Hardwick Ecological Inventory

Prepared for the Hardwick Conservation Commission

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Prepared by

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Executive Summary

In 2023 the Hardwick Conservation Commission and Town of Hardwick initiated a town-wide ecological, or natural resources, inventory. Local ecological consultant Matt Peters was retained to conduct the work. The goals of the study are to provide information supporting municipal land use planning, in particular, to enhance knowledge and understanding of some of the most ecologically significant places in Hardwick, and to help residents better enjoy and steward their place. The project helps the Hardwick Conservation Commission, established in 2019, fulfill their mission to "establish community responsibility for Hardwick's natural resources". Funding came from an award of American Rescue Plan Act (ARPA) funds from the Town of Hardwick. Substantial volunteer work by Hardwick Conservation Commission members and other community members was essential to this effort. I greatly thank Commission members, participating landowners, and town officials. The study began in early 2023 and ended in April 2024 with field studies during summer and fall of 2023.

The study process involved gathering and analyzing existing geographic and ecological data, maps, and imagery to map and describe forest blocks, and identify and prioritize the best sites for field studies, in a process known as landscape analysis. Conservation Commission members then contacted owners of priority properties to obtain permission for field studies, which only proceeded where permission was granted. Field studies focused on identifying natural communities of state and local significance, and other significant and sensitive features.

Other aspects of the project emphasized public education and engagement. These included a public kick-off presentation at the town office that provided an opportunity to incorporate local knowledge, as well as a concluding presentation of project findings. Two public field walks were well attended at sites of diverse ecological interest. One trip explored Cooper Brook and the nearby toe slopes of Buffalo Mountain from the Atkins Field, while the other explored the Lamoille River floodplain forests below the falls in East Hardwick. Site visits also often involved landowners providing opportunities for mutual knowledge sharing.

The landscape analysis yielded 38 forest blocks with potentially ecologically significant features. Also known as habitat blocks, the forest blocks encompass most of the larger areas of natural habitat in Hardwick, providing valuable perspectives for land use planning and habitat connectivity. These blocks total about 16,218 acres or about 65% of Hardwick, with the remainder of Hardwick's nearly 25,000 acres being in some form of highly human-altered land use. Though a few blocks are less than 100 acres or more than 1,000 acres, most are a few hundred acres in extent (range 22 to 2,162 acres). Blocks of greatest importance for large-scale habitat connectivity and wildlife movement, including Buffalo and Jeudevine Mountain blocks, are briefly highlighted. More extensive description is provided for blocks that had field study.

Twenty-six of the forest blocks were prioritized for their potential to contain ecologically significant features and became the focus of landowner permissions and field inventory. Among these higher priority forest blocks, there were about 170 parcels of particular interest with 145 different ownerships. Conservation Commission members and others used a combination of phone, email, in person, and postal mail outreach to seek permission for field work. Of the 145 ownerships, 39 granted permission (including municipal lands), 19 denied permission, and 87

did not respond or could not be contacted. Only the properties with landowner permission or public access were considered for field studies.

During the summer and fall of 2023 I conducted rapid ecological assessment fieldwork at 15 forest blocks where permission was obtained, including 32 properties in parts of most higher priority blocks. Many additional properties for which permission was obtained went unvisited due to time constraints. These provide ample opportunities for additional follow-up work and doubtless contain additional features of ecological significance. Field studies resulted in documentation of numerous new features of state and/or local ecological significance, such as exemplary natural communities and rare species, including features at every visited block. When combined with pre-existing data 18 of the blocks now have documented features of state or local ecological significance. The remaining twenty blocks have received little if any field study and many have strong potential for additional significant features.

Wetlands are abundantly and widely scattered across the Hardwick landscape, contributing disproportionately to biodiversity and habitat values, as well as to ecosystem services benefiting humans, such as water purification and flood mitigation. Compilation of existing state wetland maps with wetland natural communities mapped during this study, reveals that wetlands span around 1,356 acres or 5.4% of Hardwick. Of these, 1,128 acres (4.5% of Hardwick) are currently mapped by the Vermont Significant Wetlands Inventory and protected as significant under the state Wetland Rules; unmapped wetlands are also protected if they provide similar functions and values to mapped VSWI wetlands. Updated wetland mapping with substantially improved accuracy and comprehensiveness is currently being developed by the Vermont Department of Environmental Conservation's (VT DEC) Wetlands Program and should be available in 2025.

Natural communities are interacting assemblages of organisms, their physical environment, and the natural processes that affect them, making them excellent tools for understanding, managing, and conserving important aspects of our natural heritage. Out of Vermont's 120 currently recognized natural community types and variants about 32 are found in Hardwick, including 22 wetland types and 10 upland types. Eighteen of these are considered rare to uncommon at the state level, including 15 wetland and 3 upland types.

As a result of this study, the number of known natural community types of state-level significance in Hardwick increased from 1 to 8, and the number of State-Significant natural community sites or 'occurrences' increased from 1 to 14. Twenty-five additional locally-significant occurrences of 12 more natural community types were also documented, for a total of 39 state and/or locally significant occurrences of 20 natural community types. These include 17 wetland and 3 upland community types and are widely dispersed throughout the town. Natural community highlights from this study include an unusual abundance and quality of uncommon Northern White Cedar Swamp and Northern White Cedar Seepage Forest natural communities, several rare Boreal Floodplain Forest areas and other rare and uncommon riverside communities, and a large Northern Hardwood Talus Woodland on Buffalo Mountain.

Rare and uncommon plants and animals are unique and important parts of Hardwick's natural heritage. Prior to this study, the Hardwick landscape was known to support 6 total occurrences of 5 rare or uncommon species, with no state-listed Threatened or Endangered species. As a result

of this study, including compiling sensitive species (rare, Threatened, Endangered, and uncommon) from sources other than Vermont's Natural Heritage Inventory, there are now about 77 documented occurrences of 47 known rare or uncommon species (28 rare and 19 uncommon species) documented in some fashion. Two new state-Threatened plant species where found, Bog Wintergreen (*Pyrola asarifolia*) and Marsh Horsetail (*Equisetum palustre*), though the latter is proposed for delisting. Among these 47 sensitive species there are 23 vascular ('higher') plants, 16 nonvascular plants (mosses & liverworts), 5 invertebrate animals, and 3 vertebrate animals. About half (24) of these sensitive species are primarily associated with wetlands and aquatic features, underscoring the importance of these areas for biodiversity.

Thirty-three of the 47 rare and uncommon species were seen during this study, while others are based on records dating back as much as a century to 1924. Other highlights among newly documented rare species include the discovery of the tiny Four-Toothed moss (*Tetrodontium brownianum*) in talus on Buffalo Mountain. Newly found in Vermont at several sites in 2023, this cryptic moss was only historically known from New England. Hardwick boasts New England's only currently known populations of regionally rare Grove Hawthorn (*Crataegus lucorum*), known from early successional habitats near the Lamoille River. Many of the rare and uncommon plants are associated with calcareous or enriched habitats that can at least partially be attributed to underlying calcareous Waits River Formation bedrock.

Finally, generalized management recommendations are presented to enhance stewardship of the many significant features found during this ecological inventory, and additional suggestions for follow-up work are outlined.

As revealed through this study, Hardwick hosts myriad unique and ecologically important natural features, from vast forest blocks of Northern Hardwood Forest to the tiniest rare mosses. Through improved knowledge provided here, the Hardwick community can continue to wisely use, manage, conserve, and celebrate this diverse and exciting natural heritage.

Figure 1. Tuttle Pond.

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Introduction

This report summarizes the results of a town-wide ecological, or natural resources, inventory for Hardwick, VT. The goal of the study is to enhance knowledge and understanding of some of the most ecologically significant places in Hardwick, to provide information supporting municipal land use planning, and to help residents better enjoy and steward their place. The study focused on identifying natural communities of state and local significance, and other significant and sensitive features, thus helping the Hardwick Conservation Commission, established in 2019, fulfill their mission to "establish community responsibility for Hardwick's natural resources". The study was funded with an award of American Rescue Plan Act (ARPA) funds from the Town of Hardwick. Substantial volunteer work by Hardwick Conservation Commission members was essential to this effort. I greatly thank Commission members, participating landowners, and town officials. The study commenced in January 2023 and concluded in March 2024 with the bulk of field studies occurring during summer and fall of 2023.

Landscape Context

Nestled in the upper Lamoille River watershed, Hardwick's nearly 25,000-acre landscape of low to moderate elevation hill country sits at the edge of the Northeast Kingdom offering a unique blend of agrarian countryside, broad fertile floodplains, expansive hilltop fields, moist, conifer cloaked valleys, rugged hardwood hills, and secluded swamps. As we try to understand the patterns on the land, why and where natural communities, plants, animals and other creatures are, as well as why and where farms, villages and roads are, understanding the broader landscape context and underlying features of the land is often helpful. This section attempts to provide that context by broadly reviewing and synthesizing a number of 'layers' of the landscape including bedrock, soils, topography, hydrology, and land use history.

Hardwick straddles the boundary between the Northern Green Mountains and the Northern Vermont Piedmont biophysical regions, a boundary that follows Route 14 north and south through town and beyond. Biophysical regions are large areas, nine in the state, of broadly similar climate, landforms, and physical landscape attributes. Here, the climate is typically cool and moist, leading to a predominance of Northern Hardwood Forest Formation natural communities with little or no presence of oak, hickory or other associated species of warmer regions like the lower Connecticut River or Champlain valleys. While all of Hardwick can be characterized as low to moderate elevation hill country cut by numerous small stream valleys – the definition of 'piedmont' terrain – the western third has higher, somewhat more rugged terrain, particularly on Buffalo and Jeudevine Mountains, revealing the affinity with the core of the Northern Green Mountain region to the west. The Northern Vermont Piedmont region spans east from Hardwick to the Connecticut River valley and from southern Orange County north to the Canadian border, excepting the Northeastern Highlands.

In this study, the Hardwick landscape is further divided into three physiographic regions – Western Hills, Eastern Hills, and the Lamoille Valley Bottomlands (Figure 2) – which are largely synonymous with the state biophysical regions, but split out the main valley bottom landforms as worthy of separate recognition. These regions are largely defined by geology and topography,

which in turn influence many other ecological characteristics, as well as land use history and settlement patterns. This makes them a useful framework for understanding landscape patterns.

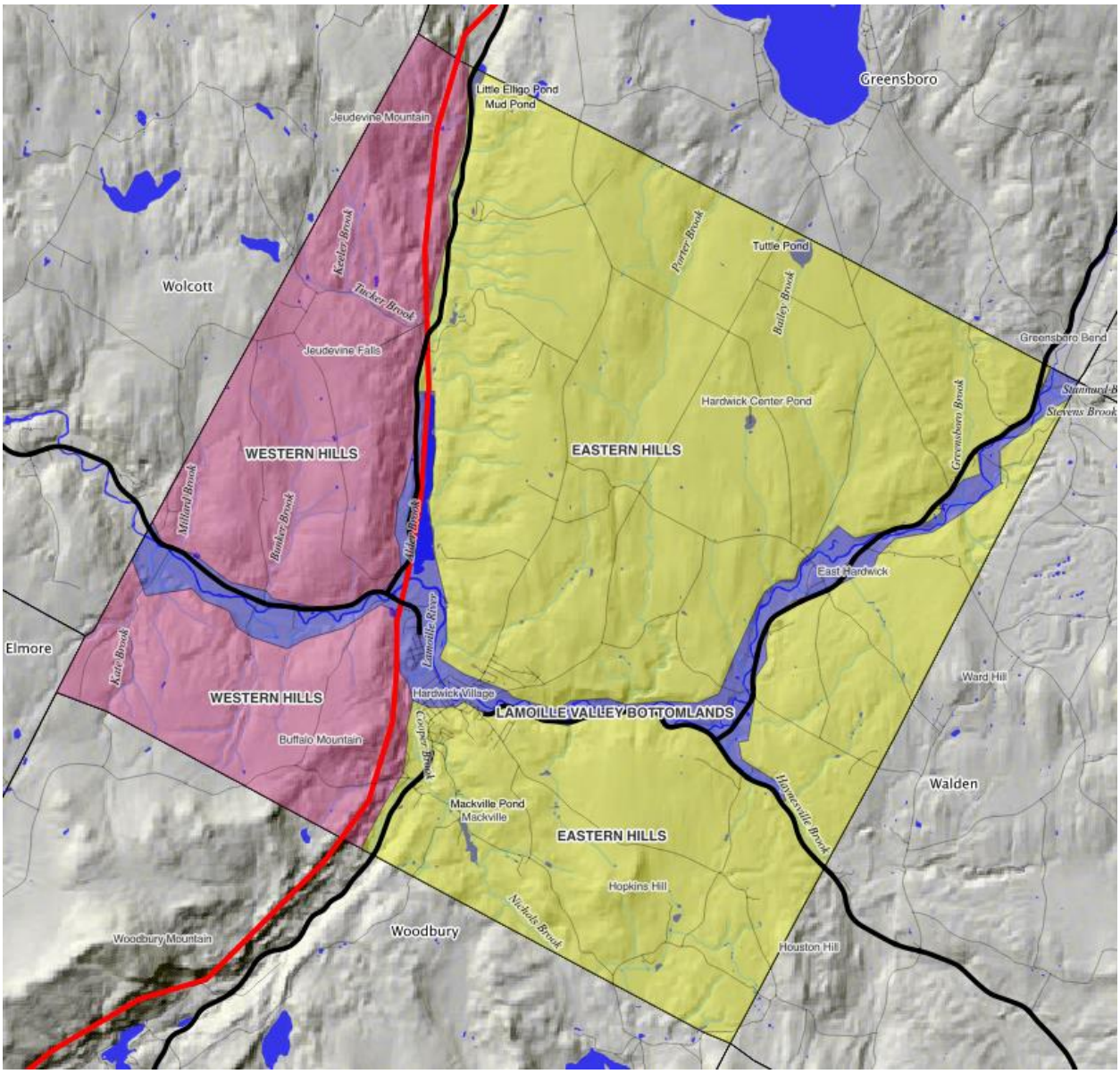

Figure 2. Physiographic Regions of Hardwick, VT.

Red line indicates biophysical region boundary.

The Eastern Hills lie east of Route 14 spanning a region of mostly broad, gentle slopes cut by numerous small stream valleys. This region is underlain by metamorphic rocks of the Waits River and Northfield Formations that are about 420-million-year-old ocean bottom sediments that were compressed and folded by ancient continental collisions. These rocks are somewhat younger, softer, and less acidic than those of the Western Hills. The Waits River Formation rocks that underlie the eastern half of Hardwick, include bands of brownish marble-like rock that is richer in important plant nutrients, especially calcium, that directly relate to both the presence of

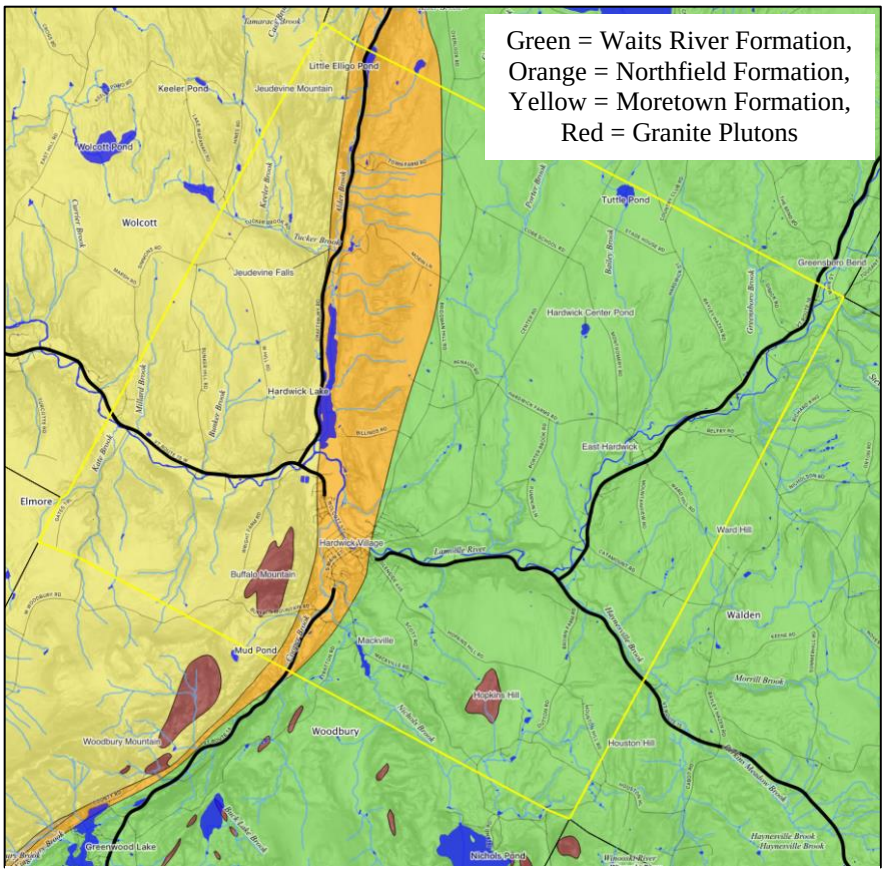

Figure 3. Bedrock Geology of Hardwick, VT.

distinctly 'enriched' natural communities and more favorable soils for agriculture. Consequently, Hardwick's cedar swamps, enriched fens, rich hardwood forests, and most of the active agricultural land outside the Lamoille Valley, lie mainly in this region.

