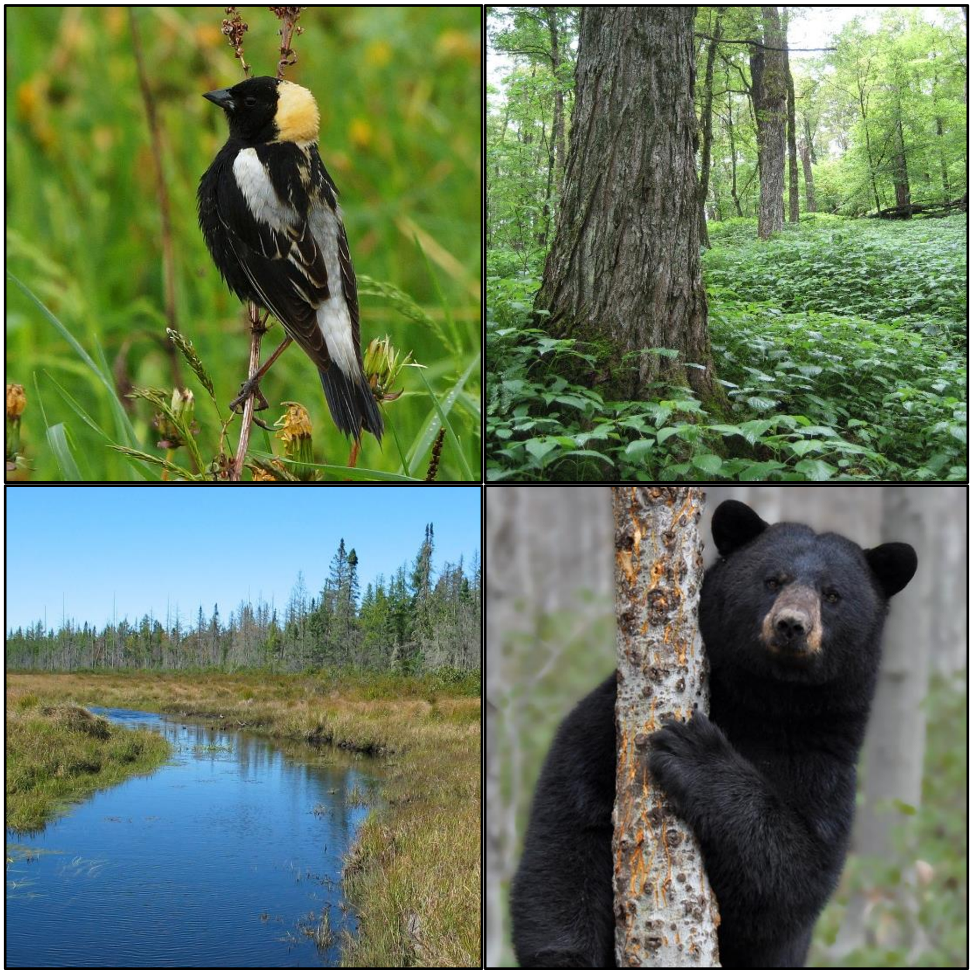
VERMONT CONSERVATION DESIGN

PART 2: NATURAL COMMUNITIES AND HABITATS TECHNICAL REPORT



March 2018

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Contents

Introduction

Forests and fields, waterways and wetlands, and the species they contain are central to Vermont's identity. Vermonters value and depend on the natural landscape for high-quality outdoor recreation, forest products and agriculture, and environmental services such as clean water, crop pollination, and flood resiliency. Time and again, public surveys show strong support for conservation in Vermont (Roman and Ericson 2015).

Thanks to nature's resilience, and thoughtful conservation and stewardship, much of the state is in good ecological condition. However, habitat loss and fragmentation, the spread of non-native species, and a rapidly changing climate all pose grave threats to species and ecosystems. The future of Vermont's landscape is uncertain.

Vermont Conservation Design is a practical and efficient plan to address that uncertainty, and to sustain the state's valued natural heritage into the future.

Vermont Conservation Design is a practical plan because it sets defined quantitative and distributional goals for maintaining and restoring an ecologically functional landscape. For the first time, there is a benchmark for long-term conservation success in the state. Vermont Conservation Design is also practical because the aim is sustaining ecological functions and environmental services, using the full range of conservation and management tools – these functions and services provide enormous benefit and cannot be replaced once they are lost. It is grounded in Vermont's tradition of responsible land stewardship.

Vermont Conservation Design is efficient because it specifically identifies or targets the minimum number of features for maximum conservation gain. Vermont has tens of thousands of native species; it is simply not possible to study and conserve each one individually. Using a "coarse-filter" approach, Vermont Conservation Design targets those features of the landscape that support the needs of most species and ecological processes. In this way, we can confidently work towards long-term support of ecological function without needing to understand the life-history of every species. We recognize that some species will always need special conservation attention.

The first phase of Vermont Conservation Design was completed by the Vermont Fish and Wildlife Department and partners in 2015. Building off a robust history of conservation planning in Vermont, that effort identified the priority forest blocks, and the network of surface waters and riparian areas needed to maintain and enhance ecological function at the landscape-scale.

Here we present the next phase of Vermont Conservation Design. While landscape-scale features such as forest blocks and riparian areas are essential for ecological function, they cannot by themselves provide for all the needs of Vermont's species. In this phase, we identify the priority habitats and natural communities that—when conserved in conjunction with the landscape-scale elements—are necessary to maintain and enhance ecological functions. Equally important, we also identify those "fine-filter" species with habitat needs that are unlikely to be met by these elements, so that they can be targeted for species-specific conservation.

Taken together, the results of these two phases represent a rigorous, science-based conservation vision for Vermont. We have very high confidence that if all these targeted elements: forest blocks, surface waters and riparian areas, habitats, and natural communities, and fine-filter species, can be conserved and managed appropriately, they will sustain Vermont's natural legacy into the future.

The Ecologically Functional Landscape

Vermont Conservation Design is based on the concept of an ***ecologically functional landscape***. Maintaining and enhancing ecological function across the landscape is fundamental to conserving biological diversity. Ecological function—the ability of plants and animals to thrive, reproduce, migrate, and move in response to climate changes and other stressors, and the ability of natural ecosystems to function under natural processes—is served by high-quality terrestrial and aquatic habitat, natural connections across the landscape, a wide variety of habitat features from low elevation to high, clean water, and healthy rivers, streams, lakes, ponds, and wetlands.

An ecologically functional landscape contains all the native species found in Vermont, and the full range of native habitats and natural communities known to occur in the state. It also contributes to regional conservation, by maintaining species and habitat conditions that may be in regional decline (such as grassland birds and their habitat), or that may be well-represented in Vermont but regionally rare (such as habitats resulting from calcareous bedrock). It must be well-connected at multiple scales, allowing species movement and gene flow across the landscape. An ecologically functional landscape is also resilient, allowing species and natural communities to adapt and rearrange themselves in response to a changing climate and other stressors.

Methods

We used the coarse-filter approach to conservation, which is well-documented in the scientific literature. It would be overwhelming to identify and manage for the individual needs of the thousands of estimated 24,000-43,000 species of plants, animals, invertebrates, and fungi in Vermont. The coarse-filter conservation approach treats larger-scale components of the landscape as proxies for the species they contain (Panzer and Schwartz 1998; Molina et al. 2011; Shuey et al. 2012). If examples of all coarse-filter elements are conserved at the scale at which they naturally occur, most of the species they contain—from the largest trees and mammals to the smallest insects—will also be conserved (Hunter 1991; NCASI 2004; Schulte et al. 2006). This approach is well-documented in the scientific literature (Jenkins 1985; Noss 1987; Hunter et al. 1988; Hunter 1991; Noss and Cooperrider 1994; Haufler et al. 1996; Jenkins 1996; Poiani et al. 2000; USDA 2004). By maintaining or enhancing these proxies, or coarse-filters, we can have high confidence we can efficiently conserve the majority of Vermont's native species.

