetland areas support wildlife species with different habitat requirements.

The wildlife team's assessment documents the Waterworks' value as habitat and as a connector within the wider landscape.

## Methods

The wildlife team regularly visited the Waterworks between February and April 2026 to document wildlife presence using a combination of game cameras, track and sign, and direct observations. We georeferenced all observations and camera locations to support spatial interpretation of wildlife use.

We deployed 14 camera traps across the parcel (Figure 63), placing at least one camera in each natural community type identified in the *Forest Resource Management Plan* (Sweet & Sweet, 2019). (The plants team updated the natural community map during the course of this study. We use their revised map throughout this report.) We prioritized locations with habitat features known to concentrate wildlife activity, as well as predictable pathways created by slope, ridgelines, drainages, stream crossings, and other pinch points. We also targeted areas with abundant wildlife sign.

Because our early field season was not conducive to breeding bird surveys, we supplemented our incomplete list of bird observations with existing eBird datasets from the site (see Appendix 2). Additionally, since the camera placements were not systematically distributed across the parcel, statistical conclusions cannot be drawn about wildlife movement or populations. We can, however, provide anecdotal observations and trends.

In addition to field work, we used spatial analyses and literature review to assess habitat connectivity and potential impacts of recreation on wildlife.



## Camera Placements on the Waterworks

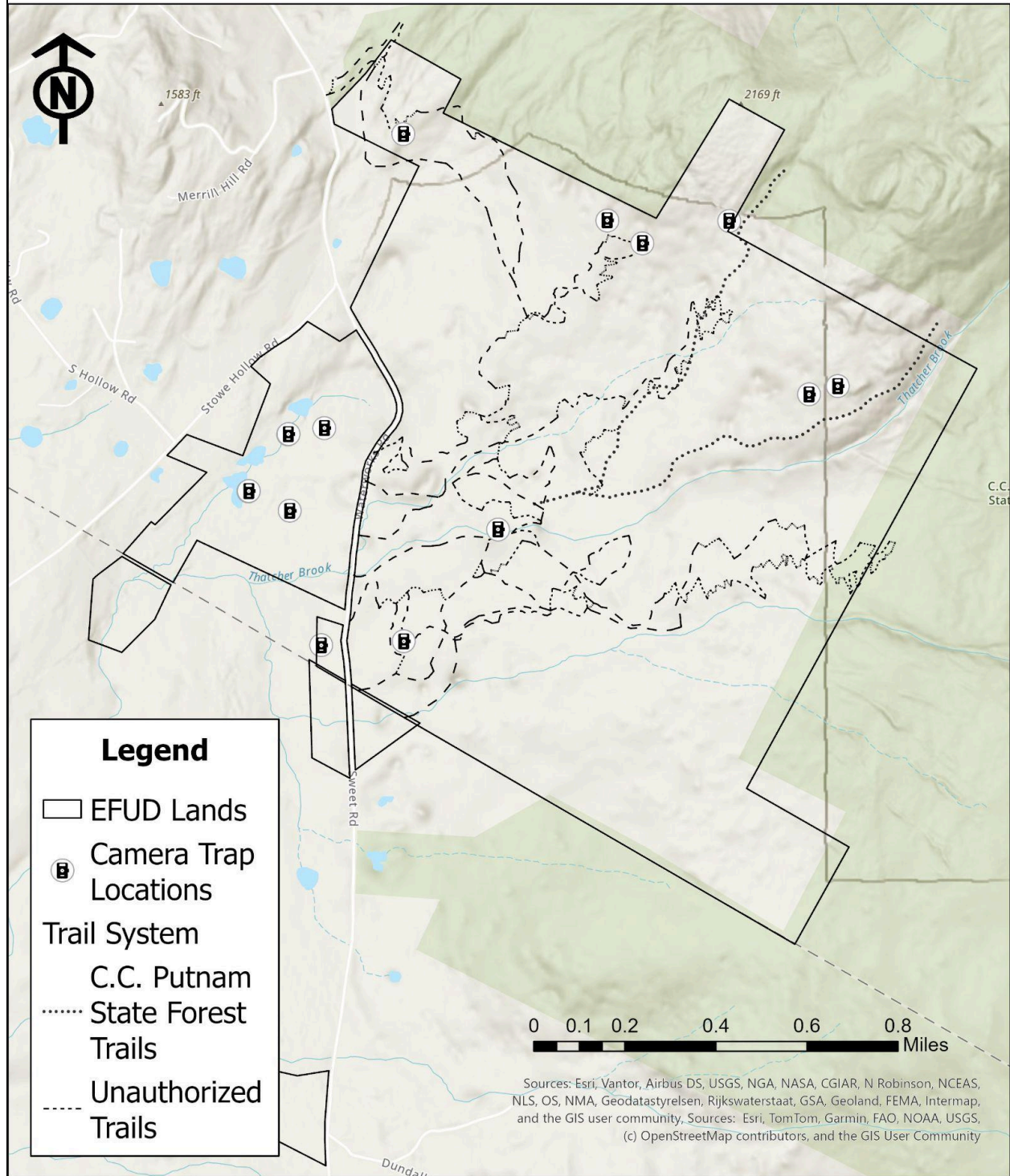


Fig. 63: Camera trap locations at the Waterworks. Cameras 13 and 14 were placed close together near the wetlands and appear as a single point.

## General Habitat Assessment

The distinct habitat types within the Waterworks serve different wildlife needs. The majority of the property is mature Northern Hardwood Forest with a closed canopy. Forests with well-developed understories, mid-stories, and canopies support more conditions for nesting and foraging birds. While there is high-quality habitat across the Waterworks, the forest has mostly even-aged trees and relatively low overall structural complexity because of a land-use history that includes clearing land for agriculture and harvesting timber. The features on the site that do contribute to structural complexity, such as standing snags, cavity trees, and downed wood, provide important habitat opportunities for birds (Hagenbuch, 2013). Certain mammals, such as fisher, also use these habitat features for denning (Vermont Fish & Wildlife Department).

American beech is common throughout the Northern Hardwood Forest, and its nutrient-dense beechnuts are an important source of hard mast for numerous wildlife species, especially black bear (Figure 64). The small patch of Red Oak Northern Hardwood Forest in Stand #10 in the northwestern corner of the property provides another source of hard mast in the form of acorns. The objective outlined for this stand in the *Forest Resource Management Plan* is to manage northern red oak for wildlife populations. Northern red oak currently supports a number of species and may become increasingly crucial for wildlife as beech bark disease (which is present on the site) and beech leaf disease (which is not yet present on the site, but is likely to arrive in coming years) take their toll.



Figure 64: Black bear scratch marks on an American beech tree.



Many stands have black cherry, and scattered apple trees grow near former homestead sites and early successional areas on the property. Their soft mast also provides a crucial food source for wildlife.

In the higher elevation and sloping portions of the property, to the north and east of Waterworks Road, rocky ledges support North American porcupine denning sites. Bobcats are also known to favor steep ledgy habitats for courtship rituals and dens (Vermont Fish & Wildlife Department). Woodland seeps, important contributors to biodiversity, are common throughout this section of the property (Thompson et al., 2019).

Pockets of softwood plantations are located on either side of Waterworks Road. These areas are well poised to support mammal and bird species. Red squirrels stash large piles of spruce cones to eat, and the trees support birds that prefer to nest in tall conifers, such as blackburnian warbler and black-throated green warbler. The softwoods also provide winter cover for white-tailed deer, ruffed grouse, and snowshoe hare.

The property transitions from upland natural communities to wetland natural communities to the west of Waterworks Road, where beaver, muskrat, mink, river otter, and waterfowl frequent the Class II wetlands. The areas of Alder Swamp adjacent to the beaver ponds are important breeding habitat for birds like alder flycatcher and swamp sparrow (Hagenbuch, 2013).

Some mammals also use wetland areas to travel and forage. Moose feed on alder twigs and use the dense foliage as cover. Bobcats rely on thickets for concealment as they move along exposed habitat edges and stalk prey. There is a well-established travel route for black bears through the Lowland Spruce-Fir Forest and the red pine plantation.

The following map shows areas where we observed key habitat features on the parcel (Figure 65). We identified habitat features by noting particular components of the landscape that have significant potential to support wildlife (e.g., cavity trees) and by noting areas with abundant wildlife sign. We identified *sensitive* habitat features by noting components of the landscape that are actively supporting wildlife and that would be disturbed by human encroachment. A porcupine denning site is one example of a sensitive habitat feature.