The Western Hills rise sharply along the west side of Route 14, more or less following the biophysical region boundary and a large-scale geologic feature known as the Richardson Memorial Contact, which runs from Newport to Northfield. This feature is perhaps most dramatically expressed through Hardwick and Woodbury, where the steep, ledgy escarpment provides sharp definition to Woodbury, Buffalo and Jeudevine Mountains and results in numerous waterfalls, including the striking Jeudevine Falls. Moretown Formation bedrock underlying the Western Hills is nearly 100 million years older than that to the east, is more acidic and harder, hence the more rugged landforms and somewhat higher elevations. Ecologically, this translates into not only waterfalls and ledges, but scattered talus woodlands, vernal pools, and less intensive land use that leaves larger blocks of unfragmented forestland. Both Western and Eastern Hills regions are punctuated by bodies of granitic rocks known as plutons, that form the cores of Buffalo Mountain and Hopkins Hill. These plutons are ancient bodies of magma that pushed up into overlying rocks derived from ocean bottom sediments roughly 400 million years ago, cooled and hardened, and then were subsequently exposed through geologic uplift and erosion.

The Lamoille Valley Bottomlands are just that, a roughly tenth- to half-mile wide ribbon of valley bottom terrain flanking the Lamoille River through the full width of the town. This loosely mapped region encompasses the current river channel, active floodplains, higher terraces, and toe slopes. It is perhaps best defined by its soils, which, unlike the predominantly glacial till soils of the other regions, are a mixture of recent riverine deposits and sediments deposited roughly 10,000-12,000 years ago into the glacial lakes that once filled the Lamoille valley. These geologic and hydrologic origins result in a region of flatter topography and water-sorted stone-free soils that are in large part highly conducive to agriculture and other human uses. Most of the concentrated settlements of Hardwick and East Hardwick villages are within this region. Sand

and gravel pits dot the periphery of the region, highlighting the pattern of glacial outwash deposits that formed deltas in Glacial Lake Winooski. This massive water body once filled the Winooski and Lamoille River valleys and major tributaries to above East Hardwick, crosscutting the town into four discontinuous land masses (Figure 4). Correspondingly, this region has been the most intensively used and is the most altered from natural conditions, but continues to foster many unique and important ecological attributes not found in other parts of the town.

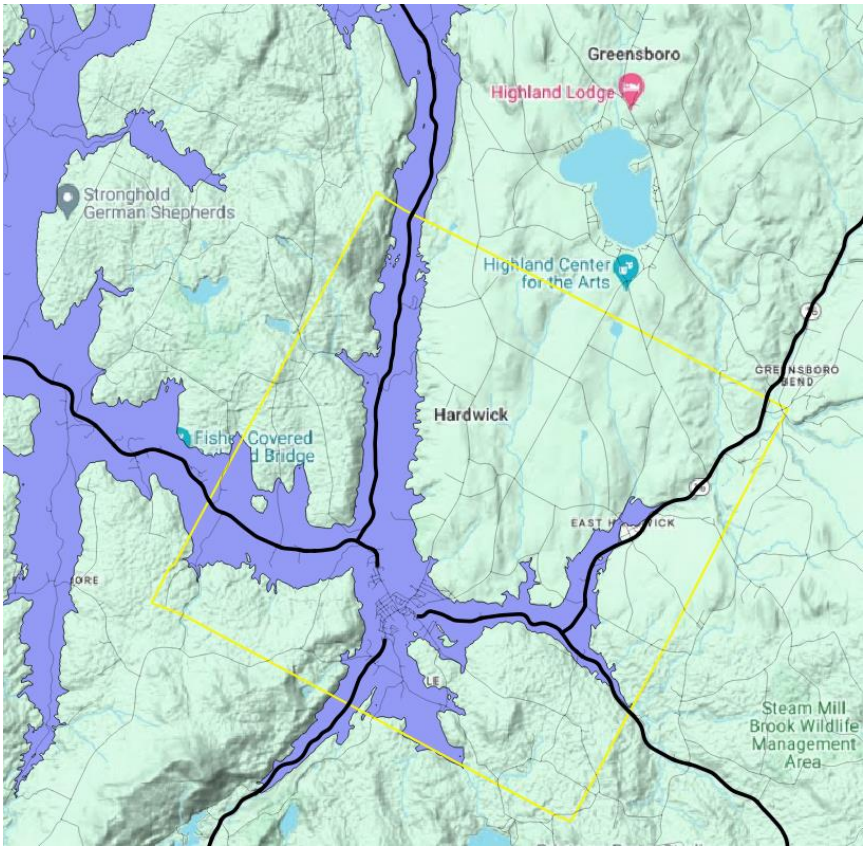

Figure 4. The upper reaches of Glacial Lake Winooski bisecting Hardwick.

Some of the noteworthy landscape features of Hardwick are familiar, while others are well hidden, though not necessarily far from roads. Notable hills include Buffalo and Jeudevine Mountains and Hopkins Hill, while the many other hills referenced by road names are broad and less well-defined elevated regions. These include West, Bunker, Slapp, Bridgman, Houston, and Ward hills, the last two of these with their highest points just east of Hardwick. The highest elevation in Hardwick is 1,836ft at the summit of Jeudevine Mountain along the northwestern town boundary, while the lowest elevation is 770ft where the Lamoille River exits town to the west. Virtually the entire town lies within the upper Lamoille River watershed, itself within the Lake Champlain Basin. The exception is a very small sliver of the north slope of Jeudevine Mountain, which drains toward the Black River and Lake Memphremagog. Apart from the Lamoille River, the drainage network consists of many small headwater streams referred to as brooks, including Millard, Bunker, Tucker, Keeler, Alder, Porter, Bailey, and Greensboro Brooks north of the Lamoille River, and Stannard, Stevens, Haynesville, Nichols, Cooper, and Kate Brooks south of the Lamoille River, as well as numerous smaller, unnamed streams on either side. Alder, Porter, Bailey, Greensboro, Stannard, Haynesville, and Cooper Brooks are the

largest among these tributaries, though some have only short sections in town. Hardwick has few named ponds. Tuttle and Hardwick Center Ponds are hidden gems lying tucked away, largely out of sight among folds of the land, while Little Elligo Pond, straddling the Greensboro town line in the Alder Brook valley, is readily seen along Route 14. Hardwick Lake and Mackville Pond, both artificial impoundments, make up the remaining major waterbodies, though there are myriad other small, unnamed waterbodies, mainly beaver ponds and artificial ponds. Hardwick also has noteworthy waterfalls, both of which once fueled industry in the area. Jeudevine Falls is the large, scenic, cascading lower reach of Tucker Brook as it tumbles down to join Alder Brook just above Hardwick Lake. The village of East Hardwick surrounds a somewhat hidden, cascading falls on the Lamoille River, just below the Main Street bridge.

As already alluded to, the land use history varies substantially across Hardwick's landscape and is an important force overlying the enduring aspects of geology, soils, and topography. Like most of Vermont, Hardwick's landscape was substantially more open even 50 years ago, and certainly 150 years ago. The rugged slopes of Buffalo and Jeudevine Mountains, as well as parts of some of the large cedar swamps are perhaps the areas least influenced by past and present human activities. While reforestation and agricultural abandonment have allowed native species to return to greater portions of the landscape, the signs of past use remain hidden in the forests, from old field white pines and wet pasture grown to dense cedar seepage to the old stone walls and granite quarries.

Methods

Landscape analysis and ecological field surveys are the core methods used in this project, and were followed by data processing and documentation to produce the final report, maps, and data products. The landscape analysis process involves gathering and analyzing existing information from a variety of databases and information sources to remotely identify features of interest and prioritize areas for fieldwork. Information sources included public geographic base data such as bedrock, soils, hydrologic, topographic, and wetland maps; aerial imagery; and vernal pool and natural heritage databases for rare and uncommon species and natural communities. This information was compiled in a GIS (geographic information system) platform to facilitate analysis and mapping. Local knowledge can also be an important information source for studies of this nature and was gathered through targeted interviews with a few individuals. I also reviewed the growing network of online biodiversity data sources to find crowd-sourced observations and museum specimen information relevant to the study. In particular, I reviewed online database records of ~330 plant specimens collected in Hardwick (CNABH 2023, CNH 2023, SERNEC 2023), as well as about 2,500 iNaturalist.org observations from the town. These were useful sources of information yielding additional rare plant and invertebrate sites and leads on natural communities of interest (albeit amid a large volume of common species observations).

The primary output of the landscape analysis process in this study was a map of forest blocks created by manual (visual) review of the entire Hardwick landscape. Forest blocks, also known as habitat blocks, are defined primarily by continuous forest and other natural vegetation cover unfragmented by roads (class 3 or better), agricultural fields, or other development. While very useful in their own right for land use planning and thinking about habitat connectivity, in this study the forest blocks were mainly used as 'bins' to group or cluster information about finer-

scale potentially ecologically significant features, which could then be prioritized for field studies. This forest block list, annotated with descriptive information and prioritized for field studies, is presented in Appendix B, and guided landowner contacts and resulting field studies. It also provides terse description for forest blocks not discussed in more detail elsewhere in the body of this report. Landowner information for sites of interest was compiled from statewide parcel maps with associated Grand List data. This was provided to Hardwick Conservation Commission members who contacted owners of priority parcels to ask permission to visit their land. I visited only priority areas where landowner permission was obtained.

Field inventory efforts involved documenting the ecological characteristics of sites via a walking route designed to capture the diversity of landscape features and natural communities of interest. Waypoint and track information was recorded using a smartphone-based GPS receiver. Extensive field notes were recorded characterizing the sites, including species composition, vegetation structure, natural community type, soils, and any rare species encountered. Natural community classification follows the current Vermont classification, *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont* (Thompson et al. 2019), and their assessment or ranking follows established protocols of the Vermont Natural Heritage Inventory (VNHI) of the Vermont Fish and Wildlife Department. Rare species searched for included those considered rare or uncommon on current state lists (VNHI 2022a, 2022b), particularly the "Rare and Uncommon Native Vascular Plants of Vermont" list and the comparable nonvascular plant list, "Vermont Bryophyte List" (Allard 2024).

Inventory Results

Forest Blocks

As described in the Methods section, landscape analysis is the process of remotely examining the entire Hardwick landscape in GIS mapping software as it is represented by the aforementioned geographic base data. This process yielded a set of 38 forest blocks, also known as habitat blocks, that encompass the larger areas of unfragmented natural habitat in Hardwick, providing valuable perspectives for land use planning and thinking about habitat connectivity. Habitat connectivity refers to the capacity for plants, animals, and other species to move across the land including both short- and long-range movements of plants and animals over differing time spans, both short-term seasonal migrations or dispersal and long-term species movements in response to stresses such as climate change. These blocks are shown and numbered in Figure 5 below.

The 38 mapped forest blocks total about 16,218 acres or about 65% of Hardwick, with the remainder of Hardwick's nearly 25,000acres being in some form of highly human-altered land use. Though a few blocks are less than 100 acres or more than 1,000 acres, most are a few hundred acres in extent (range 22 to 2,162 acres). These blocks are predominantly forested with smaller areas of naturally open wetlands, since these are the predominant natural vegetation types of Hardwick, and most of temperate eastern North America. Agricultural, open, and developed areas also have ecological and natural resource values, but they are typically lower and/or different from that of natural habitats and are not the focus of this study. Blocks 15, 20, 21, and 33 do include substantial open/agricultural land, but are included here because they encompass a unique larger riverine floodplain/valley bottom landform of highest ecological significance (i.e., the Lamoille Valley Bottomlands region) for which there are no undisturbed

examples in town. (Note this is a significant departure from state-produced forest block mapping, which is focused solely on habitat connectivity.)

Not surprisingly given the town's topography, the three largest forest blocks, each over 1,000 acres, are those anchored by Buffalo (#31) and Jeudevine Mountains (#38) as well as the block spanning the slopes east of Hardwick Lake (#2). When looking beyond Hardwick's boundaries this perspective changes somewhat (see https://anrmaps.vermont.gov/websites/BioFinder4/). The Buffalo Mountain block (#31) is part of the massive, nearly 30,000-acre Woodbury Mountain forest block that stretches south to Wrightsville Reservoir and west to Route 12, making it by far the largest to include parts of Hardwick. The Jeudevine Mountain block (#38) is part of a 9,000+acre block reaching well into Craftsbury and Wolcott and also includes blocks 34 and 36, elevating their importance for habitat connectivity. Blocks 24, 25, 27, and 29 are individually rather small and fragmented within Hardwick, but are all connected through Woodbury, Cabot, and Walden in a single, nearly 11,000-acre block of much greater importance than suggested by the lands in Hardwick alone. Much of the rest of Hardwick's landscape has gentle topography suitable for agriculture and development which has resulted in a moderately high degree of forest fragmentation, with smaller sized blocks often of highly irregular shape. More extensive analysis of habitat blocks through the lens of habitat connectivity and wildlife movements is desirable and would further support town planning around Act 171 requirements, but is beyond the scope of this study. Map data for the forest blocks used in this study accompanies this report in the shapefile "Hardwick_ForestBlocks.shp".

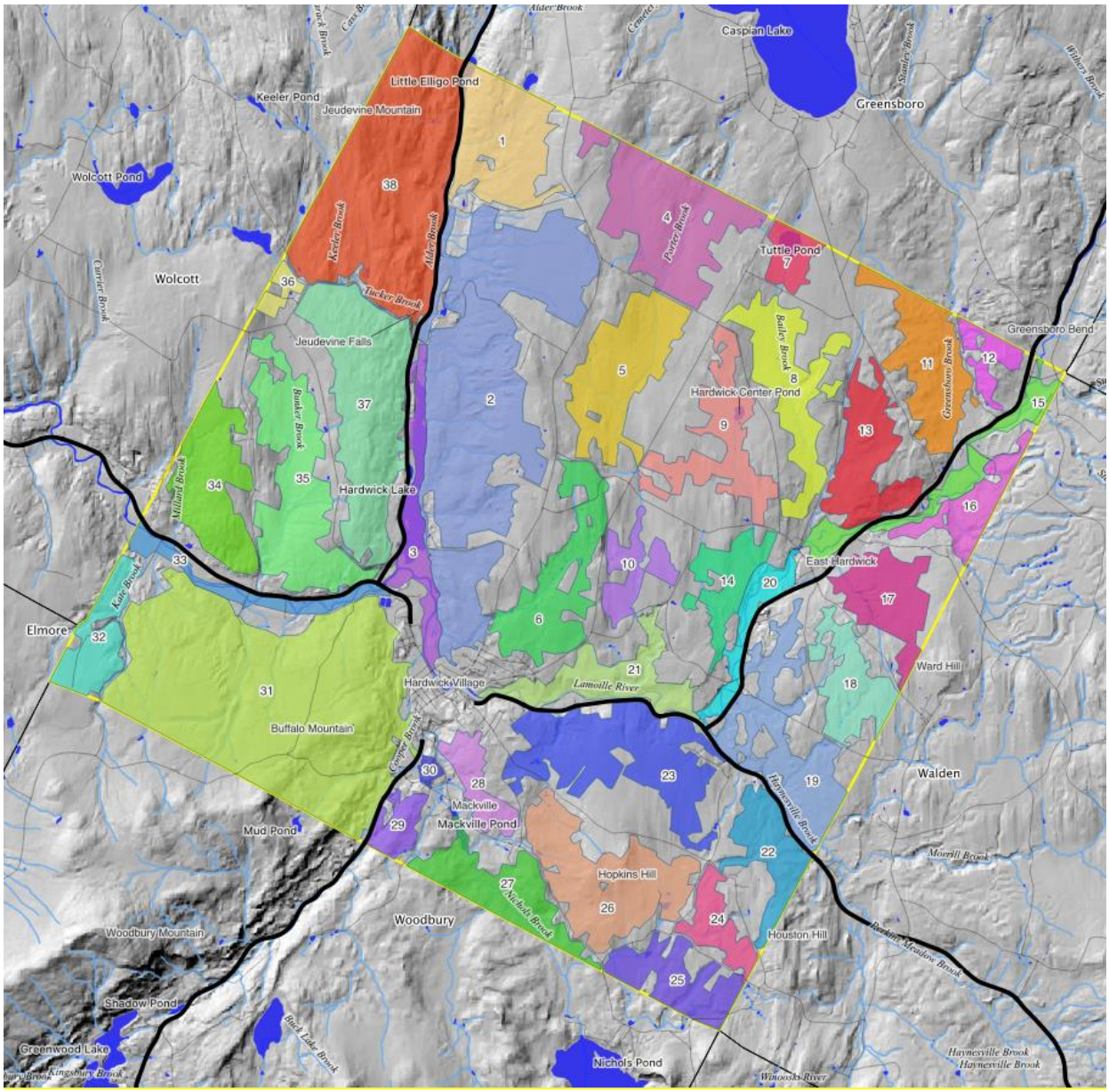

Figure 5. Forest Blocks of Hardwick, VT.

See Appendix B for block details based on remote landscape analysis, referenced by the block number labels. Blocks are numbered clockwise from the northern corner of town.