Vermont Conservation Design identifies landscape-level and natural community and habitat-level coarse filters. We have very high confidence that this conservation design identifies areas and features essential for the long-term functioning of Vermont's landscape and the vast majority of the species it naturally contains. Efficiently conserving many species using coarse-filters means we can devote more time and resources to the species that cannot be conserved by proxy. These "fine-filter" species require specific management actions. Very rare species, whose distribution on the landscape is too infrequent and unpredictable to be captured by most coarse filters, and species with very specific habitat needs (such as grassland nesting birds that in Vermont are only associated with very specific agricultural mowing regimes) require additional considerations. A complementary "fine-filter" conservation approach is needed for these species and habitats,

To develop targets for coarse-filter features, we first had to identify a list of habitat and natural community-scale elements that could serve as coarse filters. After developing a long list, it became clear that the elements could be broken out into five broad categories:

- Natural communities
- Forest structures (old and young forest)
- Aquatic, wetland, and riparian habitats
- Open lands
- Subterranean habitats

For each category, a small workgroup was tasked with further refining each category into a list of targeted elements. To serve as efficient coarse filters, each element was selected based on unique functions that are not fully conserved by landscape-scale elements. For example, not all Dry Red Oak-White Pine Forests – an uncommon natural community type that provides important contributions to ecological function – will be conserved by protecting highest priority forest blocks. Therefore, this feature warrants a specific target at this scale. In contrast, Seeps are a common and widespread natural community, and we have high confidence that highest priority forest blocks conserve the ecological functions of seeps. So, seeps are not targeted as a feature at this scale. In some cases, particularly with aquatic and riparian features, the specific location of a feature may be 'captured' by both the landscape-scale and habitat and natural community-scale elements, however, the specific ecological functions and guidelines for conserving these functions may be different at each scale. Ultimately, the workgroups arrived at a set of 14 elements at this scale.

The workgroups then defined each element and its ecological functions. Using scientific data and professional judgement, they developed spatial and/or distributional targets for each element and identified guidelines for maintaining the ecological functions of each targeted element. The specific rationale and methods for these steps are described in the individual element descriptions later in this report. In general, workgroups aimed for target levels that, in concert with the landscape-scale elements, offered high-confidence in the long-term persistence of the element, and its contribution to ecological function.

Once a complete set of elements and targets was identified, we tested the overall design against a diverse list of more than 200 common species and Species of Greatest Conservation Need (SGCN). We identified which elements contributed to the conservation of each species, and whether in our judgement the proposed coarse filter targets were likely to meet the habitat needs of the species. Species whose needs were not met were designated as "Fine Filter" species and are expected to need species-specific management actions. We noted that some species can have their habitat needs met through coarse-filter conservation within Vermont, but that other factors can affect their long-term persistence threats outside of the state (for example, loss of out-of-state winter habitat for many birds and invertebrates or disease in cave-dwelling bats). We have indicated these cases in the analysis.

This analysis, or "conservation accounting," is a significant product of this effort. It identifies those species most in need of additional, specific actions, and helps focus our species conservation efforts. Ensuring that these fine-filter species are included in a long-term effort to maintain ecological function is a key component of Vermont Conservation Design.

In addition, this serves as the underlying support for the targets presented here. Testing the targets' ability to conserve many common species and SGCN not only demonstrates the efficacy of the selected targets for known species, but also adds to our confidence that the targets presented here will effectively conserve many other species – including cryptic and poorly understood species.

If the ecological functions of the landscape-scale and habitat and natural community-scale elements are maintained or enhanced, and each element maintained or restored to the abundance and distributions described here, the majority of Vermont's species are very likely to persist into the future.

In this report, we describe each of the 14 habitat and natural community-scale elements. We have identified a "priority" and "highest priority" target for each. The highest priority targets are those that are critical for an ecologically functional landscape. In some cases, these require restoration in order to achieve full ecological function. The priority targets are also important but there is more flexibility in conserving ecological function. The highest confidence in maintaining an ecologically functional landscape will be achieved by conservation of both priority levels.

Conserving Ecological Function

The goal for each targeted element is to maintain, restore, or enhance its ecological functions. As each feature has unique functions, the strategies and tools to achieve this will be diverse. A very rare, small patch natural community such as a Pitch Pine-Oak-Heath Rocky Summit might call for a minimalist approach – perhaps little more than invasive species control. In contrast, grassland areas for nesting birds require active agricultural management. Successfully implementing these targets will likely require the full range of conservation and management tools available.

People have been and will continue to be an integral part of the ecologically functional landscape. It is a landscape that provides many economic and societal benefits, and one with room for the people of Vermont. Indeed, with approximately 80% of Vermont's land privately-owned, management and stewardship of private lands will be essential to long-term conservation success.

Habitat and Natural Community Element Descriptions and Maps

The following sections describe the 14 elements that are targeted for maintaining ecological function. Each element includes a definition, a review of the element's ecological functions, priority targets for maintaining ecological function, and a summary of the methods and rationale used to arrive at the target. Maps are provided for all elements except caves and mines. Many of the target elements are poorly mapped or in some cases not even mapped at all. In these cases, the best available spatial information is shown; it is expected that these maps will be revised over time as improved data becomes available.

Natural Communities

Definition

A natural community is an interacting assemblage of plants and animals, their physical environment, and the natural processes that affect them. As these assemblages of plants and animals repeat across the landscape wherever similar environmental conditions exist, it is possible to describe these repeating assemblages as natural community types. There are 97 natural community types in Vermont, including Northern Hardwood Forest, Hemlock Forest, Subalpine Krummholz, Red Maple-Black Gum Swamp, and Cattail Marsh.

Ecological Function

Collectively, the 97 natural community types identified in Vermont, and their associated ecological processes (including forest succession and beaver disturbances), describe the full range of habitat conditions that the native flora and fauna evolved with and are adapted to survive in. Natural communities are places that currently support the vast majority of Vermont's biological diversity.

Natural communities are relatively stable in a human timeframe, but the species assemblages in natural communities have changed over thousands of years and will continue to shift in response to a changing climate. Sites with high-quality natural communities today represent physical landscape settings that are expected to continue to support important natural communities (and associated species) into the future. Rare natural communities typically include rare species or occur in environmental settings that are rare.

Priority Target for an Ecologically Functional Landscape

All state-significant natural community element occurrences (EOs). State-significant natural community element occurrences are those that meet ranking standards developed for each natural community type by the Vermont Fish and Wildlife Department based on assessment of community size, current ecological condition, and the ecological condition of the landscape in which the community occurs.

Highest Priority:

- S1 and S2 types: all known element occurrences (EOs);
- S3, S4 and S5 types: 50% of expected EOs distributed across biophysical regions in which they occur and within an intact and connected natural landscape whenever possible;
- Exceptions:
    - Montane Spruce-Fir Forest: all known EOs;
    - Northern Hardwood Forest, Red Spruce-Northern Hardwood Forest, and Hemlock-Northern Hardwood Forest are matrix forests types (widespread forests covering large areas of the Vermont landscape) and are explicitly captured by Old Forest targets and also captured as inclusions in forest blocks, not by EOs.
    - Seeps, because of their abundance, are captured by forest blocks and as inclusions within other natural communities and are not targeted here.
    - Vernal Pools are addressed separately, to account for their particular ecological functions.

Guidelines for Maintaining Ecological Function

Targeted natural communities should be maintained in or restored to a state of high ecological integrity. Ecological integrity is the structure, composition, and function of an ecosystem operating within the bounds of natural or historic disturbance regimes. This translates into several measurable characteristics:

- Natural community characterized by a predominance of native species.
- Species composition and physical conditions (soils, hydrology, etc.) largely unaltered by, or mostly recovered from, human disturbances.
- Natural disturbance processes predominate.