# Wildlife Habitat Features on the Waterworks

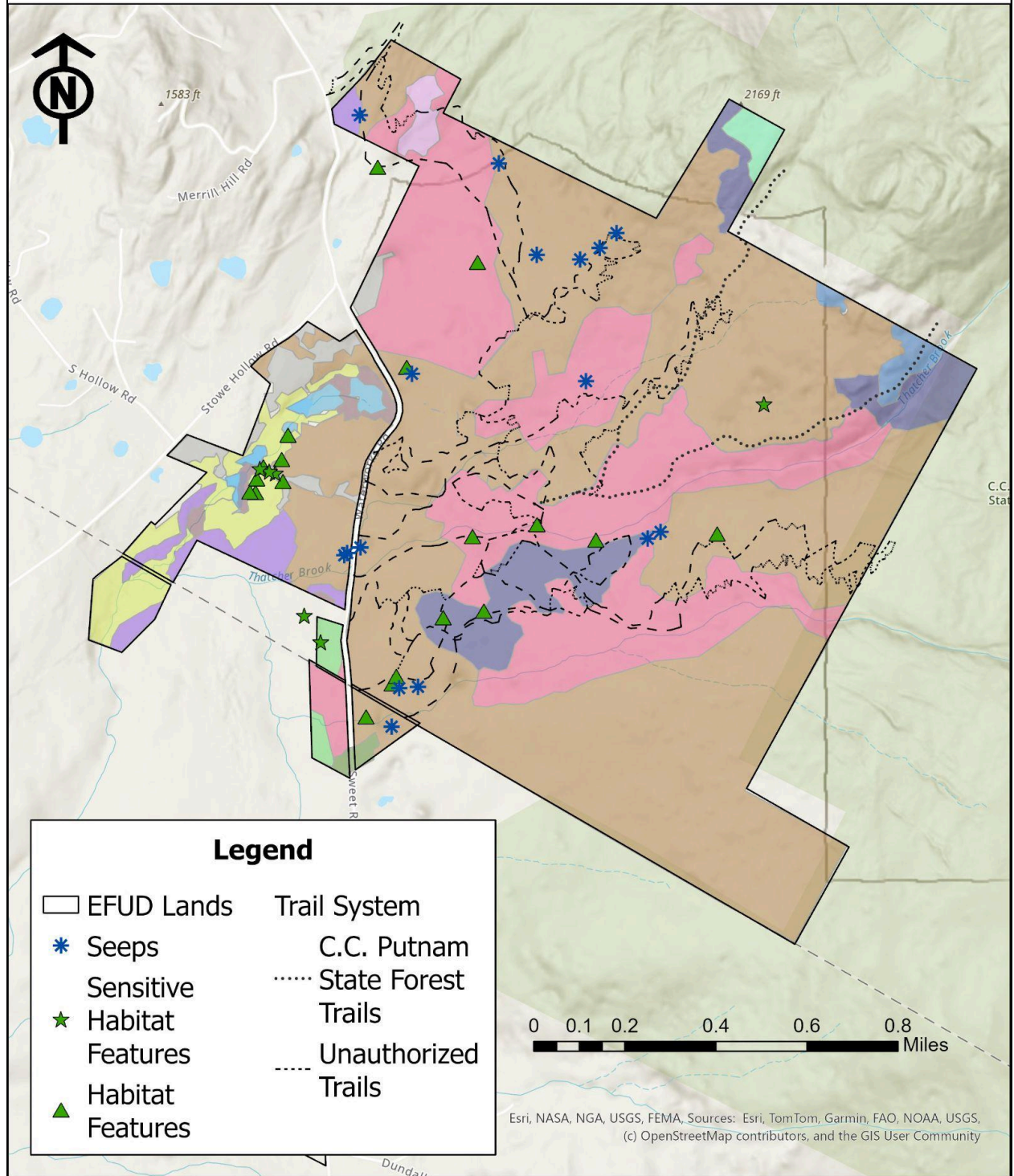


Figure 65: Key habitat features, seeps, and natural communities on the Waterworks.



## Habitat Connectivity

The Waterworks supports wildlife movement through the Northern Green Mountains biophysical region by maintaining connected forest cover. Its eastern boundary directly abuts C.C. Putnam State Forest, effectively extending a nearly 13,000-acre contiguous forest block by roughly 500 acres. This position situates the parcel within a broader east-west linkage between C.C. Putnam State Forest and Mt. Mansfield State Forest, a regional connection that includes the Shutesville Hill Wildlife Corridor (Figure 66). This corridor is recognized as the sole remaining linkage between the Green Mountains and the Worcester Range (Stowe Land Trust).

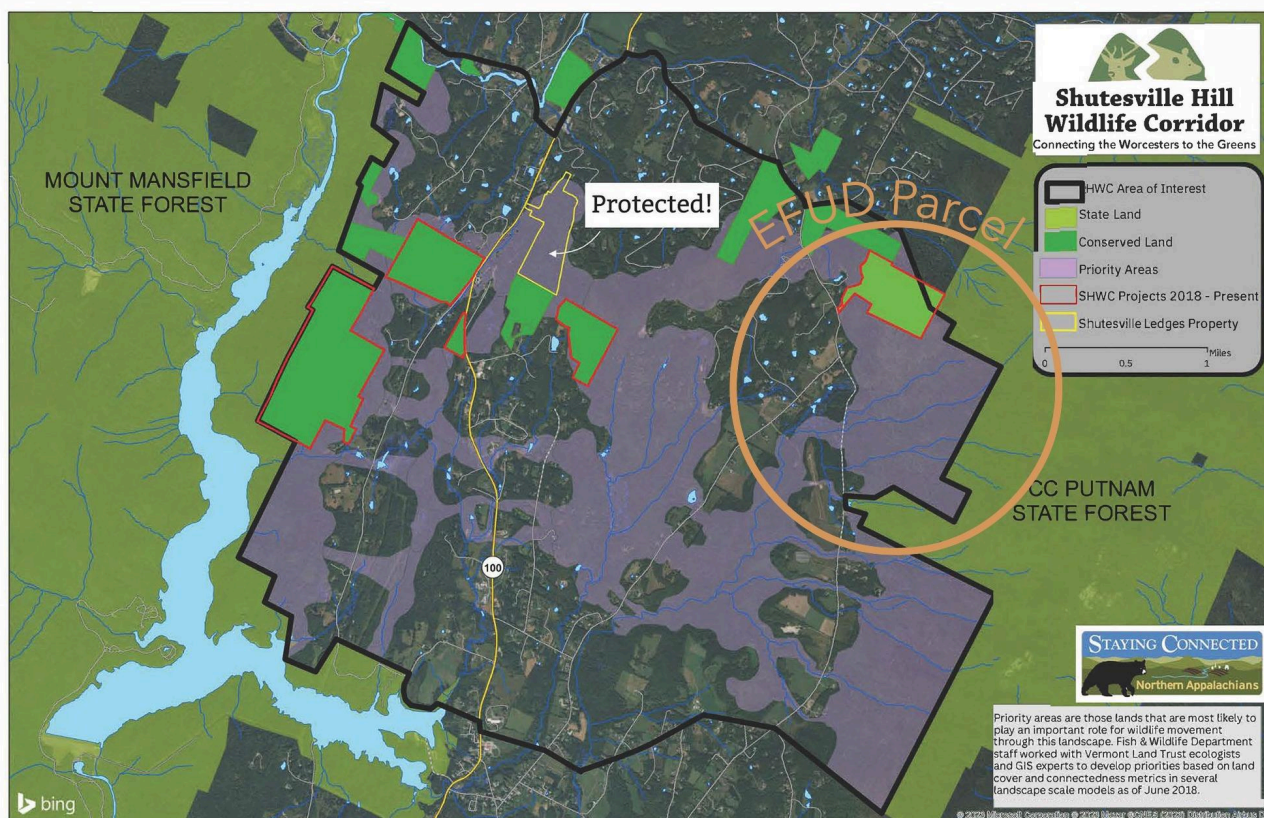


Figure 66: This map shows the Waterworks' position within the Shutesville Hill Wildlife Corridor Area of Influence. Credit: Stowe Land Trust

Connectivity is essential for wildlife because many species depend on access to feeding areas, denning sites, and other seasonal resources that are often widely separated across the landscape. In Vermont, east-west movement is particularly constrained where major roads and interstates interrupt habitat and lack functional crossing corridors. Maintaining these connections becomes even more important in the context of climate change, as species can only adjust their ranges if they are able to reach suitable habitat (Rushing et al., 2020).

Riparian corridors provide especially important linear pathways for movement, dispersal, and genetic exchange. VCD ranks Thatcher, Merriam, and Tyler Brooks and the wetlands on the western side of the property as highest priority riparian connectivity features. Additionally, most of Waterworks Road is identified as a highest priority wildlife road crossing, defined as a road

segment where forest, shrubland, or wetland habitat occurs on both sides and where wildlife is likely to cross. These crossings are equally important for animals with large and small ranges (Vermont Fish & Wildlife Department).

Many species detected through our camera-trapping efforts depend on large, connected forest blocks. For example, male black bear home ranges can span up to 32,000 acres (Sorenson & Osborne, 2014). These species routinely move on and off the parcel, ignoring property boundaries. In contrast, smaller mammals such as the snowshoe hare typically occupy home ranges of roughly 20 acres, relying on fine-scale connectivity within the parcel (Vermont Fish & Wildlife Department).



Figure 67: A bobcat captured by a camera trap near the beaver wetland complex.

## Amphibian and Reptile Community

We explored areas of the property that had promising features that could indicate vernal pools – small ponds that are not connected to streams and appear and disappear in the span of a few months. However, we could not confirm any.

We did observe red efts (the terrestrial stage of the eastern newt) and heard wood frogs near the beaver ponds and the Hemlock-Balsam Fir-Black Ash Seepage Swamp.