Landscape Analysis and Site Prioritization

The primary use of forest blocks in this study was to group information about finer scale landscape features supporting prioritization for field studies. The preliminary information about known or suspected ecologically significant features in each block is summarized in the Potentially Significant Forest Blocks List in Appendix B. The list and Figure 5 map can be easily cross-referenced using the block numbers and the list information is also provided in the attributes of the forest block shapefile.

The 38 forest blocks were prioritized for fieldwork mainly based on the likelihood of containing ecologically significant features, particularly state or locally significant natural communities. Secondarily, the prioritization sought to sample the diversity of the town's landscape in limited time. Twenty-six blocks were rated high to medium priority and became the focus of landowner permissions and field inventory. The remaining twelve blocks were rated medium-low to low priority and were not a focus of further effort at this time, though they may still harbor significant features. The Potentially Significant Forest Blocks List is an important resource going forward, as it provides comprehensive coverage of the town, including areas not visited in this study, and offers guidance for further fieldwork.

Landowner Outreach and Permissions

Among the lands encompassed by the 26 higher priority forest blocks, there were about 170 parcels of particular interest with 145 different ownerships. Note that not all parts of a priority block were of interest for field studies. Conservation Commission members graciously undertook the substantial effort of reaching out to the majority of these landowners through a combination of phone, email, in person, and postal mail outreach to obtain permission for field work. Johanna Laggis also graciously assisted in outreach for landowner permissions. Of the 145 ownerships, 39 granted permission (including municipal lands), 19 denied permission, and 87 did not respond or could not be contacted. Only the properties with landowner permission or public access were considered for field studies.

Other dimensions of this project supported project goals for public education and engagement with the town's natural heritage and the natural resource inventory. These included a public kick-off presentation at the town office that provided an opportunity to incorporate local knowledge of interesting features into the landscape analysis while informing people of the project goals. Two public field walks to sites of diverse ecological interest were offered and were well attended. One trip explored Cooper Brook and the nearby toe slopes of Buffalo Mountain near the Atkins Field, while the other explored the Lamoille River floodplain forests just below the falls in East Hardwick. Site visits also frequently involved landowners either directly in field visits or in related discussions, providing opportunities to mutually share knowledge about their places.

Field Inventory Overview

During the summer and fall of 2023 I conducted fieldwork at 15 forest blocks where permission was obtained, as shown in Figure 6. Site visits encompassed parts of 12 of the 13 highest priority blocks, 2 of 6 medium-high priority blocks, no medium and one lower priority block. The higher priority blocks not visited lacked permissions for areas of greatest interest. Site visits encompassed parts of 32 properties. Many additional properties for which permission was obtained went unvisited due to time limitations. These provide ample opportunities for additional follow-up work and doubtless contain additional features of ecological significance.

Field studies for this project resulted in documentation of many new features of state and/or local ecological significance, including features at every visited block. Table 1 summarizes the presence of state or locally significant ecological features at each block, as identified through field studies and the landscape analysis process (i.e., prior data). Sixteen of the forest blocks now have documented features of state-level ecological significance and two additional blocks have features of local-level significance. The remaining twenty blocks have received little if any field

study and many have strong potential for additional significant features based on remote analysis. The Vermont Agency of Natural Resources defines State-Significance as including all occurrences of rare, Threatened, or Endangered plant or animal species; and rare and/or exemplary natural communities. Further explanation of rarity ranking and State-Significance guidelines are provided in Appendix A. Locally significant features similarly include uncommon species, natural communities, and other landscape features that add important ecological diversity to the town, but that do not rise to State-Significance (or in a few cases are features other than species or natural communities that do not fit into the framework for State-Significance). These state and locally significant natural communities and rare or uncommon species are discussed further in the following summary sections and are described in more detail in the Forest Block Descriptions.

While this study presents important advances in our knowledge of ecologically significant features in Hardwick, it is important to note that the information presented here represents only what has been discovered to date and is not a complete inventory of the entire town. It is very likely that additional significant natural communities and rare species populations occur but are not yet known and await discovery!

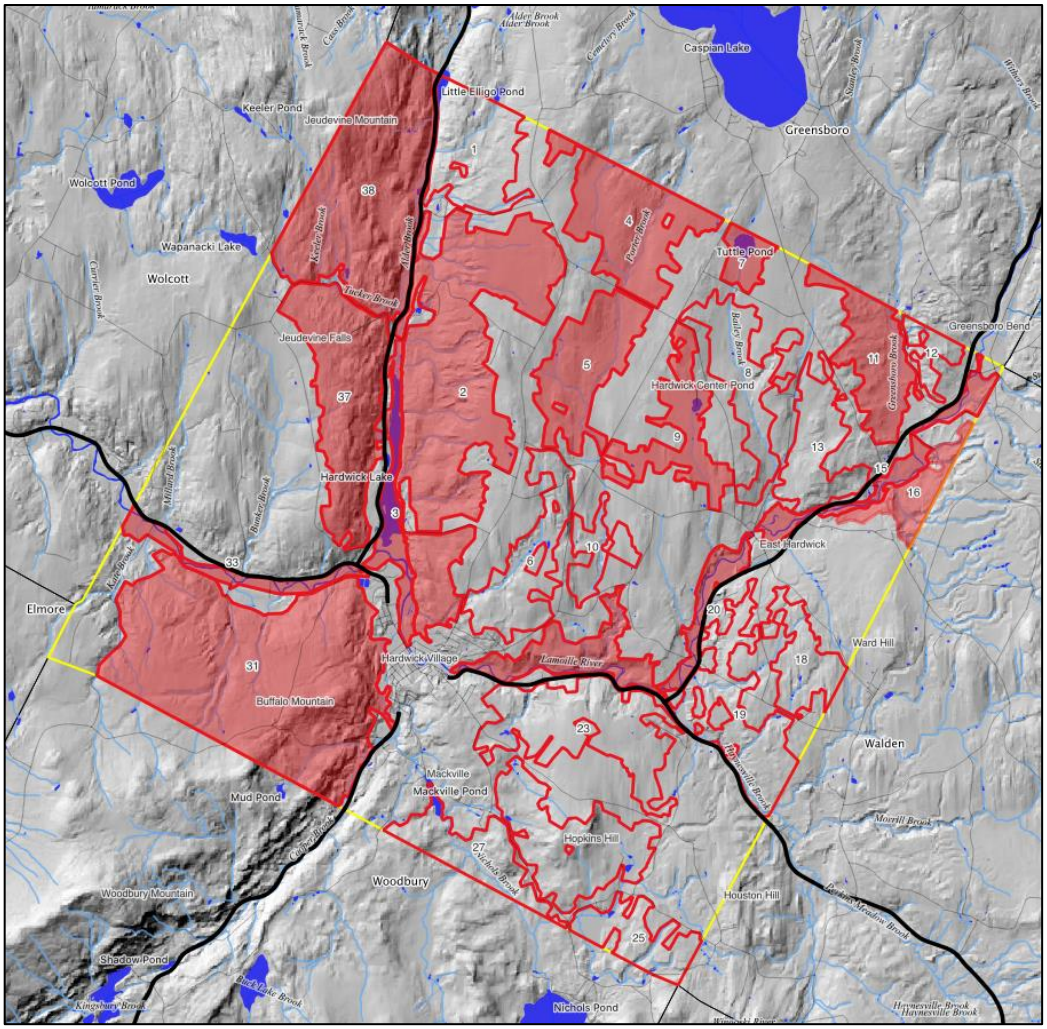

Figure 6. Visited forest blocks (pink) and higher priority forest blocks (red outline).

Table 1. Hardwick Ecological Inventory forest blocks with known state and locally significant features*.

Highlighted blocks have at least one confirmed State-Significant feature.

Block #	Block Name	Priority	2023 Visit	Nat Comm Significance	Rare Species Significance
1	Little Elligo Pond East Slope	MH	No	State Pot'l	None Known
2	Hardwick Lake Eastern Slopes	MH	Yes	Local	Local
3	Hardwick Lake & Lamoille River Village Reach	H	Yes	None Known	State
4	Bridgman Hill	H	Yes	State	State Pot'l
5	Hardwick Center North Woods	MH	Yes	State	State
6	Hardwick Center South Woods	MH	No	None Known	None Known
7	Tuttle Pond Woods	H	Yes	State	State
8	Bailey Brook Woods	M	No	None Known	None Known
9	Hardwick Center Pond Woods	H	Yes	State	State
10	Porter Brook Middle Reach	MH	No	None Known	None Known
11	Greensboro Brook Woods	H	Yes	State	State
12	West of the Bend Woods	M	No	None Known	None Known
13	Bailey Hazen Woods	M	No	None Known	None Known
14	Woods West of East Hardwick	L	No	Local	None Known
15	Lamoille River Bottomlands: Upstream Reach	H	Yes	State	State
16	Walden Line Woods	L	Yes	Local	State
17	Ward Hill Woods	L	No	None Known	None Known
18	Dows Crossing Woods	M	No	None Known	None Known
19	Haynesville Brook Woods	M	No	None Known	State Pot'l
20	Lamoille River Bottomlands: Haynesville to East Hardwick Reach	H	Yes	State	State
21	Lamoille River Bottomlands & Porter Brook Confluence	H	Yes	Local	State
22	Houston Hill North	LM	No	None Known	None Known
23	Hopkins Hill North Slope	M	No	None Known	None Known
24	Houston Hill West	LM	No	None Known	None Known
25	Hardbury Swamp & Hills	H	No	State	State Pot'l
26	Hopkins Hill	MH	No	None Known	None Known
27	Mackville Pond & Nichols Brook Woods	M	No	None Known	State
28	Mackville North Woods	L	No	None Known	None Known
29	Cooper Brook Flats	LM	No	None Known	None Known
30	Nichols Brook Gorge and Cooper Brook Confluence	LM	No	None Known	None Known
31	Buffalo Mountain and Kate Brook East	H	Yes	State	State

Block #	Block Name	Priority	2023 Visit	Nat Comm Significance	Rare Species Significance
32	Kate Brook West	L	No	None Known	None Known
33	Lamoille River Bottomlands: Lower Reach	H	Yes	None Known	State
34	Millard Brook Slopes	L	No	None Known	None Known
35	Bunker Brook Slopes	LM	No	None Known	None Known
36	Wolcott Pond Woods	L	No	None Known	None Known
37	Hardwick Lake West Slope	H	Yes	State	State
38	Jeudevine Mountain	H	Yes	Local	State

* Note that only currently known or highly likely (Pot'l) features are included here – additional undocumented features (often noted in Appendix B Prioritized Block List) are very likely to be present in many additional blocks where none are currently known. See Appendix A for definitions of State-Significance.

Natural Communities Overview

Natural communities are interacting assemblages of organisms, their physical environment, and the natural processes that affect them, making them excellent tools for understanding, managing, and conserving important aspects of our natural heritage, even those such as fungi, insects, and soil microbes that we know relatively little about.

While comprehensive natural community mapping of Hardwick was far beyond the scope of this study, some generalizations and patterns are evident. Out of 120 currently recognized natural community types and variants in Vermont (Thompson et al. 2019), about 32 are found on the Hardwick landscape, including 22 wetland types and 10 upland types (Table 2). Eighteen of these natural community types are considered rare to uncommon at the state level, including 15 wetland and 3 upland types. Hardwick's natural communities are primarily those of the Northern Hardwood Forest and Spruce-Fir-Northern Hardwood Forest Formations and associated wetland types. Communities of warmer regions, such those of the Oak-Pine-Northern Hardwood Formation, as well as those of higher elevations, are absent. Indeed, trees typical of warmer regions, such as oaks and hickories, are virtually absent, limited to only scattered planted red oaks and their locally naturalized progeny, such as on the riverbank near Hay's Service Station.

Some broader natural community patterns align neatly with the three physiographic regions discussed previously (Figure 2). Northern Hardwood Forests are present throughout town, but are by far the most extensive and dominant on Buffalo and Jeudevine Mountains in the Western Hills, likely a product of their more rugged, well-drained topography, thinner soils, and slightly higher elevations, along with the limitations these factors placed on land use history. These low mountains also appear to have virtually the only major cliff, outcrop, talus, and ledge areas in town, with other bedrock exposures being mainly limited to Hopkins Hill and scattered outcrops in river and stream banks. Though most have not been field-verified yet, it appears that natural Vernal Pools are also restricted to the more rugged, ledgy topography of the Western Hills region. Conversely, enriched wetland systems, especially Northern White Cedar Seepage Forests and Northern White Cedar Swamps, are much more abundant in the Eastern Hills region. This can be seen as a consequence of the underlying calcareous Waits River Formation bedrock, gentler topography, and extensive groundwater seepage hydrology. Riparian, or stream-side,

natural communities are, of course, most extensive in the Lamoille Valley Bottomlands region, though many also follow up smaller streams in the other regions. Floodplain forest natural communities typical of larger rivers, such as Silver Maple-Ostrich Fern Floodplain Forest and Sugar Maple Floodplain Forest, though reduced to tiny traces of their past presence, are restricted to this region.

Other towns in the area that have been similarly studied, especially Calais, Woodbury, Cabot (Peters 2016, 2017, 2020), Marshfield (Peters and Engstrom 2023), and Plainfield (Engstrom 2016) share many of the "rich" natural community types found in Hardwick, including cedar wetlands, fens, and Rich Northern Hardwood Forests. This is largely due to their shared, limy Waits River Formation bedrock geology. Nevertheless, each town has its own unique qualities and differences, such as the marked abundance of cedar wetlands and Boreal Floodplain Forests in Hardwick. Further discussion of natural community patterns is found in the following two sections.

Table 2. Natural Communities of Hardwick, VT*

Natural Community Type	State Rarity Rank
WETLANDS	
Alluvial Shrub Swamp	S3 - Uncommon
Boreal Floodplain Forest	S2 - Rare
Silver Maple-Ostrich Fern Floodplain Forest	S3 - Uncommon
Sugar Maple Floodplain Forest	S2 - Rare
River Cobble Shore	S2 - Rare
River Mud Shore	S3 - Uncommon
River Sand or Gravel Shore	S3 - Uncommon
Hemlock Seepage Forest (variant of NHSF)	S3 - Uncommon
Hemlock-Balsam Fir-Black Ash Seepage Swamp	S4 - Common
Northern Hardwood Seepage Forest	S3 - Uncommon
Northern White Cedar Seepage Forest	S3 - Uncommon
Northern White Cedar Swamp	S3 - Uncommon
Red Maple-Black Ash Seepage Swamp	S4 - Common
Red Spruce-Cinnamon Fern Swamp	S3 - Uncommon
Alder Swamp	S4 - Common
Sweet Gale Shoreline Swamp	S3 - Uncommon
Intermediate Fen	S2 - Rare
Sedge Meadow	S4 - Common
Shallow Emergent Marsh	S4 - Common
Cattail Marsh	S4 - Common
Woodland Seep	S4 - Common
Vernal Pool	S3 - Uncommon

Natural Community Type	State Rarity Rank
UPLANDS	
Hemlock Forest	S4 - Common
Hemlock-Northern Hardwood Forest	S5 – Very Common
Northern Hardwood Forest	S5 – Very Common
White Pine-Northern Hardwood Forest (NHF variant)	S5 – Very Common
Red-Spruce-Northern Hardwood Forest	S5 – Very Common
Rich Northern Hardwood Forest	S4 - Common
Lowland Spruce-Fir Forest	S3 - Uncommon
Northern Hardwood Talus Woodland	S3 - Uncommon
Temperate Acidic Cliff	S4 - Common
Erosional River Bluff	S2 - Rare

*Includes all observed and expected types - a few additional types are possible but excluded here as unconfirmed.

Wetlands

Wetlands are abundantly and widely scattered across the Hardwick landscape. Most of Hardwick's wetlands are modest in size and collectively they cover only a small part of the landscape. However, they contribute disproportionately to biodiversity and habitat values, as well as to ecosystem services for humans, such as water purification, supply, and flood mitigation. This makes wetlands particularly important features to protect for their diverse public benefits.

Compilation of existing state wetland maps, including the Vermont Significant Wetlands Inventory (VSWI) and Wetlands Advisory maps, plus wetland natural communities mapped during this study's fieldwork, reveals that wetlands span around 1,356 acres or 5.4% of Hardwick. Of these, 1,128 acres (4.5% of Hardwick) are currently mapped (VSWI) and protected as significant under the state Wetland Rules. Currently unmapped wetlands are also protected if they provide similar functions and values to mapped VSWI wetlands.

Updated wetland mapping with substantially improved accuracy and comprehensiveness is currently being developed by the Vermont Department of Environmental Conservation's (VT DEC) Wetlands Program with planned availability in 2025. Consequently, the total mapped wetland area is likely to increase somewhat when the new, more comprehensive maps are released. It is important to note that any map changes simply represent better mapping rather than a change in either the legal protected status of wetlands or the actual occurrence of wetlands on the landscape.

With the exception of Hardwick Lake's marshes, most of Hardwick's wetlands appear to have groundwater seepage or riverine processes as their main hydrologic drivers. Enriched wetland types are prevalent, particularly in the Eastern Hills, where they are often tied to calcareous Waits River Formation bedrock. Northern White Cedar Seepage Forests and Northern White Cedar Swamps are especially prevalent enriched wetland natural community types, and can often be noted at a distance while driving by the distinctive forms and color of their dominant trees, northern white cedar and taller white spruce.