In general, high ecological integrity will correspond to an A or B- ranked element occurrence, and A-ranked condition, using Vermont Fish and Wildlife Department’s Natural Community Ranking Specifications.

Methods and Rationale

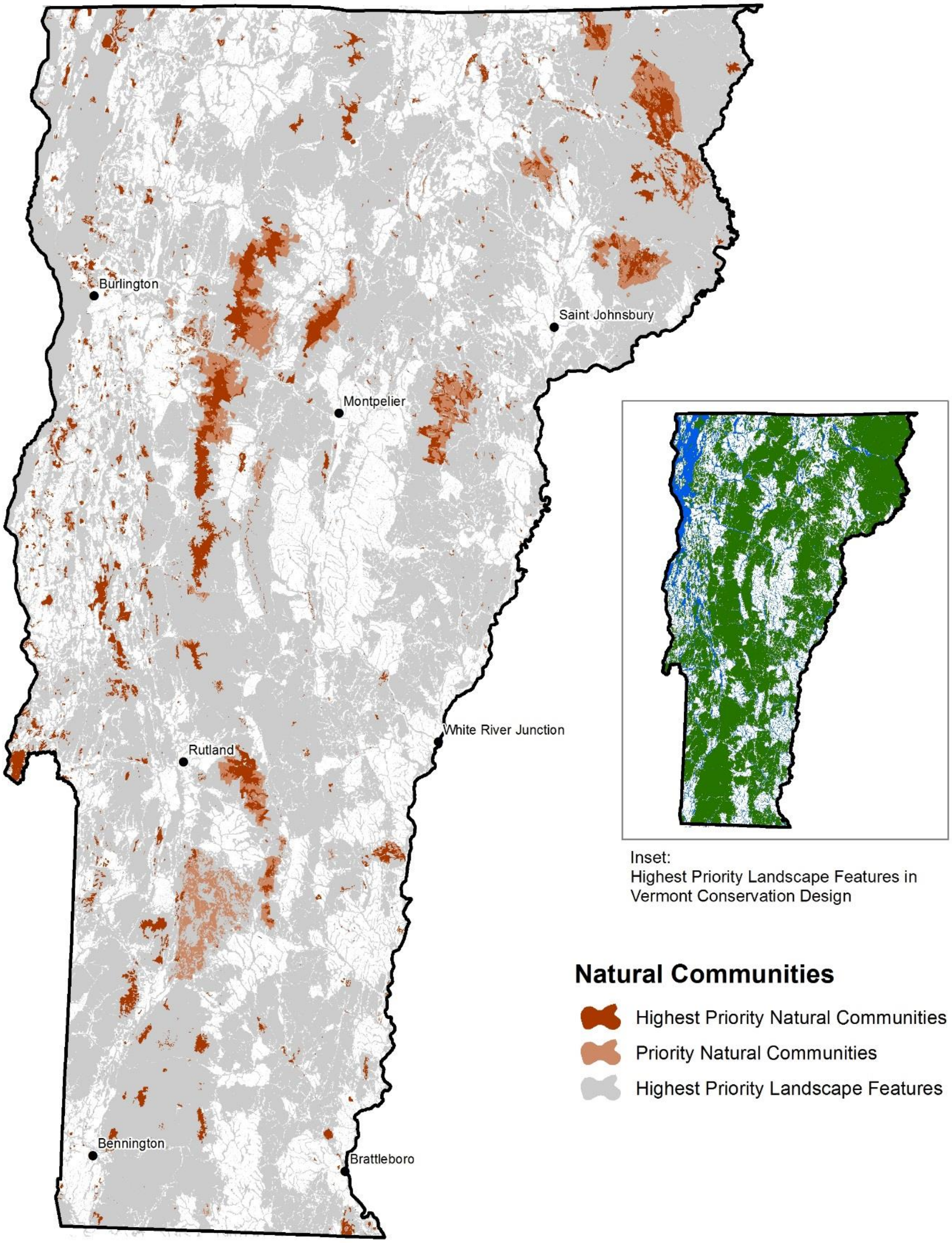
Natural communities are one of the most important "coarse filters" for conserving biological diversity (Hunter 1991, Thompson and Sorenson 2000). This is because there are relatively few natural community types (97 in Vermont) compared to the tens of thousands of plant and animal species. An efficient approach to conserve most species is to conserve high quality examples of all the natural community types across their natural range of distribution.

Selection of targets was based on professional judgement, with a goal to maintain viable examples of all of Vermont's natural community types distributed across the biophysical regions in which they occur and to represent natural community types relative to their rarity and natural distributional abundance, with greater representation of rare types. Rare natural communities occupy a small percentage of the landscape but contribute disproportionately to Vermont's biological diversity. More common natural communities are likely to be well-represented across the landscape, with many occurrences captured by the landscape scale elements of Vermont Conservation Design.

Mapping Comments

Mapping represents the best current knowledge of the location of targets on the ground. Mapped targets represent only about half of the overall conceptual goal. Additional natural community targets exist that are not represented in the map data. The gap between mapped natural community targets and conceptual goals for targets provides clear guidance on additional natural community inventory needs.

Map 1: Natural Community Targets



Note this mapping is incomplete and additional community occurrences exist that meet target criteria.

Young Forest

Definition

Young forest is forest habitat that is regenerating from natural or human disturbance and dominated by seedlings and saplings, regardless of natural community type (King and Schlossberg, 2014). It is defined as an area with greater than 50 percent cover of woody seedlings, shrubs, or saplings, up to 4.9" diameter, and at least 450 stems/acre. It includes early successional stands of shade intolerant pioneer species, as well as regenerating forest of mature forest species, such as sugar maple, hemlock, or red spruce. In general, young forest is comprised of trees less than 15-20 years old.

Ecological Function

Young forest habitat is recognized as essential to maintain viable, healthy populations of at least 65 species of wildlife in the northeast states (Gilbart 2012). Fifty-four Vermont Species of Greatest Conservation Need (SGCN) and 4 categories of insects (bumble bees, butterflies, moths, Carabid beetles) require or depend heavily upon young forest or old field/shrub habitat to maintain healthy populations. Young forest also supports many common species. Prior to European settlement in Vermont almost all young forest was created by natural disturbance. Currently, forest management creates the majority of young forest in the state.

Priority Target for an Ecologically Functional Landscape

A percentage of the forest in each biophysical region should be young forest:

- 5% of the forest in young forest condition: Northeastern Highlands, Northern Vermont Piedmont, and Northern Green Mountains
- 3-4% of the forest in young forest conditions: All other biophysical regions

Highest Priority:

Achieve the above percentage targets for young forest within VCD highest priority forest blocks, using the following acreages:

- Northeastern Highlands - 22,000 acres
- Northern Vermont Piedmont - 31,000 acres
- Northern Green Mountains - 36,000 acres
- Southern Green Mountains - 22,000 to 30,000 acres
- Southern Vermont Piedmont - 8,400 to 11,200 acres
- Taconic Mountains - 8,000 to 11,000 acres
- Vermont Valley - 1,050 to 1,400 acres
- Champlain Hills - 3,600 to 4,800 acres
- Champlain Valley - 5,700 to 7,700 acres

Guidelines for Maintaining Ecological Function

Provide young forest in discrete, contiguous blocks of at least 5 acres, with a minimum diameter of 375 feet, or in "Functional Equivalent Units." A Functional Equivalent Unit is created when a patch of young forest is created adjacent to an existing area of young forest <5 acres in size, so that the combined area is ≥5 contiguous acres of young forest with a combined diameter at of least 375 feet. Combined adjacent young forest may be a patch of regenerated forest, an area maintained by mowing, burning or herbicide such as a utility right-of-way, a successional old field, and/or young forest created by natural disturbance such as windthrow or beaver activity adjacent to these areas. When creating young forest through active management, locate young forest in common and widespread matrix natural communities. Design patches so they have a high interior to edge ratio. Prevent or control the spread of invasive plant species in young forest patches. The creation of young forest has the potential to impact other conservation targets and should be planned to avoid conflicts with other targeted elements.