We did not conduct a full survey of reptiles and amphibians.

## Bird Community

The parcel provides breeding areas and stopover points for a wide range of forest and wetland birds. eBird users recorded 100 bird species within the Waterworks between 2014 and 2024 (Cornell Lab of Ornithology, 2026). These observations collectively represent about 50% of



Vermont's 201 breeding birds species (Renfrew, 2013). The 10 most frequently observed birds on the site include black-capped chickadee, song sparrow, American crow, Canada goose, red-breasted nuthatch, swamp sparrow, chestnut-sided warbler, winter wren, purple finch, and American goldfinch.

The eBird observations also include a number of rare species. For example, Cape May warbler, green-winged teal, and Tennessee warbler are all state ranked S1 species, or critically imperiled; bay-breasted warbler is S2, or imperiled; and northern saw-whet owl is S3, or vulnerable (Renfrew, 2013). While it is not clear from the eBird data whether these species are breeding on the site, their presence is an indicator of the parcel's high-quality bird habitat.

In addition to eBird data, key findings from Steve Hagenbuch's 2013 *Forest Bird Habitat Assessment for the Waterbury Municipal Watershed Lands* remain highly relevant to current conditions on the site.

The Audubon Vermont assessment of the Waterworks (Hagenbuch, 2013) indicates that the property provides strong breeding habitat for several forest "responsibility species," including blackburnian warbler, black-throated green warbler, black-throated blue warbler, wood thrush, ovenbird, and scarlet tanager. The large, contiguous forest block on the parcel and adjacent lands offers conditions that favor these interior-forest birds by limiting edge-related pressures and supporting successful nesting.

Conifer-dominated stands on the property add further habitat diversity and are used by species associated with softwood cover, such as black-throated green warbler, blackburnian warbler, and blue-headed vireo. The wetland complex in the southwestern portion of the parcel supports shrub-wetland birds including alder flycatcher and swamp sparrow and has previously supported Canada warbler—a species of high conservation concern. In addition, the parcel's major streams (Merriam, Tyler, and Thatcher Brooks) provide suitable conditions for Louisiana waterthrush, a riparian specialist.

The *Forest Resource Management Plan* (Sweet & Sweet, 2019) describes past harvests in the lowland spruce-fir stand (Stand #19) with the explicit goal of improving early-successional habitat for American woodcock and other native birds. Our 2026 field surveys confirm that this management objective remains relevant: we observed a woodcock foraging within the Alder Swamp and beaver-influenced wetland complex on April 20, 2026.

## Mammal Community

We documented wildlife, wildlife sign, and important habitat features throughout the parcel. Our camera traps recorded a total of 19 mammal species, approximately one-third of the mammals found in Vermont. Red squirrels and raccoons were the most frequently detected species in our camera traps, followed by white-tailed deer, coyote, and snowshoe hare. Bobcat, fisher, fox and black bear occurred infrequently. Semi-aquatic species such as beaver, muskrat, mink, and river otter were concentrated around the beaver pond. Camera footage also captured small rodents (e.g., mouse-sized individuals) that could not be reliably identified to species.

The highest concentration of camera trap activity occurred in and around the wetland complex. Camera trap data indicate that the Alder Swamp natural community supports the highest observed species richness on the parcel, reflecting the value of this structurally diverse habitat. Beaver activity has played a defining role in shaping the hydrology and structure of this system, and their ongoing influence clearly supports a broader range of species that depend on standing water, edge habitat, and early successional vegetation.



Figure 68: Porcupine denning site.

Camera traps and scat evidence confirm repeated porcupine use of the rocky ledges (Figure 68). Mammals such as fox, coyote, deer, fisher, and raccoon were observed through camera traps and tracks moving along the forest-wetland interface. Within the wetland complex, muskrat, beaver, river otter, raccoon, and mink, were documented using the beaver pond. Evidence of black bear included claw marks on telephone poles, red pine, and beech trees in both low elevation and upland forests, as well as a camera trap detection in the northern portion of the parcel within the Northern Hardwood community.

All mammal species detected during field surveys and camera trap monitoring are common and currently have no special conservation status in Vermont. Nonetheless, the parcel provides a mosaic of habitats that support a diverse wildlife community, with the Alder Swamp and adjacent forest-wetland ecotones functioning as key areas of species richness and movement. Our



survey methods were not exhaustive given seasonal constraints, and further observations would almost certainly identify additional mammal species using the parcel.

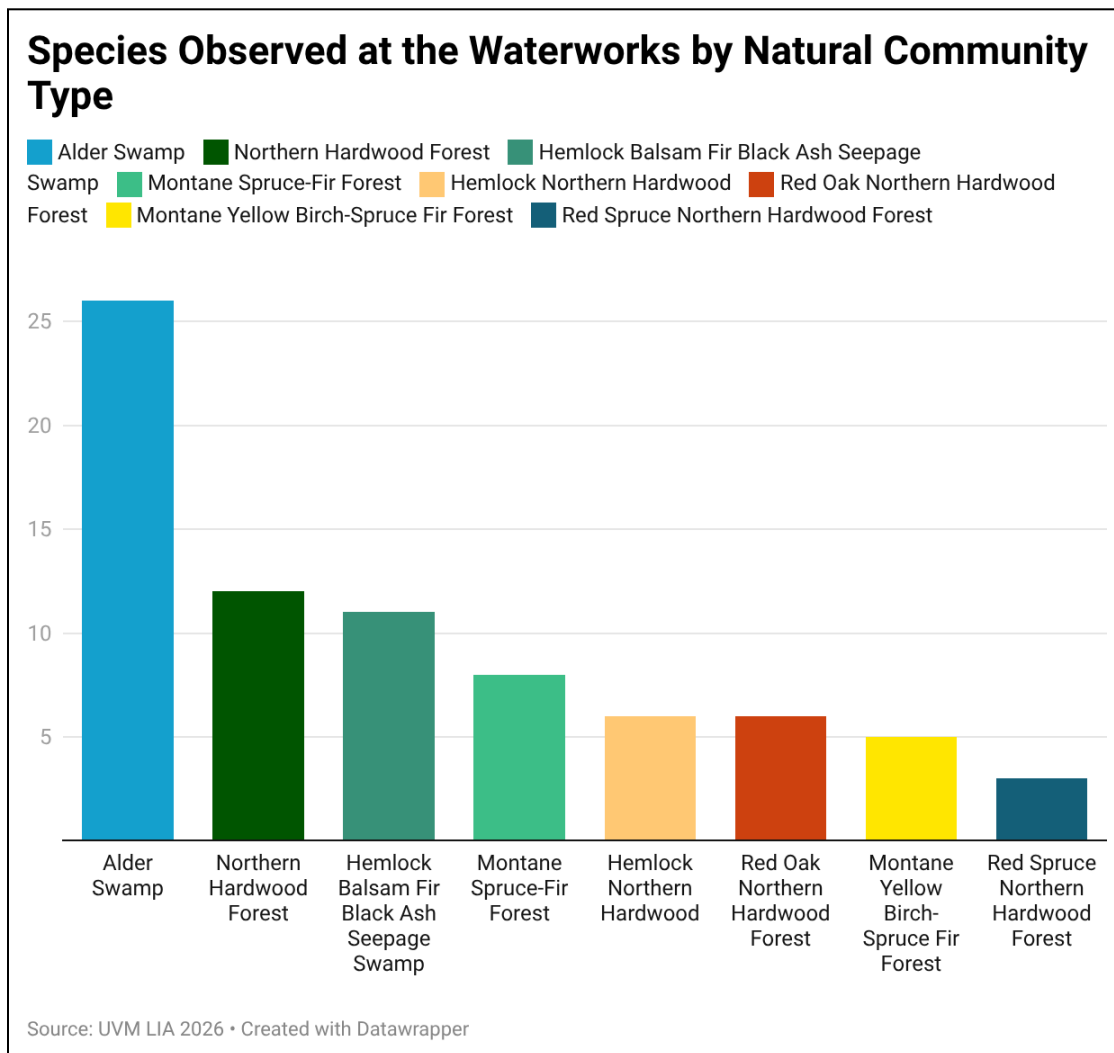


Figure 69: The number of species recorded within different natural community types.

## Impacts of Recreation on Wildlife

Prior to EFUD's decision to close all trails within the Waterworks in September 2025, the property was for many years a popular destination for walkers, mountain bikers, and other outdoor recreationists. The trail network was never explicitly sanctioned, but these activities coexisted with the water supply infrastructure until recently, when new illegally built trails raised concerns about potential impacts to water quality.

The trail closure presents an opportunity to consider how the trails at the Waterworks may impact wildlife. Studying the impact of recreation on wildlife is complex, given the highly variable ways that different species and individual animals may respond to highly variable trail-use situations, and research specific to the Northeast is still relatively new and emerging (Pontius et al., 2023; Naughton, 2021).

Meredith Naughton's 2021 report, *Understanding and Managing the Effects of Trail Use on Wildlife*, prepared for the Vermont Department of Forests, Parks, and Recreation, provides a management protocol for minimizing trail impacts to wildlife based on an exhaustive literature review. Below, Figure 70 shows the current influence the mountain bike trails have on wildlife based on this report.