These are both Uncommon (S3) natural community types at a state level, but are locally particularly abundant in Hardwick, Greensboro, and Craftsbury. The reason for this abundance of cedar is not fully clear, but it is at least in part related to the calcareous bedrock, coupled with widespread low gradient slopes on soils derived from dense glacial till. Such soils, especially Cabot series soils, resist deep infiltration of water and tend to promote groundwater seepage at the surface, which, in circumneutral pH soils, is very conducive to northern white cedar growth.

Figure 7. Locally abundant Northern White Cedar Seepage Forest along Porter Brook.

Significant Natural Communities

Locating state and locally significant natural community occurrences was a primary focus of this study as a means to identifying the most ecologically significant and sensitive places in Hardwick. The process of evaluating State-Significance follows standard protocols developed by the Vermont Natural Heritage Inventory and requires field studies to document a mapped feature. In brief, State-Significant occurrences are discrete areas of a given natural community type that display a combination of quality, landscape context, size, and rarity sufficient to be ranked as significant in a state level perspective. Thus, they are areas that are exceptional for their intact ecological processes, biodiversity, and physical makeup. Additional protocol details can be found in Appendix A. Determination of local significance applies these same concepts at a local scale and is based on professional judgement.

Figure 8 and Tables 3 & 4 provide a generalized map and summary of the known significant natural community occurrences for Hardwick, combining field data from this study with previously documented occurrences. Prior to this study, there was just one documented State-Significant natural community occurrence, a Northern White Cedar Swamp known as Hardbury Swamp, straddling the Hardwick/Woodbury town line. This study added 13 State-Significant occurrences of 7 additional types, as well as an additional 25 locally significant occurrences and 12 additional types. Thus, in total, there are now 14 known State-Significant occurrences of 8 natural community types, and 39 locally significant occurrences of 20 types (note locally significant occurrences include all State-Significant occurrences). These include 17 wetland and 3 upland natural community and feature types. Of the locally significant features, three types (4 features) are not part of the state's natural community classification system, but are nevertheless at least locally significant features in my judgment. These include two kettle ponds, a glacial esker, and a waterfall. Mapping and occurrence ranking data for the newly documented significant natural communities are provided as polygons in the shapefile "Hardwick_SigNatComs.shp".

Figure 8. State and Locally Significant Natural Communities of Hardwick, VT.

Only State-Significant features are called out with labels.

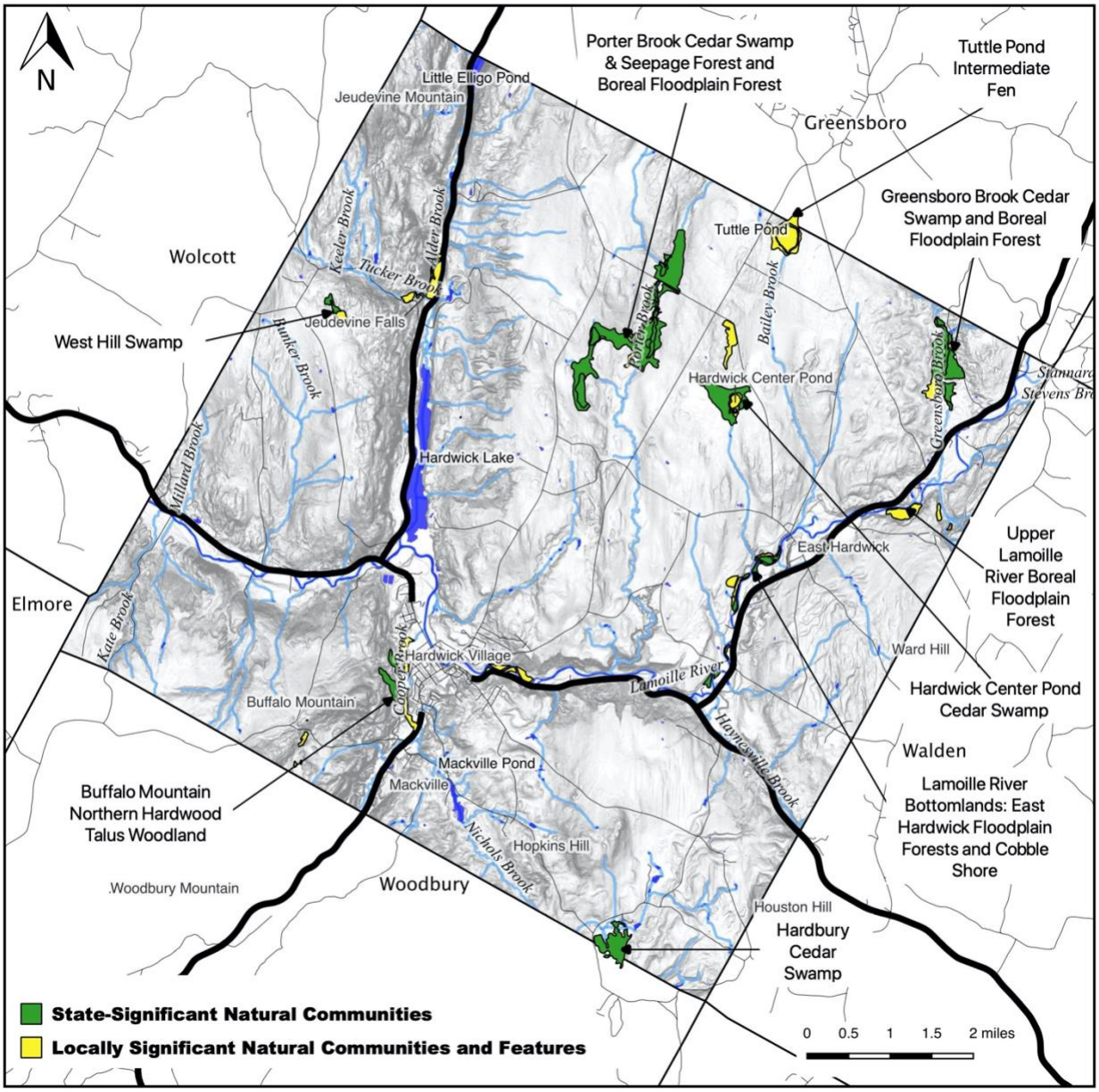

Table 3. Known State and Locally Significant Natural Communities of Hardwick.

See Appendix A for State Rank (S rank) and significance determination details. S1= very rare, S2= rare, S3= uncommon, S4-S5= common to very common, NR= Not Ranked - indicating novel types not part of the VT natural community classification system.

Natural Community Type	State Rarity Rank	Total Acres	Average Size (ac)	# of State-Significant Sites	# of Locally-Significant Sites*
WETLANDS					
Alluvial Shrub Swamp	S3	24.2	6.1		4
Boreal Floodplain Forest	S2	46.0	11.5	4	4
Successional Floodplain Forest	NR	10.4	10.4		1
Hemlock Seepage Forest (variant of NHSF)	S3	0.8	0.8		1
Hemlock-Balsam Fir-Black Ash Seepage Swamp	S4	5.0	5.0	1	1
Intermediate Fen	S2	4.9	2.5	1	2
Kettle Pond	NR	25.0	12.5		2
Northern Hardwood Seepage Forest	S3	0.5	0.5		1
Northern White Cedar Seepage Forest	S3	192.3	38.5	1	5
Northern White Cedar Swamp	S3	142.0	28.4	4	5
Red Spruce-Cinnamon Fern Swamp	S3	0.8	0.8		1
River Cobble Shore	S2	1.8	1.8	1	1
Sedge Meadow	S4	12.9	12.9		1
Sugar Maple Floodplain Forest	S2	0.5	0.5	1	1
Sweet Gale Shoreline Swamp	S3	3.6	3.6		1
Vernal Pool	S3	0.1	0.0		2**
Waterfall	NR	0.9	0.9		1
UPLANDS					
Glacial Esker	NR	4.6	4.6		1
Northern Hardwood Talus Woodland	S3	17.3	8.6	1	2
Rich Northern Hardwood Forest	S4	17.2	8.6		2
TOTALS		**510.9**		**14**	**39**

* Count includes all State-Significant sites since they are also locally significant.
** 5 additional potential Vernal Pools, likely of at least local significance, have been mapped by the VT Vernal Pool Mapping Project but remain to be verified and assessed with site visits.

All of the state and locally significant natural communities occur as small to medium-sized patches (<1 acre to ~140 acres) scattered throughout the landscape. The majority of these are wetlands or aquatic features, plus a few Rich Northern Hardwood Forests, a talus woodland, and a glacial esker. Most of Hardwick's more extensive large-patch or matrix-forming upland forest communities, such as Northern Hardwood Forest, Hemlock-Northern Hardwood Forest, or

Lowland Spruce-Fir Forest do not appear to be State-Significant, mainly due to a combination of fragmentation (i.e., smaller size) and management/ land use history (but see discussion of the Buffalo Mountain Northern Hardwood Forest in that block description below). Most of the significant features are rare (S2) or uncommon (S3) natural community types such as Boreal Floodplain Forest, cedar swamps and seepage forests, or Intermediate Fen, but some are more common types (S4), such as Hemlock-Balsam Fir-Black Ash Seepage Swamp or Sedge Meadow, that have sufficient size, quality of condition, and surrounding landscape context to be exemplary at state or local levels. Further discussion of the individual State-Significant natural community occurrences is provided in the **Forest Block** descriptions below.

Table 4. State-Significant Natural Communities Known in Hardwick, VT.

Site Name	Natural Community Type	State Rarity Rank	Acres	EO Rank
Hardbury Swamp	Northern White Cedar Swamp	S3	33.9	B
Tuttle Pond	Intermediate Fen	S2	4.2	C
Hardwick Center Pond	Northern White Cedar Swamp	S3	39.7	B
Porter Brook	Northern White Cedar Seepage Forest	S3	140.2	B
Porter Brook	Boreal Floodplain Forest	S2	15.2	B
Porter Brook	Northern White Cedar Swamp	S3	17.3	C
Greensboro Brook	Northern White Cedar Swamp	S3	46.8	B
Greensboro Brook	Boreal Floodplain Forest	S2	15.1	B
Upper Lamoille River	Boreal Floodplain Forest	S2	0.5	C
Lamoille River Bottomlands: East Hardwick	Sugar Maple Floodplain Forest	S2	0.5	C
Lamoille River Bottomlands: East Hardwick	Boreal Floodplain Forest	S2	15.3	B
Lamoille River Bottomlands: East Hardwick	River Cobble Shore	S2	1.8	C
West Hill	Hemlock-Balsam Fir-Black Ash Seepage Swamp	S4	5.0	B
Buffalo Mountain	Northern Hardwood Talus Woodland	S3	14.5	B

Rare Species

Rare and uncommon plants and animals are unique and important parts of Hardwick's natural heritage. Many, but not all, rare species are associated with the high-quality habitats and natural communities that were the main focus of this project; others can be associated with human activities that mimic certain natural disturbances or ecological processes. Plants and animals can be rare for a variety of reasons. Some are rare because of direct impacts from human activities, such as habitat destruction or illegal collection, while others are rare because they have very particular habitat needs that cannot be met across most parts the landscape. Others have life

cycles that make them particularly vulnerable, and still others remain mysteries whose rarity we don't really understand. Regardless of the reason, they warrant recognition, consideration, and protection where they exist. While this study presents important advances in our knowledge of rare species in Hardwick, it is important to note that the information presented here represents only what has been discovered to date and is not, by any means, a complete inventory of the entire town. It is almost certain that additional rare species and sites occur that are not yet known and await discovery!

The rarity of plants and animals is expressed through state rarity ranks or S Ranks assigned by the Vermont Natural Heritage Inventory (VNHI) in concert with groups of botanical and zoological specialists familiar with Vermont's species. State Threatened and Endangered listings provide additional levels of legal protection for a subset of rare species. Current lists of rare species are available from the Vermont Fish and Wildlife Department's website (e.g., VNHI 2022, Allard 2024).

Prior to this study, the Hardwick landscape was known to support 6 total occurrences of 5 rare or uncommon species, according to the Vermont Natural Heritage Inventory database. None of these are currently listed as state-Threatened or Endangered, though one is under consideration for Federal listing.

During this study numerous additional rare or uncommon species were documented from several information sources. The primary source of these additions was my own fieldwork; however, other sources of historical and recent observations were also useful. Review of recently digitized herbaria (museum collections of dried plants), proved fruitful, along with mining crowd-sourced observations through the iNaturalist platform.

In total there are now about 77 occurrences of 47 known rare or uncommon species (28 rare and 19 uncommon species) documented in some fashion. Two new state-Threatened plant species where found, Bog Wintergreen (*Pyrola asarifolia*) and Marsh Horsetail (*Equisetum palustre*), though the latter is proposed for delisting. Twenty of these are also considered Species of Greatest Conservation Need (SGCN) in the state's Wildlife Action Plan, and four are considered Regionally Rare (Brumback et al. 2013). Of these 47 sensitive species (rare and uncommon) there are 23 vascular ('higher') plants, 16 nonvascular plants (mosses & liverworts), 5 invertebrates, and 3 vertebrates. Table 5 provides a summary of all of these sensitive species including state ranks, legal status, numbers of occurrences (sites), and the year last observed.

Figure 9. State-Threatened Bog Wintergreen (*Pyrola asarifolia*), found in a cedar swamp.

Thirty-three of the 47 rare and uncommon species were observed during this study, while others are

based on records dating back a century to 1924. Fourteen of the records were gleaned from combing through nearly 3,000 observational records documented either through herbaria (CNH 2023) or iNaturalist.org. All of the 16 rare mosses and liverworts are newly documented in Hardwick. Most of these species were found on shores, especially of the Lamoille River, or wet places outside the valley bottom. The rarity of mosses and liverworts is less well understood and their rarity ranks are more likely to change as the state's bryoflora becomes more well known. Many of the rare and uncommon plants are associated with calcareous or enriched habitats that can at least partially be attributed to underlying calcareous Waits River Formation bedrock.

Of special note is the discovery of the tiny Four-Toothed Moss *(Tetrodontium brownianum)* in talus alcoves on Buffalo Mountain. This cryptic and rare moss had never before been found in Vermont before 2023, when I found it at several sites in the northern part of the state. It had not been documented in New England since 1960 (CNABH 2023). Its small size, even for a moss, and general obscurity certainly suggest it is likely overlooked elsewhere, but its discovery is nonetheless significant! Hardwick also boasts New England's only currently known populations of regionally rare Grove Hawthorn (*Crataegus lucorum*), known from early successional habitats near the Lamoille River.

Figure 10. A remarkably tenacious rare plant: this regionally rare Grove Hawthorn (*Crataegus lucorum*) survived the July flood draped in debris, as well as past beaver chewing and ice scour damage.

As shown in Table 5, Hardwick's rare and uncommon animals include 5 invertebrate animals (2 bumblebees, 3 silkmoths) and 3 vertebrate animals. Of particular note, the uncommon Wood Turtle is considered Globally Vulnerable (G3) and is under consideration for Federal listing due to a variety of threats, including illegal collection. While some of these records come from VNHI, many, particularly the showy insects and birds, were documented through iNaturalist. Further mining of crowd-sourced natural history observation platforms might continue to reveal new rare and uncommon species.

About half (24) of the 47 sensitive species - rare, threatened, endangered, and uncommon - documented in Hardwick are primarily associated with wetlands and aquatic features. Given the much, much smaller proportion of wetlands versus uplands in Hardwick's landscape, this emphasizes their importance for biodiversity, both in terms of sensitive species and natural communities.

Table 5. Rare and Uncommon Species of Hardwick, VT.