Although the majority of young forest is expected to be created through active forest management, young forest resulting from natural disturbance also contributes to these targets. When practical, allow these disturbances to proceed under natural dynamics with little or no intervention. Maintaining residual structures such as downed wood and root tip ups can provide important habitat diversity in these places.

Restoration Needs

At present young forest is not adequately represented in all biophysical regions in Vermont. Creation of young forest through a combination of forest management and natural disturbance is needed to achieve these targets.

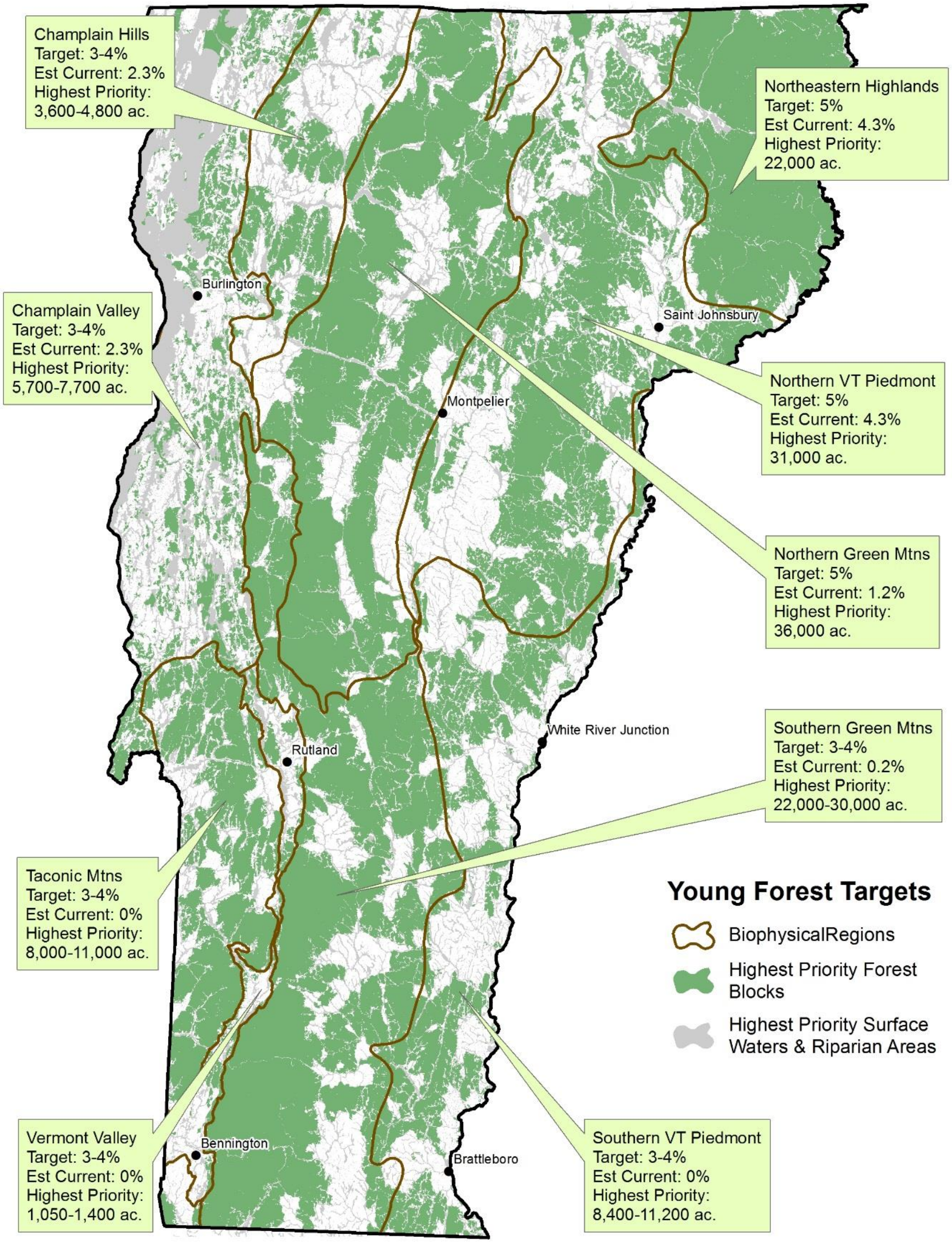
Methods and Rationale

Species requiring young forests have evolved with that habitat created by natural disturbance regimes. Since European settlement in Vermont, the abundance of young forest has varied widely, reaching a peak during the reforestation of the mid-20th century. Today, there is less young forest than before European settlement. A return to the pre-European abundance of young forest would reverse a declining trend and reach a level that at one time supported all of Vermont's native species that require young forest. Thus, target percentages of young forest condition in each biophysical region are based on the expected percentages of the regional landscape occupied by the 1-15 year age class before European settlement (Lorimer and White 2003) as applied to Vermont's forest cover (Darling et al. 2001). The patch size characteristics are recommended based habitat needs of young forest obligates as identified by multiple sources (Schlossberg and King 2007, Schlossberg and King 2015, Roberts and King 2017, Yamasaki et. al. 2014, Chandler et. al. 2009).

Mapping Comments

Young forest targets are not mapped. Spatial locations of young forest are dynamic and expected to change as a result of harvesting and natural disturbance patterns over time.

Map 2: Young Forest Percentage Targets by Biophysical Region



Highest Priority acreage represents the amount of young forest targeted within highest priority forest blocks. Est Current is best estimate of current percentage of young forest in the region, based on USFS FIA data.

Old Forest

Definition

Old forests are biologically mature forests, often having escaped stand-replacing disturbance for more than 100 years and exhibiting minimal evidence of human-caused disturbance as well as continuity of process, senescence of trees, and regeneration response. In addition, these forests may exhibit many of the following associated characteristics: 1) some trees exceeding 150 years in age for most forest types (100 years for balsam fir, 200 years for eastern hemlock); 2) native tree species characteristic of the forest type present in multiple ages; and 3) complex stand structures that include a broad distribution of tree diameters, multiple vertical vegetative layers, natural canopy gaps, abundant coarse woody material (reflecting the diameters of the standing trees) in all stages of decay and numerous large standing dead trees. It is expected that old forests operate under natural disturbance regimes and may include small areas of regenerating forest as a result of these disturbances.

Ecological Function

Historically, the vast majority of Vermont's landscape was old forest, and it is the original habitat condition for many species. The state's native flora and fauna that have been here prior to European settlement are adapted to this landscape of old, structurally complex forest punctuated by natural disturbance gaps and occasional natural openings such as wetlands or rock outcrops. The complex physical structure of old forests creates diverse habitats, many of which are absent or much less abundant in younger forests.

As a result of the persistent structural and vegetative complexity above ground and the diverse biome belowground and associated complex biotic and abiotic relationships that develop over time, old forests also protect water quality, and sequester and store carbon, provide opportunities for adaptation of species and community relationships to climate and other environmental changes, and an ecological benchmark against which to measure active management of Vermont's forests.