Key findings include:

- Trail-based recreation negatively impacts wildlife. The severity of these impacts can vary significantly, from an animal using energy to avoid a recreator to a local population disappearing from the area entirely.
- A trail's primary zone of influence, the distance within which most species are highly impacted by recreation, extends for 100 meters. A trail's secondary zone of influence, which accounts for most wide-ranging species, extends for 500 meters.
- Trail-based recreation is more disruptive to wildlife during the breeding season.
- There is no clear evidence that an increase in the volume of trail use corresponds with an increase in negative effects on wildlife.

Based on these key findings, Naughton (2021) makes the following management recommendations:

1. Identify areas of the landscape to maintain as trail-free, prioritizing large interior forest blocks, connectivity blocks, and important wildlife crossings.
2. If a trail is appropriate in a given area, create primary (100-meter) and secondary (500-meter) buffer zones around high value wildlife resources.
3. Consolidate trails within a small area so that negative impacts are not spread out across the landscape.
4. Continue to monitor new and existing trails for negative impacts on wildlife.
5. Encourage a culture of considerate trail use by educating trail users about trail placement, sensitive wildlife, and how to recreate responsibly.



## Current Zone of Influence of Trails

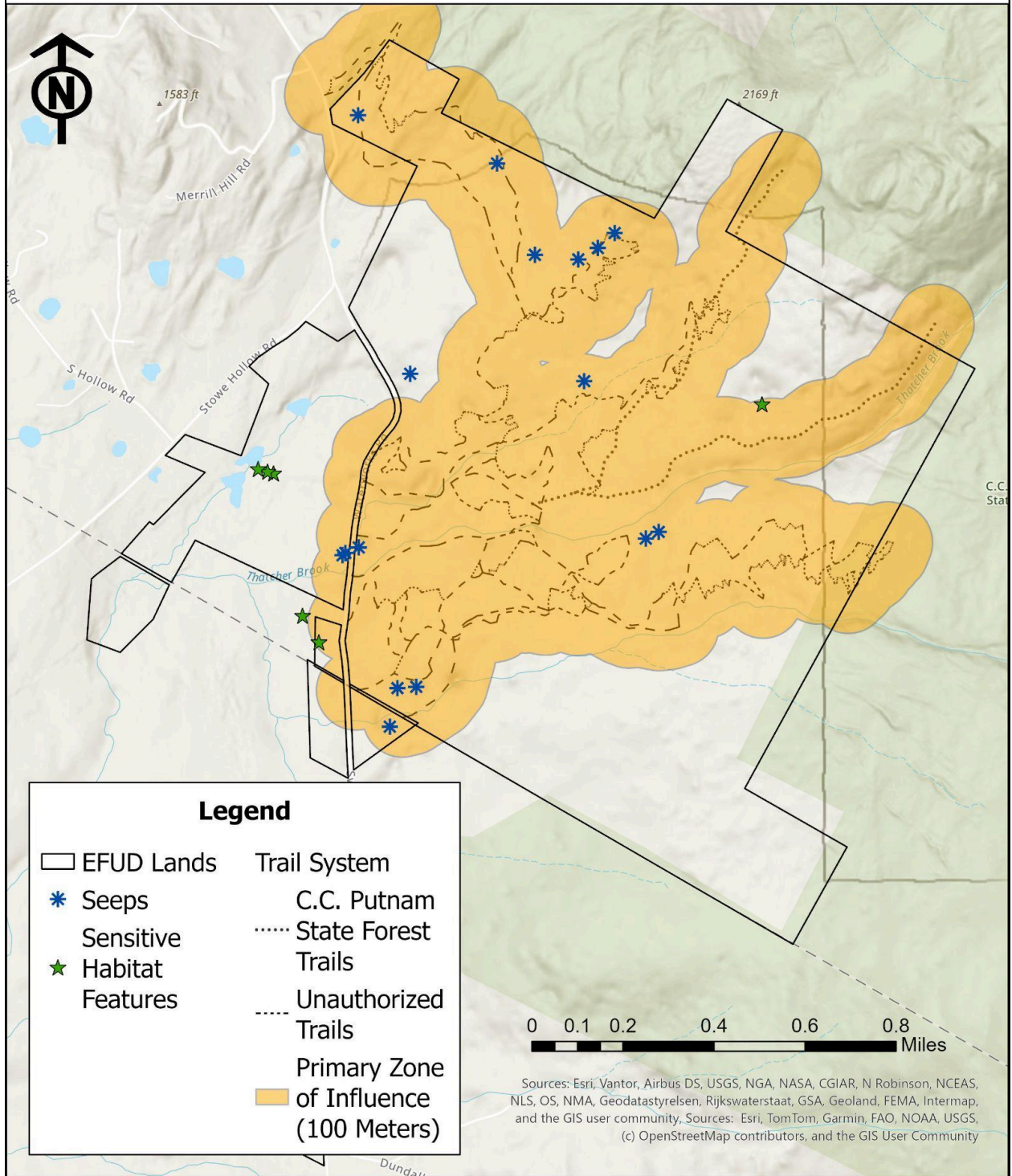


Figure 70: This map depicts the primary zone of influence (100 meters from a trail) that current trails have on wildlife based on Naughton (2021).

# Management Recommendations

## Trail Siting and Maintenance

1. Repair & Maintenance: Ameliorate existing erosion concerns through maintenance or rerouting of access roads and trails. Even trails or roads that will remain closed will need amelioration. Make ongoing maintenance plans for any that will be kept.
2. Trail Design: If mountain bike trails are a priority, consider speaking to a professional trail builder specializing in mountain bike trails to better understand the design considerations for that kind of trail in this context. If they are not a priority, consider closing trails to mountain biking specifically, and focusing on pedestrian-friendly trail design (we still recommend professional advising) for low erosion. Elements like waterbars can effectively prevent water from moving directly down trails.
3. Future Siting:
  - a. A suitable area for an interpretive loop trail may be north of Thatcher Brook, encompassing areas east and west of Waterworks Road to take advantage of this less steep section of the parcel, avoid EFUD infrastructure located on Tyler and Merriam Brooks, provide access to historical elements such as the Tyler Farm cellar, and provide potential wildlife viewing near wetlands and the Big Beaver Pond.
  - b. Use caution siting trails near the alluvial fan areas (see p. 41) in the southwestern area of the parcel as water flow paths may change significantly over time.
  - c. Any trails sited near wetlands would need appropriate boardwalk and/or causeway infrastructure, to protect wetlands and account for boundaries that may change over time.
  - d. If extensive new trails are planned in the higher elevations, work with a consultant to locate all unmapped streams and seeps. Documenting all unmapped streams and seeps may be an important future resource for EFUD.
  - e. Use 100 m primary and 500 m secondary zones of influence, which represent the distances where wildlife show the strongest responses to recreation, to buffer sensitive wildlife resources and avoid trail placement.