Green shading indicates species observed during this study. Species in bold have legal protected status as State-Endangered (E) or State-Threatened (T), PDL=proposed for delisting. State ranks indicate state-level rarity, S1= very rare, S2= rare, S3= uncommon, SU= Status uncertain (but presumed rare), G-ranks, when stated, indicate globally rare or vulnerable species, see Appendix A for further details. RR= regionally rare (Brumback et al. 2012), SGCN=Species of Greatest Conservation Need in VT Wildlife Action Plan. Source abbreviations: VNHI= Vermont Natural Heritage Inventory database, CNH= Consortium of Northeastern Herbaria digital herbarium records, C=community member report, HA= Vermont Reptile and Amphibian Atlas ('Herp Atlas'), iNat= iNaturalist.org

Species Name	English Name	State Rarity Rank	VT Status	Other Status	# of Sites	Year Last Seen	Source
VASCULAR PLANTS (wildflowers, ferns, grasses & sedges)							
Acorus americanus	American Sweet-flag	S3?			1	2003	CNH
Botrychium multifidum	Leathery Grapefern	S3			2	1966	CNH
Carex nigra	Black Sedge	S1?			1	2023	VNHI, Peters, C
Carex pseudocyperus	False Cyperus Sedge	S3			1	2023	Peters
Ceratophyllum echinatum	Prickly Hornwort	S2S3			1	2023	Peters
*Crataegus brainerdii**	Brainerd's Hawthorn	SU		RR	1	1966	CNH
Crataegus lucorum	Grove Hawthorn	SU		RR	4	2023	Peters, VNHI, CNH, C
Crepidomanes intricatum	Weft Fern	S2?		RR, SGCN	2	2023	Peters
Eleocharis intermedia	Matted Spikerush	S3			4	2023	Peters
Elymus wiegandii	Wiegand's Wild-rye	S3			1	2023	Peters
Equisetum palustre	**Marsh Horsetail**	**S2S3**	**T - PDL**	**SGCN**	**1**	**2023**	**Peters**
Galium trifidum ssp. trifidum	Small Bedstraw	S3			2	2023	Peters
Homalosorus pycnocarpos	Glade Fern	S3			1	2023	CNH, C, Peters
Liparis loeselii	Loesel's Twayblade Orchid	S3			2	1933	CNH
*Malaxis unifolia**	Green Adder's-mouth Orchid	S2		SGCN	1	1933	CNH
Platanthera obtusata	Small Bog Orchid	S1			1	1924	CNH
Potamogeton obtusifolius	Blunt-leaf Pondweed	S3			2	2023	Peters
Pseudognaphalium macounii	Winged Cudweed	S3			3	2023	Peters
Pyrola asarifolia	**Bog Wintergreen**	**S2**	**T**	**SGCN**	**1**	**2023**	**Peters**
*Spiranthes lacera var. lacera**	Northern Slender Ladies'-tresses	S3			1	1924	CNH
Spiranthes romanzoffiana	Hooded Ladies'-tresses Orchid	S3			1	2023	Peters
Sporobolus neglectus	Small Dropseed	S1?		RR, SGCN	1	2023	Peters
Utricularia minor	Lesser Bladderwort	S3			3	2023	Peters, VNHI
NONVASCULAR PLANTS (mosses & liverworts)							
Apopellia endiviifolia	a liverwort	S2			2	2023	Peters

Species Name	English Name	State Rarity Rank	VT Status	Other Status	# of Sites	Year Last Seen	Source
Dicranella schreberiana	a moss	S2		SGCN	2	2023	Peters
Didymodon fallax	a moss	S2		SGCN	1	2023	Peters
Fossombronia sp.	a liverwort	S2-SH		SGCN	1	?	C
Grimmia muehlenbeckii	a moss	S1		SGCN	1	2023	Peters
Hylocomiastrum pyrenaicum	a moss	S2		SGCN	2	2023	Peters
Hyophila involuta	a moss	S2		SGCN	4	2023	Peters
Marchantia polymorpha ssp. polymorpha	a liverwort	S2		SGCN	1	2023	Peters
Niphotrichum canescens	a moss	S2		SGCN	3	2023	Peters
Physcomitrium immersum	a moss	S1		SGCN	1	2023	Peters
Physcomitrium serratum	a moss	S2S3		SGCN	1	2023	Peters
Pseudotaxiphyllum distichaceum	a moss	S2S3			1	2023	Peters
Riccia huebeneriana ssp. sullivantii	a liverwort	S2		SGCN	2	2023	Peters
Schistostega pennata	Luminous Moss	S2		SGCN	1	2023	Peters
Tetrodontium brownianum	Four-Toothed Moss	S1		T3	1	2023	Peters
Timmia megapolitana ssp. megapolitana	a moss	S2		SGCN	1	2023	Peters
INVERTEBRATE ANIMALS							
Antheraea polyphemus	Polyphemus Silkmoth	S3			2	2023	Peters, iNat
Bombus fervidus	Golden Northern Bumblebee	S2		SGCN, G3G4	1	2021	iNat
Bombus flavidus	Yellowish Cuckoo Bumble Bee	S3			1	2019	iNat
Callosamia promethea	Promethea Silkmoth	S3			2	2022	iNat
Hyalophora cecropia	Cecropia Silkmoth	S3			3	2022	iNat
VERTEBRATE ANIMALS							
Glyptemys insculpta	Wood Turtle	S3		G3, SC, RSGCN, SGCN, Fed. Listing candidate	5	2023	Peters, VNHI, HA, C
Melanerpes carolinus	Red-Bellied Woodpecker	S3			1	2019	iNat
Setophaga tigrina	Cape May Warbler	S1B			1	1988	VNHI

* Occurrence in Hardwick is uncertain: *Crataegus brainerdii* specimen needs review and may actually be a common species (*C. flabellata* or *C. schuettei*); *Malaxis unifolia* and *Spiranthes lacera* specimens are from near the town line possibly actually in Woodbury. Additionally, *Spiranthes casei* is broadly mapped by VNHI slightly into Hardwick, but the actual occurrence is in Greensboro. Several other rare plants (*Asclepias purpurascens, Botrychium simplex, Cladium mariscoides, Conopholis americana, Galium brevipes, Luzula parviflora, Panicum virgatum, Persicaria hydropiperoides*) have been reported by other sources, but I consider the reports dubious and either unlikely/ in need of substantiation, or clearly misidentified, so have not included them (available on request).

Figure 11. A Gallery of Rare Plants, clockwise from upper left: hooded ladies'-tresses (*Spiranthes romanzoffiana*), glade fern (*Homalosorus pycnocarpos*), and the liverworts *Apopellia endiviifolia* and *Riccia huebeneriana*.

Recommendations and Future Work

One of the goals of a natural resource inventory is to provide guidance supporting conservation of the identified significant features through informed management. While the significant features in Hardwick are too numerous to provide individualized management recommendations here, I offer generalized guidance as a starting point, with the primary objective of protecting or improving the ecological condition of the significant features. Appropriate conservation strategies and compatible uses will vary depending on the type of natural community or rare species present. Some need a hands-off approach while others are compatible with a wide range of land management and recreational uses.

Landowners interested in more specific information about significant features documented on their property can reach out to the Hardwick Conservation Commission, the VT Fish and Wildlife Department's Natural Heritage Inventory, and/ or consult the VT Agency of Natural Resources' Natural Resource Atlas [https://anrmaps.vermont.gov/websites/anra5/] or BioFinder [https://anrmaps.vermont.gov/websites/BioFinder4/] interactive maps (Note that state data sets will take some time to update with information from this study).

- Customized, site-specific management recommendations are preferable to generalized guidelines and should be sought whenever possible. The VT Fish and Wildlife Department's Natural Heritage Inventory staff can provide valuable input in this regard.
- Owners of ecologically significant features who are eligible for the state Use Value Appraisal (UVA) or 'Current Use' property tax abatement program may be able to designate Ecologically Significant Treatment Areas (ESTAs) or Reserve Forestland in their UVA management plan to conserve and protect the significant features while expanding forest management options and retaining tax benefits.
- Small patch natural community occurrences, particularly for uncommon to rare types and wetlands, should ideally be treated as passive management areas and have naturally vegetated (typically forest) buffers with minimal disturbance, unless there is a compelling site-specific ecological reason to the contrary (e.g., invasive species control).
- Large-patch and matrix forming natural community types can typically be managed with routine best management practices for forestry operations, though ideally some sections would be set aside or managed with longer rotations to develop older forest conditions, and older 'legacy trees' should be maintained for their habitat and biodiversity benefits.
- Rare species occurrences are typically best left unmanaged unless species or site-specific characteristics suggest otherwise. Making management decisions for these areas should typically involve someone knowledgeable with the particular rare species as well as the site. Some exceptions to passive management might include species that benefit from increased light or soil disturbance for reproduction, or sites that need control of invasives or other ecological restoration activities.
- Controlling invasive species before they become widespread at a site is generally desirable, though not always possible. Typically, control methods creating the least disturbance are preferable to avoid creating new sites of invasive colonization, though

physical treatments (e.g., mechanical removal) are often preferable to chemical treatments to avoid toxic side effects.

- Maintaining and restoring adequate wetland and riparian (streamside) buffer vegetation and preventing further encroachment into river corridors provides important protection for these highly ecologically significant features as well as safeguarding water quality, enhancing habitat connectivity, and protecting riverine processes, such as channel evolution and flood mitigation. Both state and local (Hardwick) regulations bear on buffers and encroachments and should be adhered to.
- Additional inventory at sites and higher priority forest blocks not visited during the 2023 ecological inventory is likely to reveal additional significant features. Table 1 in this report shows which blocks were visited during this study, and Appendix B, the Potentially Significant Forest Blocks List, has information on potentially significant features to look for in each block based on the landscape analysis.
- Several vernal pools, or potential vernal pools, were mapped during this study and previously. Since visits occurred from midsummer into the fall, they could not be fully assessed for state-significance. These "locally significant" vernal pools, along with other 'unverified' potential pools from the statewide Vernal Pool Mapping Project, should be revisited in May to early June to survey amphibian egg masses of vernal pool species. Vernal pools can be assessed using VNHI data forms or through the Vermont Center for Ecostudies "Vermont Vernal Pool Monitoring Project" materials.

Forest Block Descriptions

The following forest block descriptions succinctly summarize the main features of greatest ecological interest at each of the *visited blocks*. Only a portion of each block was visited due to time and access constraints. The blocks are organized in three main landscape or physiographic regions (see Figure 2): Eastern Hills, Western Hills, and Lamoille Valley Bottomlands. Importantly, the blocks NOT discussed here also have important ecological features, both known and unknown. Further study is required to find and document these fully, but preliminary information is presented in the Potentially Significant Forest Blocks List in Appendix B.
* Asterisks after natural community types indicate State-Significant occurrences.

Eastern Hills

This region, lying east of Route 14, encompasses 27 forest blocks that span the eastern two-thirds of Hardwick, excluding the Lamoille Valley Bottomlands. The area has somewhat gentler, lower topography with many long, gradual slopes. It is mostly underlain by somewhat calcareous rocks of the Waits River and Northfield Formations resulting in fertile, if sometimes poorly drained soils. This combination of factors made the region well suited to agriculture and settlement, which has resulted in somewhat smaller, more fragmented and irregularly-shaped forest blocks relative to the Western Hills region. It also gives the region more enriched wetlands, particularly those with abundant northern white cedar (*Thuja occidentalis*).

Hardwick Lake Eastern Slopes #2
Significant Natural Communities: Vernal Pool

This 1,700+ acre forest block spans the slopes rising from the east shore of Hardwick Lake and provides the longest continuous stretch of forest within Hardwick's borders, extending for nearly 4 miles from Hazen Union School north to Town Farm Road. The area is mainly second growth mixed forest with abundant hemlock descending the slope to the Alder Brook valley. Many small, unnamed, roughly parallel stream drainages dissect the slope below expansive Cabot soil flats. Areas of extensive coniferous seepage are present, though some of the largest, perhaps 25 acres in extent were not visited. The area includes important community recreational and educational resources in the Hazen Union sugarbush and Hardwick Trails network. Pockets of localized enrichment are present in the forest and particularly in seepage wetlands.

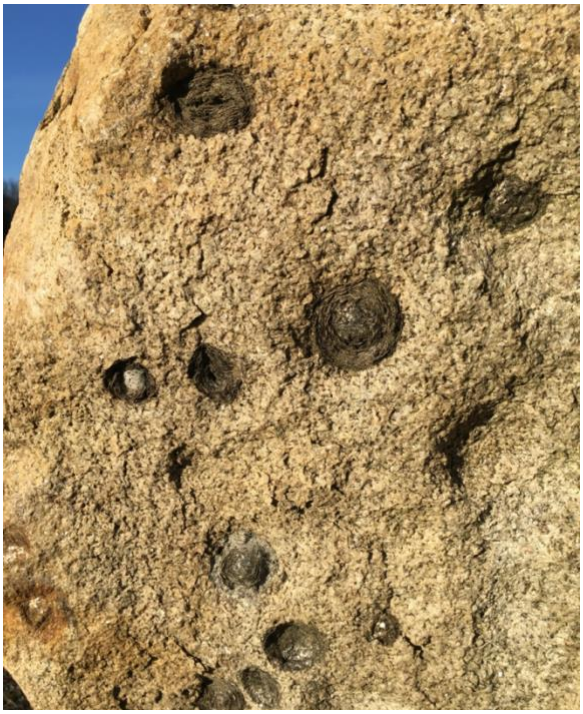

Figure 12. Glacially transported Craftsbury orbicular granite boulders are scattered about the site and town gravel pit.

Unusual Craftsbury orbicular granite glacial erratic boulders are scattered throughout and can occasionally be seen along the trails and at the periphery of the town gravel pit, which also

supports a huge population of the somewhat uncommon plant Winged Cudweed (*Pseudognaphalium macounii*), a colonizer of disturbed soils. There is a mapped Vernal Pool present, which is locally significant, despite being an old manmade impoundment, because it is the only mapped functional vernal pool habitat outside the Western Hills physiographic region. (Though pool breeding amphibians and invertebrates almost certainly find additional habitat in other natural and artificial aquatic and wetland features around town.)

Hardwick Center North Woods #5 and Bridgman Hill #4
Significant Natural Communities: Northern White Cedar Seepage Forest*, Northern White Cedar Swamp*, Boreal Floodplain Forest*

These two forest blocks, separated only by Cobb School Road, are described together here because of shared significant natural community occurrences. These two blocks encompass dense woods and wetlands on gentle slopes and flats flanking the upper 2.5+ miles of Porter Brook, which begins roughly at the Greensboro town line in a series of dense, beaver influenced conifer swamps and seepage forests. Though not fully mapped or explored, these conifer swamps and seepage forests nearly continuously flank the brook for miles making this area home to the largest contiguous wetland complex in town. If fully mapped, it would likely be well over 200 acres in extent, with much of it consisting of seepage forest on sloped ground mapped as Cabot soils.

Secluded, cedar-lined Porter Brook is easily waded across during normal flows, and is subject to intermittent beaver ponding in spots. Yet the brook is large enough to have a narrow floodplain, nicely undercut banks, and surprisingly deep pools that support an abundant population of native brook trout, who make up for their modest size with bold colors and speed. The nearly continuous groundwater seepage inputs from the flanking wetlands likely also play a major role in maintaining the clean, cold waters needed by brook trout. Other wildlife make abundant use of the stream corridor and dark, flanking cedar and spruce woods. Exposed muddy banks offer great tracking for bear, otter, mink, and many others. The narrow floodplain forest system is a State-Significant occurrence of the rare Boreal Floodplain Forest natural community type. The example here has a canopy composition very similar to the flanking Northern White Cedar Seepage Forest, with abundant white cedar, white spruce, and balsam fir, but it occurs on flat alluvial silt deposits

Figure 13. A muddy trackway along Porter Brook with bear, otter, deer, and other tracks.

Figure 14. Rare (S2) Boreal Floodplain Forest community flanking Porter Brook.

subject to flooding, ice scour and other river processes. During site visits, the edges of this community were very obvious because the herbaceous plants were still somewhat flattened by the major July floods. However, other flooding impacts were minimal, and it was clear that this intact riparian system was very resilient to even these major floods. Several brookside cedars were cored revealing trees over 100 years old that must have also survived and massive 1927 flood.

Rising out of the narrow floodplain, the forest is largely still northern white cedar dominated, but in most places shifts to the Northern White Cedar Seepage Forest natural community type, with shallow, mucky, black organic soils on gently sloping terrain. This very large, State-Significant example extends essentially continuously for over 2 miles and in places extends upslope for a half mile away from the brook. Within the vast area of cedar dominated forest there are several flatter sections with deeper accumulated organic soils that constitute State-Significant Northern White Cedar Swamp communities. While the age and condition of both the cedar swamp and cedar seepage forest varies widely across the area, both have sections that are quite old forest with larger diameter cedars and cored trees revealing ages of 150 to 200+ years. Two rare plant species were documented to live within this impressive suite of cedar dominated natural communities. Continued mapping of this important stream and wetland system up and downstream would be valuable to understand its full extent.

In better drained, upland areas of these slopes Lowland Spruce-Fir Forest frequently takes over from the cedar, with a dense mixture of red and white spruce and balsam fir. This community type is also considered uncommon, but the examples visited in Hardwick, frequently along the smaller valley bottoms, generally have extensive management history, are younger and not State-Significant. Small sections of this forest type are included in a locally significant geologic feature just west of Porter Brook. This is a roughly half-mile long, sinuous series of glacial esker deposits. Eskers are remnant signs of glacial rivers that flowed in channels through the ice at the base of the glaciers over 10,000 years ago. These ice channels filled with sand and gravel washing out of the melting ice sheet, and then the surrounding ice melted away leaving 20-30ft tall, raised, snaking ridges visible today. The coarse, well-drained soil of these ridges stands in marked contrast to the surrounding seepage slopes.

Figure 15. Uncommon and State-Significant Northern White Cedar Seepage Forest spans much of the largest wetland complex in town.

Tuttle Pond Woods #7 and Hardwick Center Pond Woods #9
Significant Natural Communities: Northern White Cedar Seepage Forest, Northern White Cedar Swamp*, Intermediate Fen*, Sweet Gale Shoreline Swamp, Glacial Kettle Pond

Tuttle Pond and Hardwick Center Pond (cover image and below) and their surrounding wetlands immediately stood out during the landscape analysis as important sites to visit, and they did not disappoint. Both are beautiful, hidden gems that appear to be undeveloped glacial kettle ponds, ringed by rare and uncommon wetlands that host numerous unusual plants and diverse wildlife. Kettle ponds formed during glacial retreat when large isolated blocks of ice were buried or surrounded by glacial till. The ice blocks then melted, leaving these roughly circular pond basins in the surrounding fairly flat terrain. Over time, the pond basins have filled with sediments and organic matter leaving only shallow waters today. A depth probe of Tuttle Pond revealed the pond basin is nearly 20ft deep and lined by dense blue silt with about 14ft of peat and muck deposits below about 3-7 feet of water. Tuttle Pond forms the head of Bailey Brook while Hardwick Center Pond feeds a smaller unnamed stream. Both streams are direct tributaries to the Lamoille River.