Priority Target for an Ecologically Functional Landscape

Within the matrix forest in the highest priority forest blocks in each biophysical region, 15% should be managed as, or for, an old forest condition. 4,000-acre minimum patch sizes are preferred as they are most likely to accommodate large-scale natural disturbance events. Smaller minimum patch sizes are offered for biophysical regions that are more fragmented and where only smaller forest blocks remain. Total Acres/minimum preferred patch sizes as follows:

- Champlain Hills - 13,000/1,000
- Champlain Valley - 15,000/500
- Northeastern Highlands - 59,000/4,000
- Northern Green Mountains - 95,000/4,000
- Northern Vermont Piedmont - 78,000/1,000
- Southern Green Mountains - 91,000/4,000
- Southern Vermont Piedmont - 31,000/1,000

- Taconic Mountains - 33,000/1,000
- Vermont Valley - 4,000/500

Matrix forest communities should be represented as old forest according to their natural distribution in each biophysical region. Patches of old forest that are smaller than the minimum preferred patch size also provide important ecological functions and contribute to the numerical goals for each biophysical region, but with the acknowledgement that these small patches are more susceptible to stand-replacing natural disturbance events and likely do not provide all the functions of larger, connected patches.

Highest Priority:
All of the above targets for old forest are highest priority.

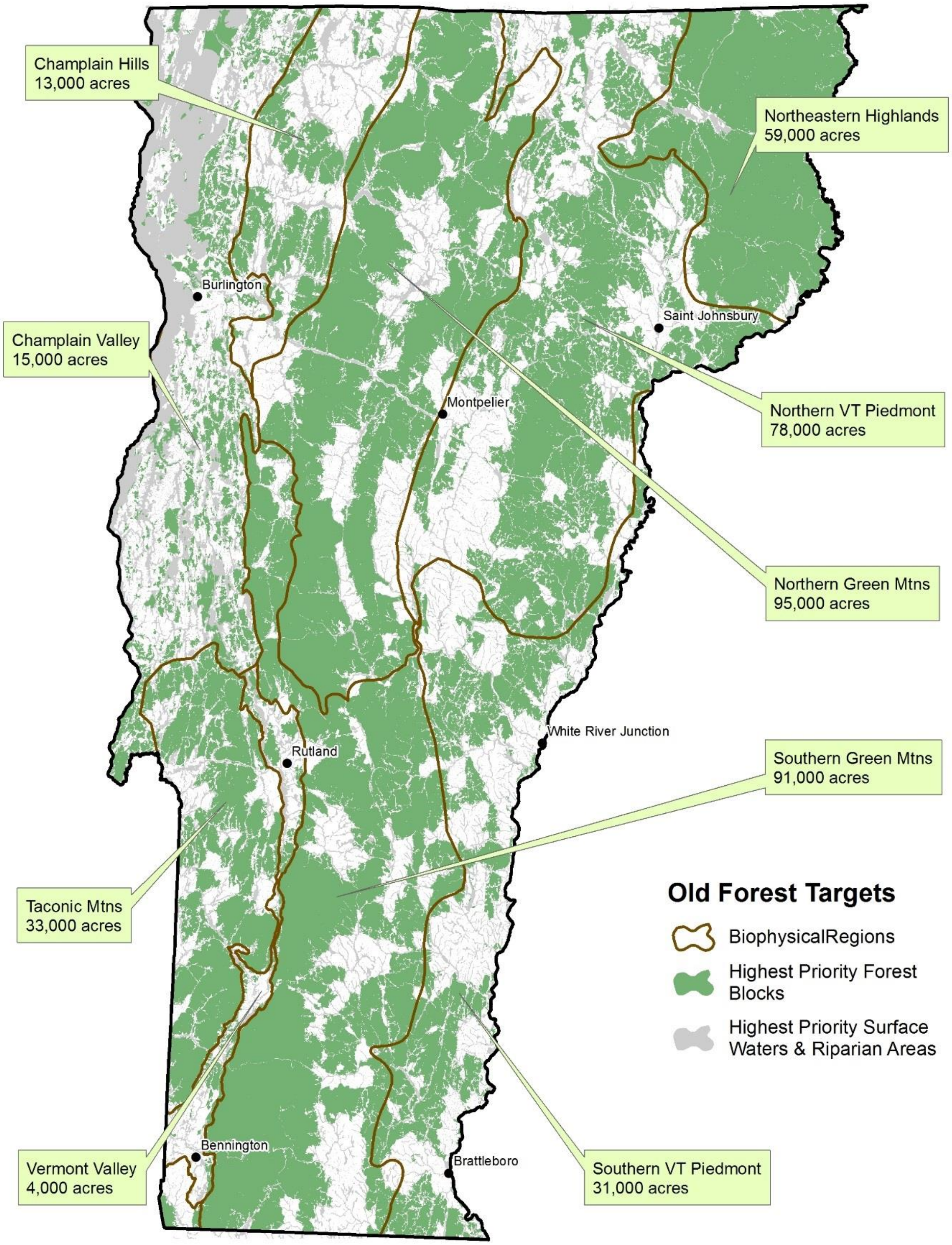
Guidelines for Maintaining Ecological Function
Old forests should operate under natural disturbance regimes, and need to be maintained in patches large enough to accommodate natural disturbance regimes without compromising old forest characteristics dominating the patch. Species composition and structures should be appropriate to the natural community type. The forest and natural community condition should not be significantly impacted by non-native plant species. Management may be needed to control invasive species or remediate human impacts, but management should not interfere with normal natural process or alter native species composition.

Restoration Needs
Although there are small patches of old forest scattered around the state, old forest is absent in Vermont as a functional component of the landscape. In most forests, passive restoration will result in old forest conditions. In some cases, active forest management may be beneficial to promote forest composition and structure suitable for subsequent passive restoration.

Methods and Rationale
The native species of Vermont evolved in a landscape dominated by old forest. Many of these species are well-adapted to the complex and diverse structure that develops in large areas of old forest. The closer the target is to the historic old forest condition, the greater the likelihood that the landscape will support all of Vermont’s native forest species and fully provide the forest’s ecological services. There are no known thresholds between the current forest condition (essentially no old forest) and the historic condition. We used professional judgement and consideration of natural disturbance regimes and the various ecological functions provided by old forest (Appendix C) to arrive at a target level we felt confident would reintroduce functioning old forest to the Vermont landscape. Minimum preferred patch sizes were established based on expected disturbance regimes (Lorimer and White 2003). These preferred patch sizes were adjusted down in biophysical regions where contiguous forest was limited by fragmentation and non-forest area.

Mapping Comments
Old forest targets are not mapped due to a lack of spatial information at this time.

Map 3: Old Forest Acreage Targets by Biophysical Region



Old forest acreage targets within the highest priority forest blocks in each biophysical region.

Important Aquatic Habitats and Species Assemblages – Rivers and Streams

Definition

These are set of river and stream reaches with known concentrations of rare species or high species diversity, or which are good examples of aquatic habitat conditions. Collectively, they are representative of the full range of stream sizes, gradients, and temperature conditions in Vermont, as identified by Anderson et al (2013).

Ecological Function

Rivers and streams are a fundamental component of an ecologically functional landscape, and provide essential habitat for aquatic species, including fish, amphibians, reptiles, invertebrates, and plants. Particular river and stream reaches make exceptional contributions to Vermont's biological diversity, because of their unique physical characteristics arising from geology or topography, or because they are good examples of aquatic habitats. These places support many species and are crucial parts of Surface Waters and Riparian Areas network, but they also depend on the successful functioning of the entire aquatic network.

Representing elements of physical diversity increases the likelihood that species can shift on the landscape – or in this case, within the aquatic network – to find suitable habitat in response to climate change (Anderson and Ferree 2010; Beier and Brost 2010; Beier et al. 2015). Conserving the physical diversity of rivers and streams helps aquatic systems adapt and be resilient to climate change.