# Areas Where Trails Should Be Limited or Excluded

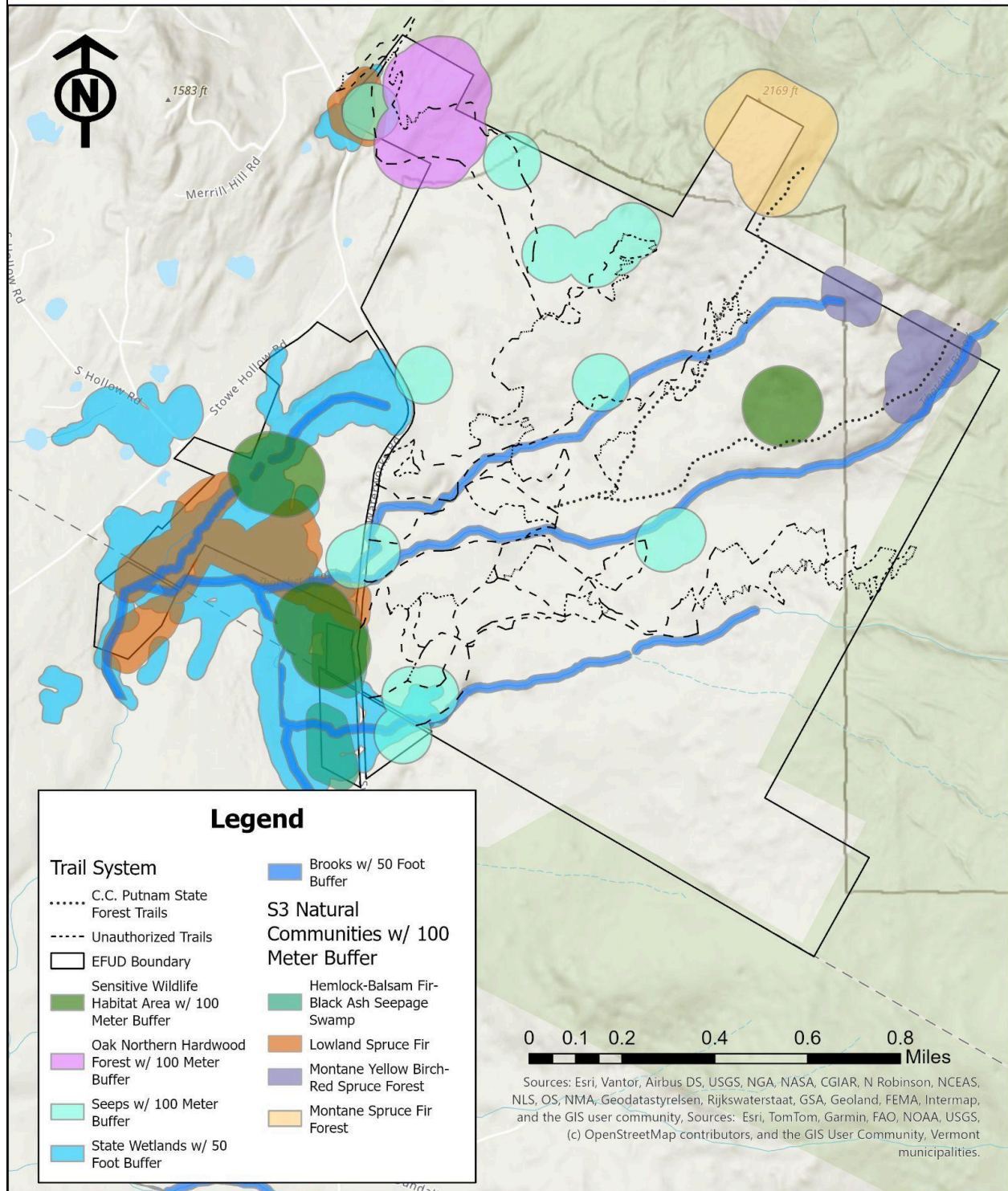


Figure 71: This map depicts the areas that should have limited or no trails. Sensitive habitat features for wildlife (including important natural communities and seeps) have 100 meter buffers around them based on the primary zone of influence from Naughton (2021). Streams and wetlands have a 50 foot buffer based on the standard buffer for timber harvesting.

## Public Outreach

1. The creation of interpretive trails on the site would encourage positive recreation and contribute to a local understanding of both history and modern land use. Signage along these trails could elaborate on the topics of:
  - a. Land use history: With much information on the families and industries that worked this land, EFUD might consider placing signs at strategic points in order to connect the public with their town's history. The nearby Little River State Park has interpretive signage about the history of the land and how it has changed. Something similar could be set up on this parcel, especially since many of the visible foundations and stone walls are along the existing main road, which is very accessible and would potentially cause less disturbance than other trails along steep slopes.
  - b. Drinking water: Educating the public about the landscape and infrastructure that provides their drinking water would contribute to a positive public understanding of landscape management decisions and responsible stewardship. If visitors have a better understanding of why trails are closed and how it is important to public health, they may be less likely to create illicit trails or cause further damage.
  - c. Sensitive habitat: Contributing to public understanding of sensitive habitats for both plants and wildlife could encourage responsible stewardship of this and other sites.
2. We recommend building partnerships with trail builders and mountain biking communities. Approaching recreation from a place of collaboration may result in productive, mutually understood approaches to land management on the parcel.

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## Going Forward

### Deed Research

We recommend hiring a professional historian (such as Samantha Ford from Turn Stone Research, who was instrumental in conducting research thus far) if additional information on the land-use history of the Waterworks parcel is desired, particularly on the Waterbury side of the town line. Tracing land deeds through history is complex and time-consuming, and a professional with the time and resources to navigate archaic records will be the most efficient route to piecing together a complete human history of the parcel.

### Ongoing Engagement with On-site Natural Resources

We recommend continuing seasonal field visits to monitor vegetation, wildlife use, hydrology, and habitat conditions across the parcel. Regular engagement will help detect early signs of invasive species establishment, shifts in beaver activity, erosion, or unauthorized recreation. Maintaining this adaptive, field-based approach ensures that management remains responsive to emerging ecological conditions and supports long-term stewardship.

### Monitor Beaver Activity

Beavers are an important influence on wetland structure and biodiversity on this parcel. To balance ecological benefits with infrastructure protection, we recommend the following:

- Monitor the core beaver activity zone within the wetland complex. As long as activity remains within this area, beavers are providing substantial ecological benefits.
- Evaluate any expansion toward upland areas or Waterworks infrastructure. If beavers begin damming culverts, flooding roads, or expanding activity into areas that threaten infrastructure, management intervention may be warranted.
- We recommend not removing beavers unless impacts are confirmed and alternatives have been evaluated. Documenting these patterns will support proactive, rather than reactive, management.

### Map Water Features

Our field assessment identified numerous unmapped water features across the parcel. A comprehensive hydrologic map will strengthen future infrastructure development and management decisions.

Because mapping all features was beyond the scope of this project, we recommend the following:



- Develop a complete, high-resolution inventory of surface water features, including intermittent streams, seeps, vernal pools, and other unmapped hydrologic elements.

# References

- 1850 Vermont Agricultural Census*. (1850). Silver Special Collections, University of Vermont Libraries.
- 1860 Vermont Agricultural Census*. (1860). Silver Special Collections, University of Vermont Libraries.
- 1870 Vermont Agricultural Census*. (1870). Silver Special Collections, University of Vermont Libraries.
- 1880 Vermont Agricultural Census*. (1880). Silver Special Collections, University of Vermont Libraries.
- 370,000 Trees Are Ordered For Spring. (1931). *Bristol Herald*. Newspapers.com. March 4, 1931. <https://vsara.newspapers.com/>.
- Coish, R., Kim, J., Morris, N., & Johnson, D. (2012). *Late stage rifting of the Laurentian continent: Evidence from the geochemistry of greenstone and amphibolite in the central Vermont Appalachians*. Canadian Journal of Earth Sciences, 49. <https://doi.org/10.1139/e11-013>.
- Cornell Lab of Ornithology. (2026). *eBird Basic Dataset: Vermont Bird Observations, 2014–2024* [Data set]. Retrieved March 1, 2026, [from https://ebird.org/data/download](https://ebird.org/data/download)
- D'Amato, A., Palik, B., Raymond, P., Puettmann, K., & Girona, M. (2023). *Building a framework for adaptive silviculture under global change*. In M. M. Girona, H. Morin, S. Gauthier, Y. Bergeron (Eds.), *Boreal Forests in the Face of Climate Change*. 359-381. Springer Nature.
- Deed Book 11: 371*. (1850a) Vermont, Lamoille County. Stowe Town Clerk. February 13, 1850.
- Deed Book 11: 475*. (1850b). Vermont, Lamoille County. Stowe Town Clerk. May 23, 1850.
- Deed Book 19: 196*. (1873). Vermont, Lamoille County. Stowe Town Clerk. January 4, 1873.
- Deed Book 25: 44*. (1890). Vermont, Lamoille County. Stowe Town Clerk. November 20, 1890.
- Deed Book 25: 360*. (1896a). Vermont, Lamoille County. Stowe Town Clerk. October 23, 1896.



*Deed Book 27: 82.* (1896b). Vermont, Lamoille County. Stowe Town Clerk. January 22, 1896.

*Deed Book 25: 364.* (1896c). Vermont, Lamoille County. Stowe Town Clerk. January 23, 1896.

Dewart, J. H. (1913). Plan of Stowe [Map].

[https://files.vcgi.vermont.gov/other/lotting-plans/Stowe\\_19160904.pdf](https://files.vcgi.vermont.gov/other/lotting-plans/Stowe_19160904.pdf)

Drenovsky, R., Grewell, B., D'Antonio, C., Funk, J., James, J., Molinari, N., Parker, I., & Richards, C. (2012). *A functional trait perspective on plant invasion*. *Annals of Botany*, 110(1), 141-153.

Duveneck, M., & Scheller, R. (2016). *Measuring and managing resistance and resilience under climate change in northern Great Lake forests (USA)*. *Landscape Ecology*. 31, 669-686.

Flower, C., Knight, K., Rebbeck, J., & Gonzalez-Meler, M. (2013). *The relationship between the emerald ash borer (*Agilus planipennis*) and ash (*Fraxinus spp.*) tree decline: Using visual canopy condition assessments and leaf isotope measurements to assess pest damage*. *Forest Ecology and Management*. 303, 143-147.

Front Porch Forum. (2026). *Front Porch Forum*. <https://frontporchforum.com/>.

Hagenbuch, S. (2013). *Forest Bird Habitat Assessment: Waterbury Municipal Watershed Lands*. Huntington, VT: Audubon Vermont.

Hawes, E. (2005). *Riparian Buffer Zones: Functions and Recommended Widths*.

*History of Forestry in Vermont | Department of Forests, Parks and Recreation*. (n.d.). Retrieved May 2, 2026, from <https://fpr.vermont.gov/forest/vermonts-forests/history-forestry-vermont>.

*Hunger Mountain Forestry*. (2019). *EFUD Forest Management Plan & Use Assessment*.

*Hydrometeorological Automated Data System—National Weather Service*. (n.d.). Retrieved May 7, 2026, from <https://hads.ncep.noaa.gov/charts/VT.shtml#>.