Figure 16. Tuttle Pond ringed by patchy Intermediate Fen and Northern White Cedar Seepage Forest.

Both ponds are enriched wetland systems with concentric rings of natural communities that vary with water level. The outer ring of Tuttle Pond's wetlands is Northern White Cedar Seepage Forest on more sloping terrain, while Hardwick Center Pond has a much larger ring of State-Significant Northern White Cedar Swamp on nearly flat terrain with deeper peat soil. The inner rings also differ somewhat, with Tuttle Pond having a narrow zone of rare and State-Significant Intermediate Fen natural community, a grassy-looking shallowly flooded zone of hairy-fuited sedge (*Carex lasiocarpa*) and other diverse herbaceous plants. Hardwick Center Pond is ringed by an extremely hummocky zone of Sweet Gale Shoreline Swamp with extensive sweet gale and leatherleaf shrubs mixed with diverse herbs and underlain by cushions of *Sphagnum* peat mosses. Several carnivorous plants can occasionally be found here, including pitcher-plants (*Sarracenia purpurea*) and bladderworts (*Utricularia* species). Hardwick Center Pond also has a tiny patch of Intermediate Fen-like community that grades into wet fields. Both areas have young, dense Lowland Spruce-Fir Forests with scattered cedar flanking their outlet streams.

The enriched, peaty wetland and aquatic habitats of both pond sites support at least 9 rare and uncommon plant species, many present in both, and all characteristic of these habitat types.

Figure 17. Hardwick Center Pond with rings of Sweet Gale Shoreline Swamp and State-Significant Northern White Cedar Swamp.

Image courtesy of Johanna Laggis and Naomi Ranz-Schleifer.

This makes these sites the densest concentrations of such unusual species in town. Numerous unusual lichens have also been found in the Hardwick Center Pond cedar swamp, which has been visited by international lichen experts. A cocoon of the uncommon Polyphemus silkmoth was observed here during the site visit, and it is likely that dedicated study of the pond's odonates (damselflies and dragonflies) would also yield some unusual species.

Both ponds are havens for wildlife, with beaver, otter, bear, a diversity of waterfowl, and many other animals being commonly seen by those lucky enough to visit these stunning places. Both sites have some history of use of their surrounding wetlands. Tuttle Pond was once cleared pasture down to its west side, now growth up into a narrow band of young regenerating cedar seepage forest. The wider swamp zone of Hardwick Center Pond has been harvested in the distant past but 100+ year old cedars are present in places.

Greensboro Brook Woods #11
Significant Natural Communities: Northern White Cedar Swamp*, Boreal Floodplain Forest*, Northern White Cedar Seepage Forest

Figure 18. Bear-scarred northern white cedar in a State-Significant Northern White Cedar Swamp along Greensboro Brook.

The Hardwick section of Greensboro Brook is a lovely, but probably seldom seen small stream with deep pools and undercut banks offering excellent wildlife habitat. Greensboro Brook has its origin in nearby Caspian Lake. Though the brook's banks are privately owned, there is a narrow riparian lands public access easement provided by the VT Fish and Wildlife Department for its entire length in Hardwick. Roughly 1.5 miles of the brook flow through Hardwick before joining the Lamoille River, and at least half of this length is flanked by a large wetland system that shares much in common with the one described previously along upper Porter Brook in blocks 4 & 5. In this case, the 70+acre wetland system of Northern White Cedar Seepage Forest, Northern White Cedar Swamp, and Boreal Floodplain Forest has a predominance of Northern White Cedar Swamp (~47acres). The somewhat flatter landscape along Greensboro Brook also results in a slightly wider Boreal Floodplain Forest area as well, and both these community types are State-Significant. While the eastern side of the brook is younger cedar swamp with extensive harvest history, parts of the west side are mature, with larger cedars over 130 years old. Though not far from roads, there is a very secluded feeling here amid the dense conifer forest and along the streambanks, and wildlife activity is abundant along the brook's muddy banks. Bear bite-marking and bark stripping on cedars was noted here and elsewhere around town, as were abundant tracks. Glimpses of the area can be had from Dimick Road, which borders the cedar swamp for much of its length.

Walden Line Woods #16
Significant Natural Communities: Northern White Cedar Seepage Forest, Rich Northern Hardwood Forest, Hemlock Seepage Forest variant

Although prioritized lower in the landscape analysis process, the southern end of this block was visited because of local knowledge of significant features. Here, a somewhat steep valley wall descends directly to the Lamoille River banks and some features are shared with the abutting riparian block (Lamoille River Bottomlands: Upstream Reach #15). A relatively steep

occurrence of locally significant Northern White Cedar Seepage Forest spans much of the lower slopes and higher parts of the floodplain terraces. Smaller areas of Rich Northern Hardwood Forest and Hemlock Seepage Forest, a conifer variant of the Northern Hardwood Seepage Forest community type, are present along a small, unnamed tributary stream.

The downcutting action of this small tributary stream, particularly after the July floods, revealed geologic features of interest. Numerous distinctive orbicular granite boulders are present along the stream and nearby Lamoille banks, having been carried by the glacier from their localized source in Craftsbury. Ironically, there are also a few hewn blocks of this same stone, carried by rail instead, to create a stone culvert under the rail bed that is now the Lamoille Valley Rail Trail (LVRT). The eroded stream banks also reveal a section of varved clay giving witness to the previous presence of a glacial lake in this upper part of the Lamoille valley, above the existing mapping for Glacial Lake Winooski. Varves are paired clay and silt layers deposited annually into glacial lakes that froze over in winter, allowing a finer clay layer to drop from the still water. These paired layers, here about an inch thick, can be counted like tree rings, recording a period of glacial time roughly 10-12,000 years ago. The approximately 10ft tall exposure here may record something like 120 years of glacial melt deposition.

Figure 19. Varves, or annually layered sediments deposited into a glacial lake, and a pock-marked Craftsbury orbicular granite boulder (lower right) along a small unnamed tributary to the Lamoille River.

The cool, moist slopes and stream banks in this area are botanically interesting as well. In addition to pockets of rich woods flora, there are an abundance of noteworthy ferns, including several wood fern hybrids and a somewhat cryptic, recently described species of beech fern, *Phegopteris excelsior*. Several rare mosses were also noted on isolated riparian boulders.

Hardbury Swamp and Hills #25
Significant Natural Communities: Northern White Cedar Swamp*

This forest block was not visited during this study, but hosts the only previously documented State-Significant natural community in Hardwick. Known as the Hardbury Swamp, this B-ranked Northern White Cedar Swamp straddles the Hardwick-Woodbury town line north of Nichols Pond. The roughly 22-acre cedar swamp occurs around the confluence of three small unnamed streams tributary to Nichols Brook. Eastern parts of the swamp have been reported to be mature forest with cedars 150-200 years old when last documented nearly 30 years ago. Western parts are younger, regenerating from past harvesting. Beavers are active in various places up and downstream of the swamp resulting in a dynamic mosaic of habitats in the larger wetland complex, which also includes shrub swamp and sedge marsh. The swamp hydrology is likely affected by the culvert under Dutton Road, which beavers can use as a point for further damming. More extensive descriptive details are available from the Vermont Natural Heritage Inventory, though the site is due for resurvey.

Western Hills
The Western Hills lie west of Route 14 spanning Buffalo and Jeudevine Mountains and the intervening terrain, excepting the Lamoille Valley Bottomlands. This somewhat more rugged portion of Hardwick is underlain by the older, somewhat harder, and more acidic Moretown Formation bedrock, composed of quartzite and granofels, with a small granite body forming the core of Buffalo Mountain. As the 'mountain' monikers suggest, this part of Hardwick has areas of higher, more rugged terrain, containing most of the bedrock exposures and rocky features in town. The prevalence of rougher, bedrock defined topography, combined with perhaps somewhat less fertile soils, produces somewhat different patterns of land use and natural communities in this region. The town's largest forest blocks are here, especially when considered in the context of the landscape beyond Hardwick, and are spanned by the most extensive Northern Hardwood Forests in town. Almost all the confirmed and potential Vernal Pools in town are found amid the ledges of this region and enriched wetlands are less frequent.

Buffalo Mountain and Kate Brook East #31
Significant Natural Communities: Northern Hardwood Talus Woodland*, Alluvial Shrub Swamp, Vernal Pool, Red Spruce-Cinnamon Fern Swamp, Northern Hardwood Forest*?

The rugged northeastern slopes of Buffalo Mountain, looming over Hardwick village, provide the defining feature of this largest (2,162 acre) forest block. The block is itself a small piece of a vast, 30,000-acre block spanning south to Wrightsville Reservoir and providing connectivity to the Worcester Range. Only small parts of the Buffalo Mountain block were visited. This remote and somewhat difficult to access part of town contains Hardwick's largest Northern Hardwood Forest, which, if evaluated in the context of the full Woodbury Mountain Forest Block, would likely be considered State-Significant. Buffalo Mountain itself tops out at about 1,560 ft making

it the second highest summit in Hardwick, though a nearby shoulder of Woodbury Mountain is slightly higher (1,590ft). The mountain has a granitic core, somewhat under-mapped in state bedrock mapping, that was explored with quarrying activity during the region's granite heyday. A few relict quarry pits and waste block piles can be found in the woods, having been partially reclaimed by natural vegetation. The most rugged slopes, including small acidic cliffs and a larger State-Significant Northern Hardwood Talus Woodland area can be readily seen above the village and are visible from the trail leaving the Atkins Field across Cooper Brook. This steep slope of boulders, also known as talus, fallen from the outcrops above is now cloaked in lush mats of mosses and rock polypody fern (*Polypodium virginianum*) with an overarching hardwood canopy, mainly of large, gnarly yellow birch. The dark, cool, moist alcoves among the boulders host several rare and uncommon mosses and the cryptic moss-like Weft Fern (*Crepidomanes intricatum*). One of the mosses, Four-Toothed Moss (*Tetrodontium brownianum*), was first discovered in Vermont in 2023, at this and several other sites in the Green Mountains.

Figure 20. A steep, fern-cloaked, State-Significant Northern Hardwood Talus Woodland boulderfield near the base of Buffalo Mountain.

A small part of the recently created Woodbury Mountain Wilderness Preserve, Vermont's largest non-governmental wilderness area, extends into Hardwick in this block, and is owned by the Northeast Wilderness Trust. This area includes two very small Red Spruce-Cinnamon Fern

Swamps, an uncommon peatland natural community. Though too small to be State-Significant, these tiny swamps are locally significant as perhaps the only examples of the type in town. Other noteworthy features of the forest block include two potential Vernal Pools. One of these, within a parcel of town owned forestland, has been confirmed. There are also small pockets of Rich Northern Hardwood Forest scattered among the coves and lower slopes of the area.

The valley bottom flats and floodplain of Cooper Brook are also part of the Buffalo Mountain forest block, though ecologically they are more closely associated with the Lamoille Valley Bottomlands or Eastern Hills physiographic regions. While significantly altered by past industrial use, settlement, roads, and other encroachments, Cooper Brook still hosts locally important habitat features. Most of the length of the brook was probably once lined by the uncommon Alluvial Shrub Swamp natural community type and numerous patches of it are still present. Indeed, this community type has redeveloped itself on former industrial rubble near the Atkins Field giving testament to its unique suitability to the conditions and stresses of living next to a frequently flooding brook. The community is shrub dominated, mostly alder, with dogwoods, and, increasingly, invasive honeysuckle. Virgin's-bower or wild clematis (*Clematis virginiana*) is a common herbaceous vine that thrives in the tangled bright sun of these floodplains along with a diverse array of herbaceous plants. The muddy banks of the brook and adjacent floodplain are great places to look for wildlife tracks and sign including bears and mink. Rare and uncommon species are also known from these areas, such as the uncommon floodplain grass, Wiegand's wild rye (*Elymus wiegandii*), discovered during our fieldwalk near the VAST bridge.

Figure 21. Uncommon Alluvial Shrub Swamp community type reclaiming the post-industrial banks of lower Cooper Brook.

Hardwick Lake West Slope #37
Significant Natural Communities: Hemlock-Balsam Fir-Black Ash Seepage Swamp*, Northern White Cedar Swamp, Northern Hardwood Seepage Forest

This forest block creates connectivity between the Buffalo Mountain and Jeudevine Mountain blocks, following the geologic feature of the Richardson Memorial Contact escarpment up the west side of Route 14. Rugged, ledgy slopes are prevalent, as seen from the highway, though the

upper, western part of the block grades out into much flatter terrain before giving way to the largest hayfields in the Western Hills region, along West Hill Road. Several perched forested swamps and potential vernal pools are sprinkled along the ridgetop, and the steeper slopes below may foster areas of rich and/or more mature hardwood forest. The largest perched swamp was visited and found to be a mixture of mature, State-Significant Hemlock-Balsam Fir-Black Ash Seepage Swamp and Northern White Cedar Swamp, with a fringing area of Northern Hardwood Seepage Forest. Larger trees in these swamps were found to be over 140 years old, though the surrounding forest is much younger. Segments of Tucker Brook flow along the north edge of the block with small, scenic cascades. Only a single property was visited in this block, leaving much to be discovered.

Jeudevine Mountain #38
Significant Natural Communities: Alluvial Shrub Swamp, Sedge Meadow, Waterfall

Sharing much in common with the Buffalo Mountain forest block, the Jeudevine Mountain block is the third largest in town (1,286ac) and is part of a much larger 9,000+acre block reaching well into Craftsbury and Wolcott. Only small areas at the periphery of this block were visited, due to access limitations. Jeudevine Mountain is almost entirely cloaked in Northern Hardwood Forest, making it the second largest area of this most common, matrix-forming natural community type. Given the ruggedness of some of the terrain, it is likely that some mature, older forest areas are present. This may be especially true on the steep, ledgy slopes rising to the west of Route 14, which are a very visible expression of the Richardson Memorial Contact geologic feature. These slopes also host areas of Rich Northern Hardwood Forest, at times discernable from the highway by their lush, diverse herbaceous plant life, that includes at least one uncommon plant. The rugged, ledgy terrain higher on the mountain hosts many small perched wetlands and at least one potential Vernal Pool that needs confirmation. Beaver influenced wetlands along upper Keeler and Tucker Brooks may also have interesting features, but were not visited.

The southeast corner of this block has several additional notable features. As it cascades down the escarpment of the Richardson Memorial Contact, Tucker Brook creates one of Hardwick's (barely) hidden gems: Jeudevine Falls. This highly scenic locale is privately owned but regularly open to public visitation with a small trail system leading to the base of the easily accessed but dramatic falls. It continues up through dense conifer forest to hemlock and spruce cloaked upper falls and cascades. While it can be fleetingly glimpsed from Route 14, this spectacular falls is well worth a visit. Several other smaller, but still dramatic, cascades are present along other unnamed streams further up the Alder Brook valley.

The bedrock lip that creates Jeudevine Falls also creates a perched example of uncommon Alluvial Shrub Swamp, a community type that can also be found extensively flanking Alder Brook below. The abundant wetlands of the Alder Brook valley, some of which were long ago submerged into Hardwick Lake, are collectively an important feature of the Hardwick landscape, though they have been somewhat encroached by Route 14. Approaching the Tucker Brook confluence, the Alluvial Shrub Swamps give way to a wetter, open, locally significant Sedge Meadow natural community with a diverse mixture of sedges, grasses, cattails, and other herbs. Most of this large marshy meadow system is state-owned land. Several rare and uncommon species are known or potentially present in this area.

Figure 22. Scenic and easily accessed Jeudevine Falls.

Lamoille Valley Bottomlands:

The Lamoille Valley Bottomlands are a roughly tenth- to half-mile wide ribbon of valley bottom terrain flanking the Lamoille River through the full width of the town. The principal ecological feature is the river itself, coupled with its active floodplains, higher terraces, and toe slopes, as well as the Hardwick Lake impoundment, and the lower reach of some of the main tributaries. Despite a substantial history of use, it is an aquatic ecosystem of the highest ecological significance, unique in town, and carrying its influence downstream to Lake Champlain. Varying by stretch or reach of river, the region is in part defined by its soils, which, unlike the predominantly glacial till soils of the other regions, are a mixture of recent riverine deposits and water-washed sediments deposited roughly 10-12,000 years ago into the glacial lakes that once filled the Lamoille valley. These origins result in a region of flatter topography and largely stone-free soils that are often highly conducive to agriculture and other human uses. Most of the concentrated settlements of Hardwick and East Hardwick villages are within the region. Correspondingly, this region has been the most intensively used and is the most altered from natural conditions, but continues to foster many unique and important ecological attributes from unique riparian habitats and rare species, to supporting habitat connectivity for wildlife, and providing essential riparian functions like flood flow attenuation.