Priority Target for an Ecologically Functional Landscape

The following river and stream reaches:

- Lake Champlain tributaries upstream to the fall line
    - Large rivers: Missisquoi River, Lamoille River, Winooski River, Mallets Creek, LaPlatte River, Lewis Creek, Otter Creek, Poultney River, East Creek
    - All other small rivers and streams that drain directly into Lake Champlain
- Large coldwater streams
    - Batten Kill from New York-Vermont border upstream on the main stem Batten Kill to elevation 798 feet (East Dorset) and on the West Branch to elevation 926 feet (Dorset Marsh in Dorset).
    - Castleton River from Whipple Hollow Road in West Rutland Marsh (West Rutland) to confluence with Poultney River (Fair Haven).
- High elevation coldwater streams
    - All streams above 1,400 feet elevation
- Connecticut River
    - Upper Connecticut River: this reach is delineated to the north by the state line (River Mile 319.0) and just upstream of Moore Reservoir (River Mile 247.0).
    - Lower Connecticut River below River Mile 120.0 to the state line.
- Connecticut River tributaries that are part of important wetland complexes

    - Nulhegan River complex; Manchester Brook/Symes Pond complex; Jewett Brook complex; Moose River/Victory Bog complex; Wheeler Stream/Dennis Pond Brook complex
- High-quality reaches with representative physical diversity
    - As mapped, including but not limited to reaches of: Barton River, Black River (Memphremagog), Clyde River, Furnace Brook, Hubbardton River, Huntington River, Lamoille River, Mettawee River, Middlebury River, Missisquoi River, Moose River, Neshobe River, New Haven River, Nulhegan River, Otter Creek, West River, White River, and Winhall River.

Highest Priority: All the river and stream reaches described above.

Guidelines for Maintaining Ecological Function

River and stream reaches with important aquatic habitats and species assemblages must be part of a fully functioning network of surface waters and riparian areas. Although reaches with exceptional biological contributions can be identified, they cannot function independent of this larger network.

The ecological integrity of an aquatic system is dependent on the condition of the watershed in which it occurs but is also critically tied to the condition of the adjacent riparian area. River channel equilibriums need to be maintained or restored. Artificial barriers to aquatic organism movement (culverts, dams, etc.) should be removed or mitigated. Natural riparian vegetation should be maintained or restored to protect water quality, stabilize shorelines, and provide shade and the recruitment of downed wood and other natural organic matter. For full ecological function, this naturally vegetated area should encompass the entire mapped valley bottom riparian area. When this is not possible, a minimum 100-foot wide vegetated area adjacent to the stream or river will protect many, but not all, riparian functions. Aquatic vegetation should be maintained. The underwater physical substrate should be maintained or restored to provide suitable habitat conditions for foraging, shelter, and reproduction of aquatic organisms.

Restoration Needs

Removal of artificial barriers and restoration of natural riparian vegetation is needed to reach full ecological function.

Methods and Rationale

River and stream reaches that are targeted as Important Aquatic Habitats and Species Assemblages were selected using professional judgement. Specific reasoning behind each selection is listed below:

- Lake Champlain tributaries upstream to the fall line: Due to the influence of biogeography, these waters support native fish and mussel species from two glacial refugia. Unlike the remainder of Vermont waters which were populated only by eastern species, the mid- and lower elevation waters in the Champlain drainage contain both eastern and western species resulting in streams that support greater numbers of species than streams of similar size elsewhere in Vermont. Due to the direct connection with Lake Champlain, these waters also provide habitats necessary for the support of Lake Champlain populations.

- Large coldwater streams: Large streams with specific geologic and hydrologic features that support coldwater species assemblages due to the combination of high alkalinity and abundant cold baseflow from groundwater inputs.
- High elevation coldwater streams: Streams characterized by simple, cold water obligate aquatic communities dominated by native species, especially brook trout and sculpin. These streams will be the refugia for cold water obligate taxa under predicted climate change warming in the next century.
- Upper Connecticut River: supports burbot, round whitefish, and coldwater fish communities.
- Lower Connecticut River: the historic upper limit of American shad in the river, and habitat for American eel, anadromous sea lamprey, blueback herring and alewife floater (mussel).
- Connecticut River tributaries that are part of important wetland complexes: good examples of wetland-influenced aquatic habitats and known occurrences of rare species
- Reaches representing the range of physical conditions in aquatic features, as categorized by stream size, gradient, and temperature setting, providing a coarse filter for capturing the habitat and needs of many aquatic species including invertebrates and aquatic plants.

Mapping Comments

The map layer is a complete representation of the priority and highest priority targets, except it does not show all streams above 1,400 feet in elevation. These streams, regardless of mapping, are considered highest priority at this scale. Otherwise, all highest priority river and stream reaches with important aquatic habitats and species assemblages are mapped as part of the "Important Aquatic Habitats and Species Assemblages" layer. This layer also includes lakes and ponds with equivalent contributions to biological diversity.

Map: Important Aquatic Habitats and Species Assemblages

River and stream, and lake and pond targets for Important Aquatic Habitats and Species Assemblages are mapped together. See map page 23.

Important Aquatic Habitats and Species Assemblages – Lakes and Ponds

Definition

These are lakes and ponds with known concentrations of rare species, exceptional species diversity, or which are examples of high-quality aquatic habitat.

Ecological Function

Lakes and ponds are essential habitat for many of Vermont's aquatic species, including fish, amphibians, reptiles, invertebrates, and plants. Some lakes and ponds make exceptional contributions to Vermont's biological diversity, because of their unique physical characteristics arising from their water chemistry and physical setting, or because they support concentrations of rare or uncommon species. These lakes and ponds are crucial parts of Surface Waters and Riparian Areas network, but they also depend on the successful functioning of the entire aquatic network.

Priority Target for an Ecologically Functional Landscape

The following lakes and ponds:

- Lake Champlain
- Lakes and ponds supporting round whitefish and/or naturally reproducing lake trout: Great Averill, Little Averill, Beaver, Caspian, Crystal, Echo (Charleston), Elligo, Seymour, Willoughby
- Rutland County Lakes: Austin, Beebe, Black, Breese, Burr, Choate, Doughty, Echo, Halfmoon, High, Hinkum, Hough, Huff, Johnson, Mill (Benson), Mud (Benson), Mudd (Hubbardton), Perch, Roach, Spruce, Sunrise, Sunset, Walker
- High elevation ponds: Bourn and Branch (Sunderland), Stratton (Stratton), Lake Pleiad (Hancock), North Pond (Chittenden), Griffith Lake (Mount Tabor), Big Mud (Mount Tabor), and Little Rock (Wallingford)
- Wild Brook Trout ponds: Beck Pond, Cow Mountain Pond, Hidden Pond, Jobs Pond, Lake Pleiad (Hancock), Martins Pond, North Pond (Chittenden), Unknown Pond (Avery's Gore), West Mountain Pond

Highest Priority: All the lakes and ponds listed above.

Guidelines for Maintaining Ecological Function

Lakes and ponds with important aquatic habitats and species assemblages must be part of a fully functioning network of surface waters and riparian areas.

The ecological integrity of an aquatic system is dependent on the condition of the watershed in which it occurs but is also critically tied to the condition of the adjacent riparian area. Natural riparian vegetation should be maintained or restored to protect water quality, stabilize shorelines, and provide shade and the recruitment of downed wood and other natural organic matter. For full ecological function, this naturally vegetated area should encompass the entire mapped valley bottom riparian area. When this is not possible, a minimum 250-foot wide vegetated area adjacent to the lake or pond will protect many, but not all, riparian functions. Developed shorelines that cannot be fully restored should minimize runoff, erosion, and other negative impacts to water quality and shoreline stability. Aquatic vegetation should be maintained, and invasive species controlled. The underwater physical substrate should be maintained or restored to provide suitable habitat conditions for foraging, shelter, and reproduction of aquatic organisms.

Restoration Needs

Restoration of natural riparian vegetation is needed to reach full ecological function.