Isaac Merriam, of Stowe... (1861). *The Lamoille Newsdealer*. Newspapers.com. July 26, 1861. <https://vsara.newspapers.com/>.

Knapp, W. (1987). *A History of Waterbury*.

- Kosiba, A. (2024). *Climate change impacts on northeastern forests*. Northern Woodlands. Spring 2024. 31-35.
- Lambert, T., McIntyre, P., Moody, K., & Ellner, S. (2023). *Optimizing invader suppression to restore native species: Leveraging species traits to overcome collateral damage*. Journal of Applied Ecology, 60(12), 2636-2651.
- Mechanic Arts. (1847). *The Green Mountain Freeman*. Newspapers.com. October 28, 1847.  
<https://vsara.newspapers.com/>.
- Mechanic Arts. (1849). *The Green Mountain Freeman*. Newspapers.com. November 1, 1849.  
<https://vsara.newspapers.com/>.
- Moroney, D. (2026). *EFUD Trails & Erosion. LIA Class Guest Presentation*.
- Naughton, M. (2021). *Understanding and Managing the Effects of Trail Use on Wildlife*. Vermont Fish & Wildlife Department.
- NPS Geologic Resources Division & American Geosciences Institute. (2020). *Convergent Plate Boundaries—Collisional Mountain Ranges—Geology* (U.S. National Park Service).  
<https://www.nps.gov/subjects/geology/plate-tectonics-collisional-mountain-ranges.htm>.
- NRCS. (n.d.). *VT ANR Soil Fact Sheets*. Retrieved April 26, 2026, from  
<https://anrmaps.vermont.gov/websites/SOILS>.
- Peet Law Group. (n.d.). *Glebe land and perpetual lease land in Vermont: Understanding its impact on real estate today*. <https://www.peetlaw.com/understanding-vermont-glebe-land>.
- Pontius, J., Hellwig, V., & Schuett, E. (2023). *Monitoring the connection between forest health and outdoor recreation*. Forest Ecosystem Monitoring Cooperative.  
<https://doi.org/10.18125/h9tg50>.
- Research Guides: Vermont: Local History & Genealogy Resource Guide: Introduction. (n.d.). Retrieved May 2, 2026, from  
<https://guides.loc.gov/vermont-local-history-genealogy/introduction>.



- Renfrew, R. B. (ed.). (2013). *The Second Atlas of Breeding Birds of Vermont*. University Press of New England. 576 pp. <https://doi.org/10.6084/m9.figshare.11499330.v1>.
- Rushing, C. S., Royle, J. A., Ziolkowski, D. J., & Pardieck, K. L. (2020). Migratory behavior and winter geography drive differential range shifts of eastern birds in response to recent climate change. *Proceedings of the National Academy of Sciences*, 117(23), 12897–12903. <https://doi.org/10.1073/pnas.2000299117>.
- Smith, J. (2026). *Climate-Smart Forestry I The Nature Conservancy*. The Nature Conservancy. <https://www.nature.org/en-us/what-we-do/our-priorities/tackle-climate-change/climate-change-stories/climate-smart-forestry>.
- Sorenson, E., & Osborne, J. (2014). *Vermont Habitat Blocks and Habitat Connectivity: An Analysis Using Geographic Information Systems*. Vermont Fish and Wildlife Department.
- Special Village Meeting. (1895). *The Waterbury Record*. Newspapers.com. December 10, 1895. <https://vsara.newspapers.com/>.
- Springs and Seeps. (n.d.). *Groundwater Resource Hub*. Retrieved April 26, 2026, from <https://www.groundwaterresourcehub.org/groundwater-101/springs-and-seeps>.
- Stowe. (1888). *The Burlington Weekly Free Press*, 8. Newspapers.com. October 19, 1888. <https://vsara.newspapers.com/>.
- Stowe. (1890). *News and Citizen*. Newspapers.com. October 30, 1890. <https://vsara.newspapers.com/>.
- Stowe Journal. (1895). *The Waterbury Record*. Newspapers.com. December 17, 1895. <https://vsara.newspapers.com/>
- Stowe Scribblings. (1889). *Argus and Patriot*. Newspapers.com. February 13, 1889. <https://vsara.newspapers.com/>.
- Stowe Scribblings. (1890a). *Argus and Patriot*. Newspapers.com. October 22, 1890. <https://vsara.newspapers.com/>.

Stowe Scribblings. (1890b). *Argus and Patriot*. Newspapers.com. August 6, 1890.

<https://vsara.newspapers.com/>

Stowe Historical Society. (n.d.). *A history of Stowe*.

<https://www.stowehistoricalsociety.org/a-history-of-stowe>.

Stowe Land Trust (n.d.). *Shutesville Hill Wildlife Corridor*.

<https://www.stowelandtrust.org/work/projects/shutesville-hill-wildlife-corridor>

Strava. (n.d.). *Strava: Running, cycling & hiking app – Train, track & share*.

<https://www.strava.com>.

Stuhl, E. (n.d.). *The UVM PLACE Program*. Retrieved April 26, 2026, from

<https://www.uvm.edu/place/towns/newhaven/bedrock.php>.

Sweet, T., & Sweet, D. (2019). *Forest resource management plan and use assessment for municipal watershed lands owned by Edward Farrar Utility District. Hunger Mountain Forestry, Inc.*

The committee appointed... (1895). *The Waterbury Record*. Newspapers.com. November 26, 1895. <https://vsara.newspapers.com/>.

The Water Supply Situation. (1895). *The Waterbury Record*. Newspapers.com. September 3, 1895. <https://vsara.newspapers.com/>.

Thompson, E., Sorenson, E., & Zaino, B. (2019). *Wetland, woodland, wildland: A guide to the natural communities of Vermont. Vermont Fish and Wildlife Department* (2nd ed.). Chelsea Green.

Trees Ordered for Spring. (1931). *St. Albans Daily Messenger*. Newspapers.com. March 30, 1931. <https://vsara.newspapers.com/>.

Tuesday's Village Meeting Brought Forth Some Watery Talks. (1895). *The Waterbury Record*. Newspapers.com. September 3, 1895. <https://vsara.newspapers.com/>.

U.S. Fish & Wildlife Service. (n.d.). *Wetlands Mapper*. Retrieved April 20, 2026, from <https://www.fws.gov/program/national-wetlands-inventory/wetlands-mapper>.



Vermont Conservation Design | Vermont Fish & Wildlife Department. (n.d.). Retrieved April 25, 2026, from <https://www.vtfishandwildlife.com/conserve/vermont-conservation-design>.

Vermont Fish & Wildlife Department. (n.d.). *BioFinder 4.0* [Interactive map]. Vermont Agency of Natural Resources. <https://anrmaps.vermont.gov/websites/BioFinder4/>

Villars, T. (n.d.). *Tunbridge—Vermont State Soil*. *Soil Science Society of America*. Retrieved <https://www.soils4teachers.org/files/s4t/k12outreach/vt-state-soil-booklet.pdf>.

VT Department of Environmental Conservation. (n.d.). *Wetland Functions and Values*. Retrieved April 26, 2026, from <https://dec.vermont.gov/watershed/wetlands/functions/wetland-functions-and-values-water-storage-flood-water-and-storm>.

*War & Industry: Vermont's Changing Landscape—Vermont Historical Society*. (n.d.). Retrieved May 2, 2026, from <https://vermonthistory.org/freedom-unity-vermonts-changing-landscape>.

Waterbury. (1895). *The Vermont Watchman & State Journal*. Newspapers.com. December 4, 1895. <https://vsara.newspapers.com/>.

Waterbury can now boast... (1896). *The Waterbury Record*. Newspapers.com. September 29, 1896. <https://vsara.newspapers.com/>.

Waterbury Center. (1874). *The Vermont Watchman & State Journal*. Newspapers.com. December 23, 1874. <https://vsara.newspapers.com/>.

We commend the judgement... (1931). *The Waterbury Record*, 2. Newspapers.com. April 8, 1931. <https://vsara.newspapers.com/>.

We have been shown... (1867). *The Vermont Christian Messenger*. Newspapers.com. August 1, 1867. <https://vsara.newspapers.com/>.

Will Have Municipal Forest. (1926). *The Waterbury Record*. Newspapers.com. March 3, 1926. <https://vsara.newspapers.com/>.

Wright, S. (2026). *Surficial Geology & Glacial History on Waterworks Parcel [Field Walk]*.