While not the focus of this study, the major July 2023 floods had their greatest and most concentrated effects throughout this region of town, an obvious consequence of being along the largest, most powerful waterway in Hardwick. It beyond the scope of this project to summarize all the impacts of such a major flood event, perhaps as much as a '500-year' flood in parts of the watershed, but the following discussion is provided for ecological context on the flood. In the lives of people, this and other major floods are overwhelmingly tragic, damaging events, which should not be in any way downplayed; however, an ecological perspective on flooding is more mixed. In unaltered landscapes, floods, even very large ones, are natural events that the landscape, natural communities, plants, and animals are largely adapted to withstand or quickly recover from. They create periods of intense change in the structure of the river and its floodplains, and in the aquatic ecosystem, but these are part of natural disturbance cycles that over time result in heightened levels of diversity and habitat complexity along rivers.

The presence of extensive human activity in the landscape obviously changes those natural flood dynamics, from our climate altering activities that are leading to heavier precipitation events, to physical alteration of stream channels, floodplains, and their habitats, to the introduction of pollutants and spread of invasive species. This has made the ecological effects of flooding even more complex and more mixed. For example, ecologically positive or neutral effects, like floodplain fertilization, soil deposition, and habitat creation, are now potentially combined with industrial pollutants or higher sediment loads, and may occur at historically unusual timing that is out of sync with plant and animal life cycles.

Ecological effects of flooding noted during this study are varied. The recent floods clearly resulted in increased areas of mass failure, or collapsing banks, up and down the river system. This is, in part, an aspect of normal channel migration and valley creation as the river moves though floodplain deposits and continues the long-term process of working down through the great depth of soil materials deposited after glacial retreat about 10,000 years ago. However, some of the increased mass failure is likely also related to the river adjusting to (pushing back against) human encroachments into the floodplain, channel alterations, and historical sedimentation off the cleared landscape, all of which tend to increase the erosive power of the river. Large areas of fresh sediment deposition were created by the floods, from fine silt and sand to coarse gravel, cobbles, and even boulders, along with abundant new piles of woody debris. While often problematic for human activities, these features largely contribute to habitat diversity in the river system, providing fresh habitat for disturbance-adapted plants and animals, which are more frequent along river systems. However, problematic invasives can also be widely dispersed to these areas. Fortunately, Japanese knotweed (*Fallopia japonica*), a common riparian invasive plant that has been widely dispersed by flooding in other regions, has a fairly limited presence in Hardwick at this time. The effects in Hardwick remain to be seen. Most of the remaining floodplain forest and wetland habitats along the river, concentrated above Hardwick village, appear to have come through the flooding with little lasting damage. As noted at various sites below, tree cores revealed many of these areas came through the 1927 flood as well. A number of rare plants and animals were also observed along the river post-flooding – indicating their populations survived, or in the cases of disturbance adapted bryophytes, may actually have benefited from fresh flood deposits. Effects on other groups of organisms like fish, mussels, and aquatic macroinvertebrates may show negative effects, but were beyond the scope of this study to assess.

Lamoille River Bottomlands: Upstream Reach #15
Significant Natural Communities: Boreal Floodplain Forest*, Northern White Cedar Seepage Forest

This block spans over 2.5 miles of the Lamoille River and its floodplains, from the town line near Greensboro Bend downstream to the falls in East Hardwick village. Site visits occurred along the middle section and the LVRT. This section of river has substantial stretches that are forested down to river, mainly on the east bank, helping to foster habitat connectivity toward the large forest blocks to the east around Steam Mill Brook Wildlife Management Area. There are also extensive areas of active agricultural fields with only scattered pockets of semi-natural habitat and ample opportunities for expanding buffer vegetation. Several tributaries join the Lamoille in this uppermost section in Hardwick, including Stannard, Stevens, Greensboro, and Bailey Brooks, as well as other unnamed smaller streams.

Site visits revealed a narrow strip of rare, State-Significant Boreal Floodplain Forest natural community along one part of the river. This fairly mature floodplain forest has a mixture of cedar, white spruce, and hardwoods, particularly yellow birch and black ash. One larger black ash was cored and revealed to be at least 108 years old, a survivor of the 1927 floods. This floodplain forest grades upslope into locally significant Northern White Cedar Seepage Forest that spans into the Walden Line Woods (#16) block. Several rare species have also been documented along this section of river and the adjacent LVRT.

Figure 23. A secluded section of the upper Lamoille River along an extensive forested stretch, note the metal roofing wrapped around a boulder by the July flood.

Lamoille River Bottomlands: Haynesville to East Hardwick Reach #20
Significant Natural Communities: Boreal Floodplain Forest*, Sugar Maple Floodplain Forest*, Northern White Cedar Seepage Forest, River Cobble Shore*, Alluvial Shrub Swamp

This block spans about over 1.5 miles of Lamoille River bottoms from the falls in East Hardwick village downstream to the mouth of Haynesville Brook near the junction of Routes 15 & 16. It spans some of the most natural floodplain vegetation in town, including forested floodplains and higher terraces, substantial floodplain wetlands, and river shore communities, as well as active agricultural fields and other cleared lands. Several site visits occurred in this block, along with one public field walk below the falls.

Though once harnessed for mills, the cascading falls at East Hardwick now flow freely, but seem to be somewhat poorly known as a scenic feature, perhaps because vantages from below or downstream are somewhat hard to find. Major flooding events from Tropical Storm Irene and the July 2023 flood caused, or reactivated a nearly 100-ft tall eroding bank or mass failure below the falls exposing a roughly 10,000-year-old cross section of glacial deposits in what was the uppermost part of Glacial Lake Winooski.

Figure 24. Cascading falls on the Lamoille River at East Hardwick, VT.

Below the falls, a suite of rare and uncommon riparian, or steam-side, natural communities can be found extending downriver in intermittent patches. These include rare and State-Significant Boreal and Sugar Maple Floodplain Forest community types, rare River Cobble Shores, uncommon and locally significant Alluvial Shrub Swamps and Northern White Cedar Seepage Forest. Cedars in the Boreal Floodplain Forest and the base of the cedar seepage forest, that were lapped by July floodwaters were cored, revealing ages up to 118 years or more. As noted elsewhere, riparian forests of this age and maturity are not common and provide direct evidence of continuity through the major

1927 flood. The Boreal Floodplain Forest examples here are similar to those elsewhere in town on smaller streams, but differ in having slightly coarser, better drained soil, as could be expected adjacent to a larger, more powerful river. Several rare species are also known from the area.

Figure 25. A recently flood scoured and sparsely vegetated area of River Cobble Shore natural community.

Lamoille River Bottomlands and Porter Brook Confluence #21
Significant Natural Communities: Floodplain Forest

This reach spans nearly 2 miles from the mouth of Haynesville Brook, near the intersection of Routes 15 & 16, downstream to Hardwick village and includes the mouth of Porter Brook and adjacent upland forests. Brief visits were made to the lower, town-owned parts of the area, along the LVRT, and various highway embankments at river's edge. Located immediately upstream of the village, this reach has some important flood mitigation attributes. However, it is also a slightly steeper section of river with a narrower valley bottom that has been further narrowed by road and rail encroachments, and has fewer opportunities for floodplain access and floodwater storage than the reaches above. This makes the existing areas of floodplain all the more important for slowing and spreading high flows. Several areas of floodplain forest and associated wetlands are mapped here as a locally significant feature, both for the flood mitigation they provide and from a habitat perspective. While somewhat weedy with invasive honeysuckle and

tree lilac (*Syringa reticulata*), these areas have maturing forest canopy and are recovering toward more mature forest. These areas include seepage wetlands with abundant black ash, as well as some small patches of the rare Boreal Floodplain Forest community type discussed previously. Several rare plants were also noted along the river banks and LVRT. This section of river is also the longest forested segment of the Lamoille River in town, spanning nearly 2 miles of continuity between the river and adjacent upland forest habitats on the steep north bank, giving it increased importance for habitat connectivity.

Hardwick Lake and Lamoille River Village Reach #3
Significant Natural Communities: none mapped (needs further study)

This block spans from the Church Street bridge in Hardwick village downstream to Jackson dam, encompassing Hardwick Lake, its extensive marshes, the impoundment-influenced lower part of Alder Brook, and about a mile of Lamoille River shorelines and floodplain that are the most directly influenced by the Hardwick Lake impoundment. Due to time constraints and past study, this area received only minor visitation during this study. Completed in 1920, the Jackson Dam impounds the Lamoille River mainstem and lower Alder Brook to form the approximately 180-acre Hardwick Lake, which largely fills the lower Alder Brook valley. The subject of the dam's, and therefore the lake's, continued existence has been, and no doubt will continue to be, a subject of local controversy. This study was in no way designed to greatly inform that debate. The report *Hardwick Lake Today and Tomorrow* (NRLT 2013) focuses on this topic. While unquestionable that the dam and lake transformed riverine habitats and continues to have up and downstream effects, it is also unquestionable that the substantial span of their existence has allowed a degree of natural adaptation including the development of large lake-associated marsh complexes that have their own habitat values. Despite the highly unnatural seasonal drawdowns currently created by dam management, a diversity of aquatic and wetland plants and animals use the area – many of which were catalogued in the NRLT report. Additionally, a rare plant is known from early successional upland habitat along the lake's shore.

Hardwick Lake aside, there are other natural features of note in this area that warrant further examination. There are small patches of remnant floodplain forest just above the typical impoundment level behind Top's/ Walgreens, which provide fertile ground for local tracking enthusiasts. Immediately upstream is an area of maintained open floodplain used for ice jam management. The area might also have habitat restoration potential.

The lower remaining lower reaches of Alder Brook near Smith Farm Road host uncommon Alluvial Shrub Swamp and Sedge Meadow natural communities with varying influences from the lake impoundment. There is also a large population of somewhat uncommon Hayden's sedge (*Carex haydenii*) in this area, not seen elsewhere in town.

Lamoille River Bottomlands: Lower Reach #33
Significant Natural Communities: none mapped (needs further study)

This lowermost section or reach stretches from below Hardwick Lake, the Jackson dam, and the 'Yellow Barn' to the west edge of town. Spanning over 2 miles, this reach spans some of the broadest valley bottom lands in Hardwick, mainly between Route 15 and the LVRT. Only a

small area was visited during the study. The block is largely active farmland with small scraps of regenerating floodplain forest and river associated scrub wetlands. Prior to clearing for agriculture much of the area was likely comprised of a mixture of Silver Maple and Sugar Maple Floodplain Forest types, all of which are today considered uncommon or rare due to conversion. They are presently very rare in Hardwick. The river channel itself has seasonally exposed areas of mud and sand/gravel shoreline natural communities, as well as a few small Riverside Outcrops. The reach includes the mouths of Kate, Millard, and Bunker Brooks, as well as smaller unnamed tributaries. Accumulations of wood and other debris from the July 2023 floods are particularly visible in places. While messy and at times problematic for agriculture or other uses, woody debris jams are a normal part of natural riverine processes and can play roles in habitat creation and channel evolution/stabilization processes. A few rare and uncommon species are known from shorelines and adjacent floodplains in this area, and there is substantial potential for others to be found with additional survey. Riparian buffer vegetation is relatively scant and narrow throughout this reach and presents opportunities for restoration work and habitat enhancement.

Figure 26. Cascading falls at East Hardwick. Note the large mass failures downstream and invasive knotweed in the foreground.

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Appendix A: Vermont Natural Heritage Inventory Protocols

Explanation of Legal Status and Information Ranks[1]

State Rank and Global Rank - Value that best characterizes the relative rarity (abundance) or endangerment of a native taxon within Vermont's geographic boundary or throughout its range, respectively. Ranks are as follows:

1 - Very rare (Critically imperiled): At very high risk of extinction or extirpation due to extreme rarity (often 5 or fewer populations or occurrences), very steep declines, or other factors

2 - Rare (Imperiled): At high risk of extinction or extirpation due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors

3 - Uncommon (Vulnerable): Moderate risk of extinction/extirpation due to restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, or other factors

4 - General, regular, and apparently secure: May be locally uncommon or widely scattered but not uncommon on a statewide basis

5 - Common (Secure): widespread and abundant

H - Possibly extinct/extirpated: Missing; only historical occurrences but potential for rediscovery

X - Presumed extinct/extirpated: Not located despite intensive searches and little likelihood of rediscovery

U - Unrankable: Currently unrankable due to lack of information or due to substantially conflicting information about status or Trends

NR - Not ranked: Not yet assessed

NA - Not applicable. Element is not a suitable target for conservation for one of the following reasons: Hybrid, Exotic Origin, Accidental/Nonregular, Not Confidently Present, No Definable Occurrences

An indicator of uncertainty about the rank, either in the form of a range rank (e.g. S1S3) or a ? qualifier, may follow a numeric rank. For global ranks only, an appended T-rank indicates an infraspecies, and a qualifier after the rank in the form of a Q indicates questionable taxonomy.

State Status - Legal protection under Vermont Endangered Species Law (10 V.S.A. Chap. 123)
E = Endangered: in immediate danger of becoming extirpated in the state
T = Threatened: with high possibility of becoming endangered in the near future
PDL = Proposed for Delisting
PE = Proposed for Endangered Status (not legally protected by 10 V.S.A. Chap. 123)
PT = Proposed for Threatened Status (not legally protected by 10 V.S.A. Chap. 123)
RE = Recommended (by the Endangered Species Committee) for Endangered Status (not legally protected)
RT = Recommended (by the Endangered Species Committee) for Threatened Status (not legally protected)
RDL = Recommended (by the Endangered Species Committee) for Delisting

Federal Status - Legal protection under the federal Endangered Species Act, U.S. Fish & Wildlife Service
LE = Listed Endangered
LT = Listed Threatened
PDL = Proposed for Delisting
C = Candidate for Listing (not legally protected under ESA)

[1] Excerpted from *Rare and Uncommon Native Vascular Plants of Vermont* web-published by the Vermont Natural Heritage Inventory, Vermont Fish & Wildlife Department 9 August 2018.

Guidelines for State-significance

Natural Heritage Inventory
Vermont Fish & Wildlife Department
Initially drafted November 5, 1996, latest revision July 25, 2013

The following guidelines are for determining whether a particular area will be entered into the Vermont Fish & Wildlife Department's Natural Heritage Database as a species or natural community occurrence of statewide conservation significance. They are used in conjunction with the Natural Heritage Network's Element Occurrence Data Standard and Element Occurrence Specifications. These guidelines are primarily intended for staff and others providing Natural Heritage data to the Vermont Natural Heritage Inventory (VNHI)

These guidelines represent VNHI's default position on determining state-significance for a species or natural community Element Occurrence (EO). Any deviation from the guidelines needs to be clearly justified and documented either in these guidelines (see Exceptions Section) or in the Natural Heritage Database.

The terms state-significant and exemplary have been used synonymously in the past to describe important Natural Heritage Element Occurrences. The term exemplary is currently used in the Vermont Wetland Rules (Exemplary Wetland Natural Community, section 5.5) and includes all wetland natural community occurrences that VNHI determines to be state-significant.
Meeting any of the following criteria would constitute state-significance for the purpose of entering an Element Occurrence into the Natural Heritage Database.

PLANT SPECIES

- Presence of any S1, S2, or state-listed (Threatened or Endangered) species;
- Presence of any G3/S3 species (e.g. Ginseng, Hill's Pondweed).

  Note that split-rank species default to the lower ranking, e.g. an S2S3 species is treated as S2 and mapped and tracked as an EO.

  S3 (but not S3S4) plant species are documented in the Natural Heritage Database with limited observational information but are not considered as state-significant.

ANIMAL SPECIES

- Known or suspected occupied breeding-season habitat for any S1, S2, or state-listed species;
- Known or suspected occupied breeding-season habitat for a G3/S3 species (e.g. West Virginia White);
- Known overwintering concentrations of S1, S2, or state-listed species;
- Known overwintering concentrations of G3/S3 species.

  Note that split rank species default to the lower ranking, e.g. an S2S3 species is treated as S2 and mapped and tracked as an EO.

  S3 and S3S4 animal species are documented in the Natural Heritage Database with limited observational information but are not considered as state-significant.

NATURAL COMMUNITIES

- Presence of an S1 or S2 natural community type with an EO Rank of A, B, or C;
- Presence of an S3 or S4 natural community type with an EO Rank of A or B;
- Presence of an S5 natural community type with an EO Rank of A.

  Note that D-ranked S1 and S2 natural communities, C-ranked S3 and S4 natural communities, and B-ranked S5 natural communities may be tracked in the Natural Heritage Database, and may be considered state-significant, if their EO Rank has been downgraded due to a temporary lowering of their condition for which recovery is expected. Justification must be provided. C-ranked Vernal Pools are tracked regardless

of whether their condition is downgraded and expected to recover because the primary basis for ranking vernal pools is amphibian breeding.

ASSOCIATIONS OF NATURAL COMMUNITIES

A site may be considered state-significant if it contains an association of natural communities for which ecologically intact examples are rare or declining in the state. There are typically strong ecological connections between the natural communities in these associations that relate to specific site characteristics, such as topography, soils, hydrology, or natural disturbance. In these cases, the association of natural communities is the state-significant feature, not necessarily all of the individual natural communities that are components of the association, although at least one component natural community should be state-significant. Examples include the following: Lake Champlain associations of Deep Rush Marsh, Lakeshore Grassland, Lakeside Floodplain Forests, Sand Beach, and Sand Dune, all closely tied to the ecological processes of flooding, wave action, wind, and sand deposition; and associations on calcareous hills of the Champlain Valley, including Mesic Maple-Ash-Hickory-Oak Forest, Dry Oak-Hickory-Hophornbeam Forest, and Temperate Calcareous Outcrop and Cliff, all tied to the warm, dry to mesic calcareous substrate of these hills.