Methods and Rationale

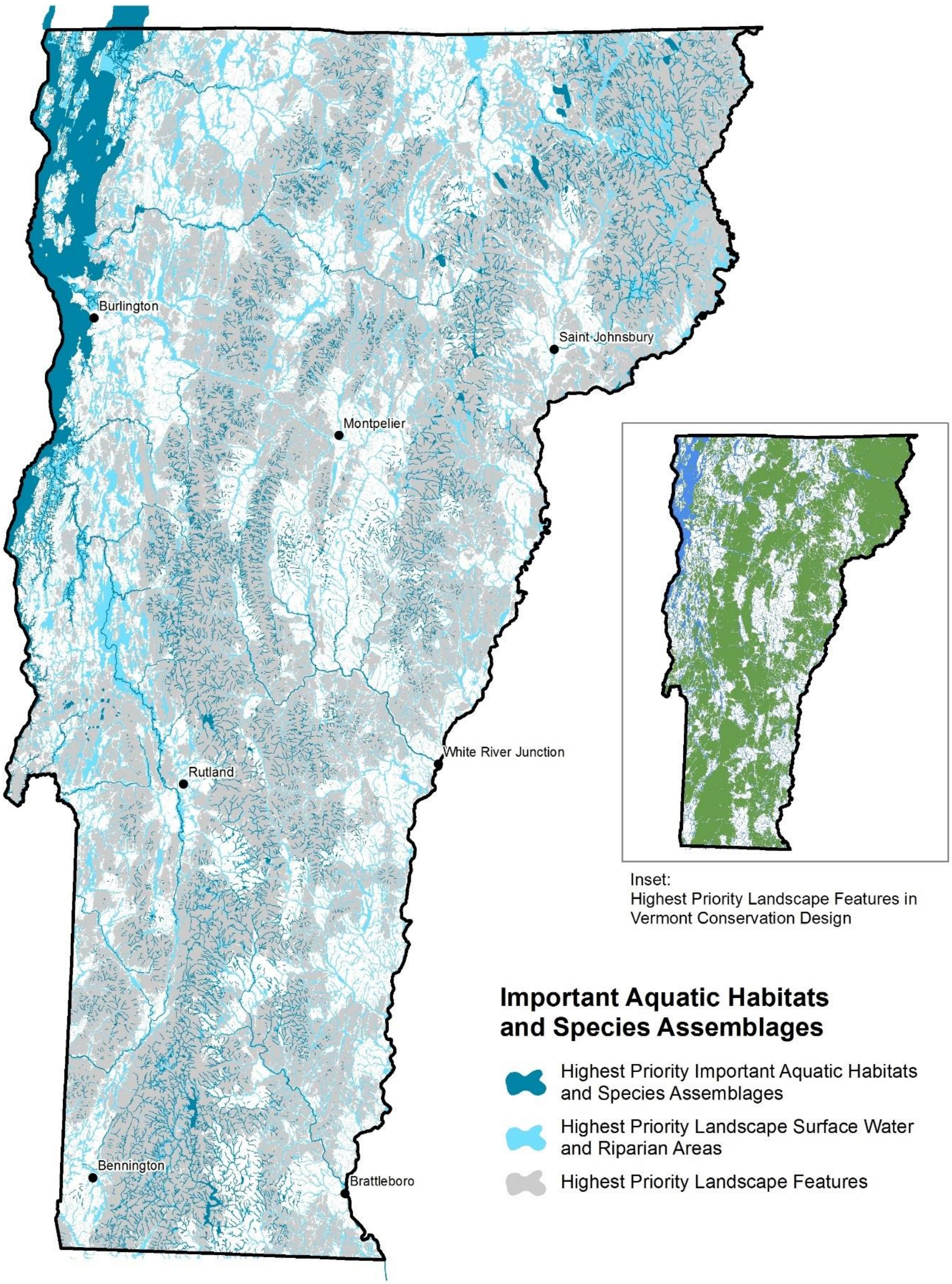
Conserving lakes and ponds with known contributions to biological diversity helps ensure that all aquatic species are maintained as part of the ecologically functional landscape. Lakes and ponds that are targeted as Important Aquatic Habitats and Species Assemblages were selected using professional judgement. Specific reasoning behind each selection is listed below:

- Lake Champlain: due to the influence of biogeography, Lake Champlain supports native fish and mussel species from two glacial refugia.
- Lakes and ponds supporting round whitefish and/or naturally reproducing lake trout are limited in the state and conserve these rare and uncommon species
- Rutland County Lakes: supporting or expected to support species assemblages including blackchin shiner, bridle shiner, blacknose shiner, and redfin pickerel.
- High elevation ponds: habitats characterized by simple, cold water obligate aquatic communities.
- Wild brook trout ponds: the presence of self-sustaining wild brook trout populations in ponds indicates good water quality and habitat conditions expected to benefit many aquatic species.

Mapping Comments

The map layer is a complete representation of the priority and highest priority targets. All highest priority lakes and ponds with important aquatic habitats and species assemblages are mapped as part of the “Important Aquatic Habitats and Species Assemblages” layer. This layer also includes river and stream reaches with equivalent contributions to biological diversity.

Map 4: Important Aquatic Habitats and Species Assemblages



Important Aquatic Habitats and Species Assemblages targets, including both lakes and ponds as well as rivers and streams.

Representative Lakes and Ponds

Definition

These are a subset of all lakes and ponds that occur in Vermont that represents the majority of lake types and examples of each type that are in the best condition for that type. The lakes and ponds are classified based on their trophic status, depth, and alkalinity, which are generally the main factors that shape biological communities in lakes (Wetzel 2001).

Ecological Function

Lakes and ponds provide critical habitat for many species of fish, amphibians, reptiles, invertebrates (e.g., insects, mussels, snails, worms, freshwater sponges), and plants. They also provide supporting habitat for many terrestrial wildlife species such as otter, mink, deer and moose. The distribution of species found in Vermont's lakes and ponds is partially the result of variations in their physical and chemical nature. The lakes and ponds in this component are therefore a tool for ensuring that this physical and chemical variation and the aquatic habitats and species assemblages they support are adequately represented.

Priority Target for an Ecologically Functional Landscape

The 72 lakes and ponds in the table below (next page):

Table: Representative Lakes and Ponds Targets

	Low Alkalinity		Moderate Alkalinity		High Alkalinity	
	Lake	***Pond***	***Lake***	***Pond***	***Lake***	***Pond***
Dystrophic	*Branch** Turtle* Wheeler (Brunswick)* *Haystack* *Bourn*	Cow Mountain Dennis*, McConnell* West Mountain* *Little (Woodford)* *Big Mud (Mt. Tabor)*				
Ultra-Oligotrophic	*No Lakes*	*No ponds*	Crystal (Barton)* Willoughby*	*No ponds*	*No lakes*	*No ponds*
Oligotrophic	Great Averill* Little Averill* Sunset (Marlboro)*	Norford*	Echo (Plymouth)* Miller** Woodward*	*No ponds*	Caspian*	Mitchell**(see note below)
Mesotrophic	Grout* Holland* Green River*(see note below)	Kettle* Lewis* Schofield* Tiny**	Bald Hill Buck** Hinkum** Long (Greensboro)** Long (Sheffield) Mud (Westmore)-W Round (Sheffield)	Blake (Sutton)* Bruce** Flagg** Fosters** Lower Symes** Milton** Stannard** Upper Symes**	Black (Hubbardton)* Rood* Warden*	Jobs* Johnson (Orwell)** Little Hosmer* Mud (Leicester)**
Eutrophic	Chittenden* Minards* Silver (Georgia)*	Little (Franklin)* Mile* Spruce (Orwell)**	Glen** High (Sudbury)** Spring (Shrewsbury)*	Molly's* Mud (Morgan)-N* Toad (Charleston)*	Great Hosmer* Inman** Vail Zack Woods**	Indian Brook** Lily (Poultney)* Tildy's*
Lake Champlain	Lake Champlain includes parts in different trophic levels.					
* Top three lakes in best condition for each class of lakes, in some cases these are also the only lakes in a particular class (n=52) ** Lakes in best condition in the state: In Vermont Lake Score Card they score good for watershed disturbance, lakeshore disturbance and water quality status (n=21). Underline denotes climate change reference research lakes (n=15). *Italics* denotes core acid rain research lakes (n=5). Note: Green River Reservoir and Indian Brook Reservoir are artificially maintained lakes and pond that potentially conflict with goals for maintaining the overall ecological functions of surface waters and riparian areas; however, these places are recognized here because they make important contributions to biological and physical diversity in their current condition.						