# Appendices

## Appendix 1: Plant Species List

\*= Non-native

| <b>Trees</b>                 |                      |
|------------------------------|----------------------|
| <i>Abies balsamea</i>        | Balsam fir           |
| <i>Acer rubrum</i>           | Red maple            |
| <i>Acer saccharum</i>        | Sugar maple          |
| <i>Betula alleghaniensis</i> | Yellow birch         |
| <i>Betula papyrifera</i>     | Paper birch          |
| <i>Fagus grandifolia</i>     | American beech       |
| <i>Fraxinus americana</i>    | White ash            |
| <i>Fraxinus nigra</i>        | Black ash            |
| <i>Juglans cinerea</i>       | Butternut            |
| <i>Malus domestica</i> *     | Apple                |
| <i>Ostrya virginiana</i>     | Eastern Hophornbeam  |
| <i>Picea abies</i>           | Norway spruce        |
| <i>Pinus resinosa</i>        | Red pine             |
| <i>Pinus strobus</i>         | Eastern white pine   |
| <i>Populus grandidentata</i> | Bigtooth aspen       |
| <i>Populus tremuloides</i>   | Quaking aspen        |
| <i>Prunus pensylvanica</i>   | Pin cherry           |
| <i>Prunus serotina</i>       | Black cherry         |
| <i>Quercus rubra</i>         | Northern red oak     |
| <i>Thuja occidentalis</i>    | Northern white cedar |



|                                |                       |
|--------------------------------|-----------------------|
| <i>Tilia americana</i>         | American basswood     |
| <i>Tsuga canadensis</i>        | Eastern hemlock       |
| <i>Ulmus americana</i>         | American elm          |
| <i>Ulmus rubra</i>             | Slippery elm          |
| <b>Shrubs</b>                  |                       |
| <i>Acer pensylvanicum</i>      | Striped maple         |
| <i>Alnus incana</i>            | Speckled alder        |
| <i>Amelanchier spp.</i>        | Shadbush              |
| <i>Berberis thunbergii</i> *   | Japanese barberry     |
| <i>Cornus amomum</i>           | Silky dogwood         |
| <i>Cornus stolonifera</i>      | Red osier dogwood     |
| <i>Hamamelis virginiana</i>    | Witch hazel           |
| <i>Rubus spp.</i>              | Raspberry             |
| <i>Lonicera morowii</i> *      | Morrow's honeysuckle  |
| <i>Rhus typhina</i>            | Staghorn sumac        |
| <i>Ribes lacustre</i>          | Bristly black currant |
| <i>Salix bebbiana</i>          | Bebb's willow         |
| <i>Salix spp.</i>              | Willow                |
| <i>Sambucus racemosa</i>       | Red elderberry        |
| <i>Spiraea alba</i>            | Meadowsweet           |
| <i>Spiraea tomentosa</i>       | Steeplebush           |
| <i>Virburnum alnifolium</i>    | Hobblebush            |
| <b>Herbs</b>                   |                       |
| <i>Aegopodium podagraria</i> * | Goutweed              |
| <i>Allium tricoccum</i>        | Wild leek             |
| <i>Anemone acutiloba</i>       | Sharp-lobed hepatica  |

|                                   |                             |
|-----------------------------------|-----------------------------|
| <i>Asarum canadense</i>           | Canadian wild ginger        |
| <i>Aster spp.</i>                 | Aster                       |
| <i>Caltha palustris</i>           | Marsh marigold              |
| <i>Cardamine diphylla</i>         | Two-leaved toothwort        |
| <i>Carex plantaginea</i>          | Plantain sedge              |
| <i>Carex spp.</i>                 | Sedge                       |
| <i>Carex stricta</i>              | Tussock sedge               |
| <i>Caulophyllum thalictroides</i> | Blue cohosh                 |
| <i>Claytonia caroliniana</i>      | Carolina spring beauty      |
| <i>Convallaria majalis*</i>       | European lily-of-the-valley |
| <i>Coptis trifolia</i>            | Common goldthread           |
| <i>Cornus canadensis</i>          | Canadian bunchberry         |
| <i>Crocus spp.*</i>               | Crocus                      |
| <i>Cypripedium acaule</i>         | Pink lady's slipper         |
| <i>Cystopteris fragilis</i>       | Fragile fern                |
| <i>Dactylis glomerata</i>         | Orchardgrass                |
| <i>Dicentra canadensis</i>        | Squirrel corn               |
| <i>Dicentra cucullaria</i>        | Dutchman's Breeches         |
| <i>Echinocystis lobata</i>        | Wild cucumber               |
| <i>Epifagus virginiana</i>        | Beechdrops                  |
| <i>Erythronium americanum</i>     | American trout lily         |
| <i>Eurybia divaricata</i>         | White wood aster            |
| <i>Eutrochium maculatum</i>       | Spotted Joe-pye weed        |
| <i>Fragaria virginiana</i>        | Common strawberry           |
| <i>Galium mollugo*</i>            | Hedge bedstraw              |
| <i>Geum macrophyllum</i>          | Large-leaved avens          |



|                                 |                          |
|---------------------------------|--------------------------|
| <i>Geum rivale</i>              | Water avens              |
| <i>Glyceria canadensis</i>      | Canada mannagrass        |
| <i>Heracleum maximum</i>        | Common cow parsnip       |
| <i>Hydrophyllum virginianum</i> | Virginia waterleaf       |
| <i>Mitchella repens</i>         | Partridgeberry           |
| <i>Hemerocallis spp.*</i>       | Day lily                 |
| <i>Osmunda regalis</i>          | Royal fern               |
| <i>Oxalis montana</i>           | Northern wood sorrel     |
| <i>Phalaris arundinacea*</i>    | Reed canary grass        |
| <i>Ranunculus repens*</i>       | Creeping buttercup       |
| <i>Rumex obtusifolius</i>       | Broad-leaved dock        |
| <i>Sanguinaria canadensis</i>   | Bloodroot                |
| <i>Solidago spp.</i>            | Goldenrod                |
| <i>Sparganium spp.</i>          | Bur-reed                 |
| <i>Sphagnum spp.</i>            | Moss                     |
| <i>Symphyotrichum puniceum</i>  | Purple-stemmed aster     |
| <i>Taraxacum officinale</i>     | Common dandelion         |
| <i>Tiarella cordifolia</i>      | Creeping foamflower      |
| <i>Trillium erectum</i>         | Red trillium             |
| <i>Tussilago farfara*</i>       | Coltsfoot                |
| <i>Typha latifolia</i>          | Broadleaf cattail        |
| <i>Uvularia sessilifolia</i>    | Wild oats                |
| <i>Veratrum viride</i>          | American false hellebore |
| <i>Viola rotundifolia</i>       | Round-leaved violet      |
| <b>Ferns &amp; Fern Allies</b>  |                          |

|                                     |                             |
|-------------------------------------|-----------------------------|
| <i>Adiantum pedatum</i>             | Northern maidenhair fern    |
| <i>Athyrium filix-femina</i>        | Common lady fern            |
| <i>Dendrolycopodium dendroideum</i> | Prickly tree-clubmoss       |
| <i>Dennstaedtia punctilobula</i>    | Eastern hay-scented fern    |
| <i>Diphasiastrum digitatum</i>      | Fan clubmoss                |
| <i>Dryopteris intermedia</i>        | Evergreen wood fern         |
| <i>Huperiza lucidula</i>            | Shining clubmoss            |
| <i>Lycopodium clavatum</i>          | Common clubmoss             |
| <i>Onoclea sensibilis</i>           | Sensitive fern              |
| <i>Osmundastrum cinnamomeum</i>     | Cinnamon fern               |
| <i>Polypodium virginianum</i>       | Rock polypody               |
| <i>Polystichum acrostichoides</i>   | Christmas fern              |
| <i>Spinulum annotinum</i>           | Common interrupted clubmoss |
| <b>Fungus</b>                       |                             |
| <i>Sarcoscypha austriaca</i>        | Scarlet elf cup             |
| <b>Lichen</b>                       |                             |
| <i>Umbilicaria mammulata</i>        | Smooth rock tripe           |

## Appendix 2: Confirmed Wildlife Species List

Species documented through direct observation, track, sign, or camera-trap detection.

\*=non-native

|                           |                          |
|---------------------------|--------------------------|
| <b>Class Mammalia</b>     |                          |
| <i>Canis latrans</i>      | Coyote                   |
| <i>Castor canadensis</i>  | North American beaver    |
| <i>Erethizon dorsatum</i> | North American porcupine |
|                           | Mouse                    |
| <i>Lepus americanus</i>   | Snowshoe hare            |



|                                 |                            |
|---------------------------------|----------------------------|
| <i>Lontra canadensis</i>        | North American river otter |
| <i>Lynx rufus rufus</i>         | Eastern bobcat             |
| <i>Neogale frenata</i>          | Long-tailed weasel         |
| <i>Neogale vison</i>            | American mink              |
| <i>Odocoileus virginianus</i>   | White-tailed deer          |
| <i>Ondatra zibethicus</i>       | Muskrat                    |
| <i>Pekania pennati</i>          | Fisher                     |
| <i>Procyon lotor</i>            | Raccoon                    |
| <i>Sciurus carolinensis</i>     | Eastern gray squirrel      |
| <i>Sylvillagus floridanus</i> * | Eastern cottontail         |
| <i>Tamiasciurus hudsonicus</i>  | American red squirrel      |
| <i>Urocyon cinereoargenteus</i> | Gray fox                   |
| <i>Ursus americanus</i>         | American black bear        |
| <i>Vulpes vulpes</i>            | Red fox                    |