EXCEPTIONS TO THE GUIDELINES

Great Blue Heron: While this species is ranked S3S4B, because of their concentrated nesting and vulnerability to human disturbance, VNHI does track Great Blue Heron rookeries.

Double-crested Cormorant: While this species meets the criteria for S2B it currently is not of conservation concern and is not tracked by VNHI. The species is considered a nuisance and its population in Vermont is being actively controlled. Under current conditions it is expected the population size would return to at least S4 levels if active control activities ceased.

American Eel: Though rare and of conservation concern, there are no definable occurrences to track due to their dispersed distribution while in their juvenile stage here. VNHI tracks observations as Independent Source Features.

Bryophytes: Most bryophyte S-ranks are provisional. VNHI will not track S3 bryophyte species, even as Independent Source Features, until further notice.

Appendix B: Potentially Significant Forest Blocks List. Compiled from Landscape analysis, VNHI and other sources.

Block #	Block Name	Priority	Acres	Features	Location
1	Little Elligo Pond East Slope	MH	463	South end of Little Elligo Pond with shorelines, steep eastern slope w/ a little cedar; outlet of Greensboro Mud Pond, likely w/ cedar swamps along drainage plus adjacent perched cedar? swamps, with pot'l rich fenny openings; extensive Cabot soils = seepage. Also wooded areas of glaciofluv & glaciolac soils along Rte 14.	Between Rte 14 and Bridgman Hill Rd north of Town Farm Rd
2	Hardwick Lake Eastern Slopes	MH	1721	Slopes of mainly mixed forest with lots of hemlock adjacent the east side of Hardwick Lake; ~25+ ac. probable cedar swamp, very dense looking - young?; large Cabot soil flats with likely seepage; some forested patches of glaciofluv soils; Hazen Union sugarbush & seepages, other richer areas possible, Craftsbury orbicular granite erratics; VPMP confirmed vernal pool but is manmade. 2nd largest block within town.	Slopes east of Hardwick Lake to Bridgman Hill Rd, north to Town Farm Rd
3	Hardwick Lake & Lamoille River Village Reach	H	235	Hardwick Lake & extensive marshes, lower Alder Brk shrub swamps, Lamoille R. shores and floodplain; lake with unnatural hydrologic regime, uncertain future; scraps of floodplain forest and artificial floodplain grassland with restoration, Crat. lucorum EO, Eagles.	Hardwick Lake and Lamoille R. bottomlands upstream to Church St. bridge
4	Bridgman Hill	H	624	Extensive conifer forest on hill top, especially along headwater reaches of Porter Brook; several larger mapped wetlands and muck areas, and unmapped wetlands; extensive cedar swamps/ seepage forests; extensive Cabot soils along drainages; some small outlying pocket cedar swamps and seepage wetlands in surrounding fields - likely enriched; high rare plant pot'l overall.	north of Cobb School Rd along town line between Bridgman Hill and Center Rds
5	Hardwick Center North Woods	MH	484	Heavily coniferous forest on extensive Cabot soils; several larger mapped wetlands of dense conifer; cedar seepage forest, parts look dense and young; long reach of upper Porter Brook with mapped alluvial soils and flanked by esker to west.	North of Hardwick Center between Bridgman Hill and Center Rds

Block #	Block Name	Priority	Acres	Features	Location
6	Hardwick Center South Woods	MH	412	Mainly mixed woods with substantial edge fragmentation and successional or recent harvested areas; numerous small unmapped wetlands, many look like cedar/larch?; two larger parallel wetland/muck soil areas - beaver meadows to west and S-F-T Swamp or cedar with fenny openings to east; pot'l band of rich slopes along Renaud Rd; probably an esker with adjacent fenny? open wetland.	from Hardwick north to H. Center between Bridgman Hill and Center Rds.
7	Tuttle Pond Woods	H	111	Small block of heavily coniferous forest surrounding Tuttle Pond, an apparently natural undeveloped circular pond at head of Bailey Brook, encircled by aquatic beds, shoreline marshy/fen mats and cedar swamp/seepage forest in a large area of mapped muck soil, perhaps a kettle pond; high rare plant potential	North of Stage House Rd along north town line, around Tuttle Pond
8	Bailey Brook Woods	M	418	Small elongate block of densely coniferous woods flanking Bailey Brook for ~2.3 miles; largely Cabot soils, mapped muck/swamp, likely extensive cedar seepage forest with some small beaver impoundments and perched cedar swamps; substantial cedar/wet areas with recent harvesting - overall somewhat degraded condition, otherwise looks like a large pot'l significant occurrence.	Between Montgomery Rd and Hardwick St north of E. Hardwick
9	Hardwick Center Pond Woods	H	360	Highly irregularly-shaped block around Hardwick Center Pond, its outlet stream, and numerous other smaller wetlands; lots of cedar throughout, ringing most wetlands and on seepage slopes; ~40-acre cedar swamp around the pond, plus shrub swamp/fenny shores. Extensive Cabot soils with seepage; high rare plant pot'l; rich woods pot'l?; Rare plant in wet meadow pasture.	Between Hardwick Farms, Montgomery, and Center Roads
10	Porter Brook Middle Reach	MH	163	Small, highly fragmented patch of largely conifer/mixed woods flanking mid reach of Porter Brook, very sinuous section, often lined by cedar, through mapped alluvial soils; separate linear, small, cedar? swamp to west; extensive Cabot soils. Laggis's manure pit birding hotspot is nearby.	Between Porter Brook and Hardwick Farms Rds, NW of Hardwick Center
11	Greensboro Brook Woods	H	396	Elongate block on slopes mainly west of Greensboro Brook with heavily coniferous forest (LSFF?) flanking ~1.7 miles of brook; extensive, maybe 60+ ac cedar swamp along brook looks in good condition; likely additional cedar seepage along other sections, rare animal EO.	West of Rte 16 between Bailey Hazen and Dimick Rds, north to town line
12	West of the Bend Woods	M	99	Small fragmented block with 10+ acre cedar? swamp straddling town line, Hardwick side looks good, cut to north; other small perched cedar seepages.	West of Rte 16 along town line

Block #	Block Name	Priority	Acres	Features	Location
13	Bailey Hazen Woods	M	351	Small block rising from the Lamoille R. to small hardwood hilltop with good rich woods pot'l; surrounding slopes with scattered seepage and cedar probable, some Cabot soils along western drainage; small perched probably cedar swamp near Rte 16, small cedar? woodland fenny swamp at north end.	North of East Hardwick between Hardwick St & Bailey Hazen Rd
14	Woods West of East Hardwick	L	204	Small, irregular block of dense conifer and mixed woods on lower slopes west of Lamoille R.; seepage forests likely, though no mapped wetlands, though likely cedar along drainages and small wet spots; continuous forest down to river in places.	above LVRT west of E. Hardwick to Porter Brook Rd
15	Lamoille River Bottomlands: Upstream Reach	H	225	Roughly 2.5 miles of Lamoille R. shores & floodplains above East Hardwick; forested down to river and slightly across in spots, but mostly flanked by active ag lands with scraps of semi-natural veg; Includes confluence of Greensboro Brook; rare animal habitat pot'l.	Lamoille River bottoms above East Hardwick
16	Walden Line Woods	L	194	Small forest block, mainly mixed/ coniferous with some sugarbush hardwood stands, rich pot'l?; few distinct features but forested down to river in spots.	Along Walden town line north of Belfry Rd east of Lamoille River
17	Ward Hill Woods	L	296	Small block at east edge Lamoille R. floodplain; largely gently sloping Cabot soils with high seepage pot'l, small drainages with small beaver pools; extensive conifer cover - LSFF? on lower slopes; small perched wetland impounded at Ward Hill Rd. Pot'l VP in NE corner at field edge, but likely excavated/artificial based on topography - uncertain.	East of East Hardwick along town line between Ward Hill and Belfry Rds
18	Dows Crossing Woods	M	259	Small irregular block, largely mixed woods with patches of sugar maple, likely some small sugarbushes, rich woods pot'l; series of small beaver meadows, with some rich fen pot'l at top of drainage; small pot'l VP in one maple area.	Between Mountain View and Ward Hill Rds along Walden town line
19	Haynesville Brook Woods	M	497	Highly irregularly shaped block spanning largely glacial lacustrine and fluvial soils, lots of loamy fine sands; spans most of H. Brook in town with its narrow floodplain; old floodplain terraces; small cedar swamps, alder, marshy thickets in floodplain wetlands, some fenny pot'l; upland forest with lots of pine on sands, extensive harvesting; rare animal pot'l; some floodplain needs restoration.	Rte 15 north to Mountainview Rd east of Rte 16

Block #	Block Name	Priority	Acres	Features	Location
20	Lamoille River Bottomlands: Haynesville to East Hardwick Reach	H	151	Lamoille R. bottoms spanning some of the most natural floodplain vegetation in town; including active and former floodplain terraces with semi-natural vegetation, some floodplain wetlands, shrub swamps, as well as active ag fields at Riverside Farm; River shore communities, likely rare plants; Glacial & alluvial soils; outcrops/rapids/ failed dam at East Hardwick; small patches of forested lower slopes, patch of piney? floodplain forest; pot'l rare animal habitat/nesting sites; ~1.5 miles long.	Haynesville Brook confluence upstream to East Hardwick, west of Rte 16
21	Lamoille River Bottomlands & Porter Brook Confluence	H	324	Stretch of Lamoille R. from village up to Haynesville Brook including active and former floodplain terraces with semi-natural vegetation, some floodplain wetlands, shrub swamps; steep valley wall to north, cedar in spots; deeply incised lower Porter Brook; Glacial and recent alluvial soils; Crat. lucorum EO; small perched beaver wetlands with muck soils near solar arrays; potential rare animal habitat?	north of Rte 15 from village east to Rte 16/ Haynesville Brk confluence
22	Houston Hill North	LM	246	Mainly mixed and coniferous forest on N aspect slopes draining to Haynesville Brk, perhaps with substantial larch in sections indicating rich seepage?, extensive harvesting in parts; west side Houston Hill summit with nice hardwood grove, other small hardwood groves and steep slopes with enrichment pot'l given Waits R. bedrock, substantial Cabot soils and glaciolacustrine loamy sands.	east edge of town south of Rte 15
23	Hopkins Hill North Slope	M	660	Broad flats and north aspect slopes down to Rte 15/Haynesville Brk, largely mixed and conifer forest; a few areas of mapped muck soils likely with enriched seepage wetlands, possibly cedar, toward SE edge; SW edge with mapped muck soil wet beaver meadow/ old pasture complex, likely some cedar, with nearby small larchy openings south of Hopkins Hill Rd. Lower hemlock slopes with seepage likely; lots of dense till soils.	Route 15 south to Hopkins Hill Rd east of the village
24	Houston Hill West	LM	154	Small block of mixed and coniferous forest on low relief terrain, recent harvesting; a few small beaver ponds and meadows along drainages, maybe small associated cedar swamp; small impoundment at Dutton Rd., lots of Cabot soils with seepage pot'l; Waits River Formation bedrock= general rich pot'l.	east edge of town between Dusty Swamp and Houston Hill Rds

Block #	Block Name	Priority	Acres	Features	Location
25	Hardbury Swamp & Hills	H	269	Small region of mainly mixed forest surrounding Hardbury Cedar Swamp EO with extensive associated beaver meadows, marshes, ponds, some pot'lly fenny, high rare plant pot'l, swamp includes old forest sections; some small separate beaver wetlands; small ledge/ steep slope systems in Waits River rock with rich pot'l; large patches of Cabot soils with seepage pot'l, several old rare plant specimens from 'Camp Kahagon'.	SE corner of town
26	Hopkins Hill	MH	577	Larger block spanning hill with granite pluton core and areas of steep slopes with mature forest or talus woodland potential; toe slopes have several areas of muck soils and extensive wetlands; largest wetland complex heavily disturbed but probably with cedar swamp fringes and potential fenny areas; west, south and north edges with small fenny/cedar glade/old pasture wetland openings; old quarry pond and grout piles along southwest edge; pot'l VP (unmapped) at east edge. Cabot soils.	Between Hopkins Hill and Nichols Pond Rds on the hill
27	Mackville Pond & Nichols Brook Woods	M	332	Mainly mixed forest adjoining large eastern Woodbury block; Mackville Pond with shoreline wetlands; middle reach of Nichols Brook including 2 small beaver meadows with fen/ rare plant pot'l.	Mackville Pond south to town line and east to Nichols Pond Rd
28	Mackville North Woods	L	148	Small area of mainly mixed woods, likely mostly young and disturbed forest with some successional areas; drains to Nichols Brook; no distinctive features; some glaciofluv & glaciolac soils.	north of Mackville, west of Scott Rd.
29	Cooper Brook Flats	LM	105	Small patch of fragmented hardwood and mixed forest east of straightened section of Cooper Brk with disturbed floodplain flats that include small cattail marshes, shrub swamps, and pool with amphib breeding pot'l; a few other small disturbed looking perched wetlands. extensive glaciofluv & glaciolacustrine soils including sands, pot'l rare animal habitat.	east of Rte 14 & south of Mackville
30	Nichols Brook Gorge and Cooper Brook Confluence	LM	22	Tiny scrap of forested knoll with a short gorge-like section of lower Nichols Brook along Carey Rd; confluence of Nichols and Cooper Brooks below with floodplain area largely converted to lawn, but some of it flooding regularly. mainly glaciofluvial soils.	Between Carey and Mackville Rds, east of Cooper Brook

Block #	Block Name	Priority	Acres	Features	Location
31	Buffalo Mountain and Kate Brook East	H	2162	Buffalo Mtn with extensive ledges, small cliffs, steep slopes, talus on east face/RMC escarpment, hardwood knobs with rich forest pot'l, 2 pot'l VPs, linear open beaver meadows/fen pot'l on unnamed trib. Lower Cooper Brook with associated Alluvial Shrub Swamps, successional wet fields, pot'l rare animal habitat, other small mapped wetlands along Cooper Brk and LVRT, some Cabot soils with seepage pot'l; largest forest block in town with extensive hardwood forest.	South of Lamoille R., west of Rte 14
32	Kate Brook West	L	227	Small area of fragmented mixed woods with many patch cuts, includes lower part of Kate Brook, 2 small mapped swamps.	SW corner of town
33	Lamoille River Bottomlands: Lower Reach	H	162	Valley bottom lands mainly between Rte 15 and LVRT beds below Hardwick Lake dam; largely active farmland with tiny scraps of regenerating floodplain forest and river associated scrub wetlands; river channel itself with associated rivershore communities: mud, sand/gravel, cobble? shores, small rivershore outcrops; unique large river valley bottom setting/ habitats; needs restoration work; includes mouths of Kate, Millard, Bunker, unnamed brooks; rare plant and animal habitat potential.	Along Lamoille River valley bottom below Hardwick Lake
34	Millard Brook Slopes	L	426	Small area of mixed forest descending to Lamoille valley, drained by Millard Brook, few distinctive features.	West of Bunker Hill Rd, north of Lamoille R. along townline
35	Bunker Brook Slopes	LM	630	Encompasses most of Bunker Brook and headwaters in small area of mixed and coniferous forest, generally south aspect, likely good deer wintering. Lots of disturbed gaps and old field margins, wet looking meadows, several likely wet openings near top of drainage where branches coalesce, fenny potential, or more likely disturbed seepages.	Between Bunker Hill and West Hill Roads north of the Lamoille R.
36	Wolcott Pond Woods	L	50	Tiny part of larger block mainly in Wolcott; includes a tiny segment of Tucker Brook; small hardwood stand, possibly sugar woods with rich pot'l.	Along Wolcott town line west of Wapanacki Rd

Block #	Block Name	Priority	Acres	Features	Location
37	Hardwick Lake West Slope	H	777	Steep, ledgy/rocky, east aspect hardwood slopes down to Rte 14/Hardwick Lake along RMC escarpment, rich and mature woods pot'l; several mapped perched mixedwood swamps/ muck soil areas, possibly with larch or cedar; 3 pot'l VPs that look very nice; impounded marshy wetland along Rte 14; Tucker Brook along N. edge with a small open wet meadow and probably natural falls/cascade. 2 small landslide scars.	West of Hardwick Lake/Rte 14 to W. Hill Rd, Rte 15 north to Tucker Brook
38	Jeudevine Mountain	H	1286	Steep, ledgy/rocky, east aspect hardwood slopes down to Rte 14 along RMC escarpment, rich and mature woods pot'l; extensive sedge meadows/ wet meadows along Alder Brook, with some state land; many perched wetlands, largely seepage and beaver influenced; ~4 pot'l fens in beaver meadows on upper Keeler & Tucker Brooks; 1+ pot'l VPs (see advisory wetlands); Rare animal EO and other pot'l habitat, uncommon plant site; 3rd largest block in town with extensive hardwood forest.	NW corner of town, west of Rte 14