| Class Aves                   |                           |
|------------------------------|---------------------------|
| <i>Accipiter striatus</i>    | Sharp-shinned Hawk        |
| <i>Actitis macularius</i>    | Spotted Sandpiper         |
| <i>Aegolius acadicus</i>     | Northern Saw-whet Owl     |
| <i>Agelaius phoeniceus</i>   | Red-winged Blackbird      |
| <i>Aix sponsa</i>            | Wood duck                 |
| <i>Anas crecca</i>           | Green-winged Teal         |
| <i>Anas platyrhynchos</i>    | Mallard                   |
| <i>Anthus rubescens</i>      | American Pipit            |
| <i>Archilochus colubris</i>  | Ruby-throated Hummingbird |
| <i>Ardea herodias</i>        | Great Blue Heron          |
| <i>Baeolophus bicolor</i>    | Tufted Titmouse           |
| <i>Bombycilla cedrorum</i>   | Cedar Waxwing             |
| <i>Bonasa umbellus</i>       | Ruffed grouse             |
| <i>Botaurus lentiginosus</i> | American Bittern          |
| <i>Branta canadensis</i>     | Canada Goose              |
| <i>Buteo platypterus</i>     | Broad-winged Hawk         |
| <i>Cardellina canadensis</i> | Canada Warbler            |
| <i>Cardinalis cardinalis</i> | Northern cardinal         |

|                                |                         |
|--------------------------------|-------------------------|
| <i>Cathartes aura</i>          | Turkey Vulture          |
| <i>Catharus fuscescens</i>     | Veery                   |
| <i>Catharus guttatus</i>       | Hermit thrush           |
| <i>Certhia americana</i>       | Brown Creeper           |
| <i>Charadrius vociferus</i>    | Killdeer                |
| <i>Colaptes auratus</i>        | Northern Flicker        |
| <i>Columba livia</i>           | Rock Pigeon             |
| <i>Corvus brachyrhynchos</i>   | American crow           |
| <i>Corvus corax</i>            | Common raven            |
| <i>Cyanocitta cristata</i>     | Blue jay                |
| <i>Dolichonyx oryzivorus</i>   | Bobolink                |
| <i>Dryobates pubescens</i>     | Downy Woodpecker        |
| <i>Dryocopus pileatus</i>      | Pileated Woodpecker     |
| <i>Dumetella carolinensis</i>  | Gray Catbird            |
| <i>Empidonax alnorum</i>       | Alder Flycatcher        |
| <i>Empidonax minimus</i>       | Least Flycatcher        |
| <i>Falco sparverius</i>        | American Kestrel        |
| <i>Gallinago delicata</i>      | Wilson's Snipe          |
| <i>Geothlypis philadelphia</i> | Mourning Warbler        |
| <i>Geothlypis trichas</i>      | Common Yellowthroat     |
| <i>Haemorhous purpureus</i>    | Purple Finch            |
| <i>Hirundo rustica</i>         | Barn Swallow            |
| <i>Hylocichla mustelina</i>    | Wood Thrush             |
| <i>Junco hyemalis</i>          | Dark-eyed junco         |
| <i>Leiothlypis peregrina</i>   | Tennessee Warbler       |
| <i>Leiothlypis ruficapilla</i> | Nashville Warbler       |
| <i>Leuconotopicus villosus</i> | Hairy Woodpecker        |
| <i>Lophodytes cucullatus</i>   | Hooded merganser        |
| <i>Megaceryle alcyon</i>       | Belted Kingfisher       |
| <i>Meleagris gallopavo</i>     | Wild turkey             |
| <i>Melospiza georgiana</i>     | Swamp Sparrow           |
| <i>Melospiza melodia</i>       | Song Sparrow            |
| <i>Mniotilta varia</i>         | Black-and-white Warbler |
| <i>Molothrus ater</i>          | Brown-headed Cowbird    |



|                                  |                              |
|----------------------------------|------------------------------|
| <i>Pandion haliaetus</i>         | Osprey                       |
| <i>Parkesia noveboracensis</i>   | Northern Waterthrush         |
| <i>Passerculus sandwichensis</i> | Savannah Sparrow             |
| <i>Passerella iliaca</i>         | Fox Sparrow                  |
| <i>Phalacrocorax auritus</i>     | Double-crested Cormorant     |
| <i>Pheucticus ludovicianus</i>   | Rose-breasted Grosbeak       |
| <i>Piranga olivacea</i>          | Scarlet Tanager              |
| <i>Poecile atricapillus</i>      | Black-capped chickadee       |
| <i>Quiscalus quiscula</i>        | Common Grackle               |
| <i>Regulus calendula</i>         | Ruby-crowned Kinglet         |
| <i>Regulus satrapa</i>           | Golden-crowned Kinglet       |
| <i>Sayornis phoebe</i>           | Eastern Phoebe               |
| <i>Scolopax minor</i>            | American Woodcock            |
| <i>Seiurus aurocapilla</i>       | Ovenbird                     |
| <i>Setophaga americana</i>       | Northern Parula              |
| <i>Setophaga caerulescens</i>    | Black-throated Blue Warbler  |
| <i>Setophaga castanea</i>        | Bay-breasted Warbler         |
| <i>Setophaga coronata</i>        | Yellow-rumped warbler        |
| <i>Setophaga fusca</i>           | Blackburnian Warbler         |
| <i>Setophaga magnolia</i>        | Magnolia Warbler             |
| <i>Setophaga pensylvanica</i>    | Chestnut-sided Warbler       |
| <i>Setophaga petechia</i>        | Yellow Warbler               |
| <i>Setophaga pinus</i>           | Pine Warbler                 |
| <i>Setophaga ruticilla</i>       | American Redstart            |
| <i>Setophaga tigrina</i>         | Cape May Warbler             |
| <i>Setophaga virens</i>          | Black-throated Green Warbler |
| <i>Sialia sialis</i>             | Eastern Bluebird             |
| <i>Sitta canadensis</i>          | Red-breasted Nuthatch        |
| <i>Sitta carolinensis</i>        | White-breasted nuthatch      |
| <i>Sphyrapicus varius</i>        | Yellow-bellied Sapsucker     |
| <i>Spinus pinus</i>              | Pine Siskin                  |
| <i>Spinus tristis</i>            | American Goldfinch           |
| <i>Spizella passerina</i>        | Chipping Sparrow             |

|                               |                        |
|-------------------------------|------------------------|
| <i>Strix varia</i>            | Barred Owl             |
| <i>Sturnus vulgaris</i>       | European Starling      |
| <i>Tachycineta bicolor</i>    | Tree Swallow           |
| <i>Toxostoma rufum</i>        | Brown Thrasher         |
| <i>Tringa solitaria</i>       | Solitary Sandpiper     |
| <i>Troglodytes aedon</i>      | Northern House Wren    |
| <i>Troglodytes hiemalis</i>   | Winter wren            |
| <i>Turdus migratorius</i>     | American Robin         |
| <i>Tyrannus tyrannus</i>      | Eastern Kingbird       |
| <i>Vireo gilvus</i>           | Warbling Vireo         |
| <i>Vireo olivaceus</i>        | Red-eyed Vireo         |
| <i>Vireo philadelphicus</i>   | Philadelphia Vireo     |
| <i>Vireo solitarius</i>       | Blue-headed Vireo      |
| <i>Zenaidura macroura</i>     | Mourning Dove          |
| <i>Zonotrichia albicollis</i> | White-throated sparrow |

## Appendix 3: Introduced Non-native Plant Habitat Suitability Modeling - Technical Description

To perform habitat suitability modeling for non-native invasive plants, we compiled occurrence records for Morrow's honeysuckle and European buckthorn from the Global Biodiversity Information Facility (GBIF) and then cleaned the georeferenced datasets and treated these as presence-only observations. Nineteen bioclimatic predictors (BIO1–BIO19) were obtained from WorldClim at 2.5 arc-minute resolution. For each species, environmental layers were cropped to a spatial extent defined by occurrence coordinates and expanded by 25% to reduce edge effects. In the absence of true absence data, 1,000 pseudo-absence points per species were randomly sampled from the environmental background and combined with presence records to construct binary response datasets. Climate variables were extracted at all sampling locations, and data were partitioned into training and testing subsets using stratified 5-fold cross-validation. Species distribution models were then fitted using generalized linear models (GLMs) with a binomial error distribution and logit link, incorporating all bioclimatic variables as predictors. Model performance was evaluated on withheld data, and classification thresholds were selected by maximizing sensitivity and specificity.

Model outputs were projected onto current climate conditions to generate continuous habitat suitability surfaces and corresponding binary maps. Future suitability was estimated using downscaled projections from CMIP6 under the SSP2-4.5 scenario for 2061–2080 (MPI-ESM1-2-HR), with predictor variables aligned to the current dataset. To assess invasion risk within the EFUD property boundary, a management-area shapefile was reprojected to



match the raster coordinate system and used to crop and mask model outputs. Occurrence points were intersected with the EFUD boundary to quantify on-site observations, and predicted suitability values were extracted for points within the boundary where applicable. All spatial processing, modeling, and visualization were conducted in R using the terra, geodata, and predicts packages and ArcGIS Pro.

Results from the habitat suitability model indicate that the EFUD property is classified as suitable under present and future predicted climatic conditions for the establishment of Morrow's honeysuckle and European buckthorn. Predicted suitability values within the property exceeded the species-specific thresholds (0.091 for Morrow's honeysuckle; 0.711 for European buckthorn), based on the maximum sensitivity–specificity criterion.

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