Highest Priority: All the lakes and ponds in the table above. A total of 72 lakes and ponds.

Guidelines for Maintaining Ecological Function

Maintain all representative lakes and ponds within an ecologically functional network of surface waters and riparian areas. Maintain or restore the ecological integrity of aquatic habitats and their riparian areas and watersheds. Excellent water quality, natural geophysical conditions, and native aquatic and terrestrial vegetation appropriate to the lake or pond are all needed in both the waterbody and surrounding watershed to maintain natural habitat structure and function. Natural riparian vegetation should be maintained or restored to protect water quality, stabilize shorelines, and provide shade and the recruitment of downed wood and other natural organic matter. Uninterrupted aquatic connectivity for lakes and ponds with connections to the larger network of surface waters.

Restoration Needs

Restoration of natural riparian vegetation is needed to reach full ecological function.

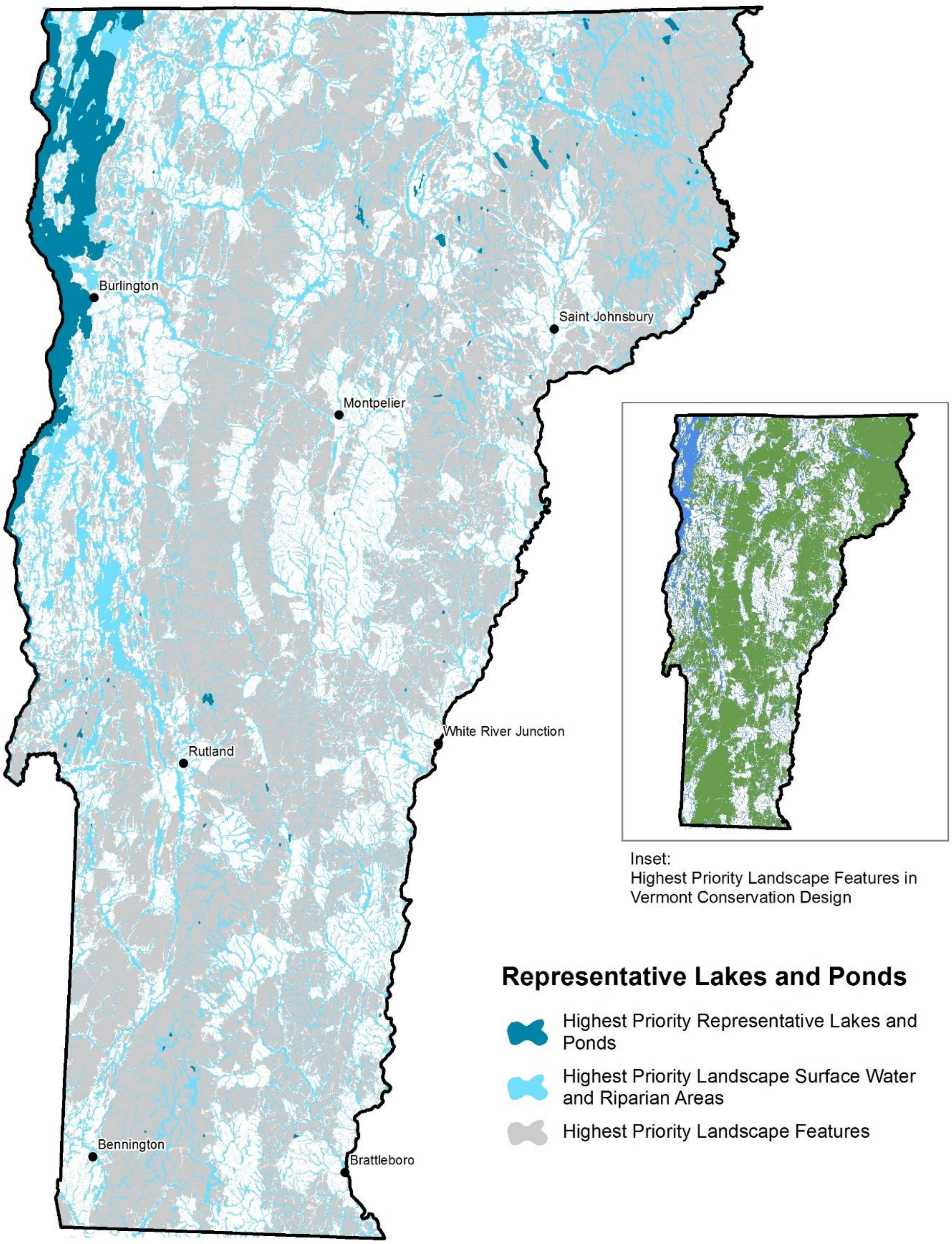
Methods and Rationale

Parallel to physical diversity and the landscape scale, conserving representative examples of all lake and pond types increases the likelihood that the full diversity of aquatic species is maintained. Vermont lakes and ponds were grouped into different classes based on their trophic status, depth, and alkalinity, which are generally the main factors that shape biological communities in lakes (Wetzel 2001). Twenty-six classes of lakes were identified, with each class expected to support biological communities unique to that class. No lakes in Vermont fall into six of the classes. Lakes that are Hypereutrophic due to excessive amounts of phosphorus pollution were not included as targets at all. To ensure the existing biological diversity of Vermont lakes is conserved into the future, at least some lakes and ponds in each class should be protected from anthropogenic impacts that would stress, alter or impair the biological community they support. Hence, within each class, three lakes in the best condition were identified as conservation targets. For some classes, these are all the lakes that exist in that class and their current condition may not be very good. The twenty-one lakes that are currently in the best condition in the state were also included as conservation targets. These are the lakes that score good for watershed disturbance, lakeshore disturbance and water quality status in the VT Department of Environmental Conservation's Vermont Lake Score Card. Also important to setting long term conservation targets for biological communities in lakes and ponds is an understanding of how atmospheric pollution and climate change are affecting them. Hence, the fifteen lakes and ponds used as reference research lakes for the long-term monitoring of climate change and five of the lakes and ponds essential for the long-term monitoring of acid rain impacts were also included as conservation targets. In total, 72 lakes and ponds were ranked as the highest priority because they met at least one of the above criteria.

Mapping Comments

The map layer is a complete representation of the priority and highest priority targets. All targeted lakes and ponds are identified in the map layer.

Map 5: Representative Lakes and Ponds Targets



Wetlands

Definition

Wetlands are vegetated ecosystems characterized by abundant water. All wetlands have three characteristics in common. First, all are inundated by or saturated with water during varying periods of the growing season. Second, they contain wetland or hydric soils, which develop in saturated conditions and include peat, muck, and mineral soil types. Finally, wetlands are dominated by plants that are adapted to life in saturated or inundated soils. Vermont's wetlands range in size from vernal pools and seeps that may be a few hundred square feet or less to vast swamps and marshes occupying thousands of acres along Otter Creek and Lake Champlain. (Note that vernal pools, although a type of wetland, are treated separately in this project because of their unique ecological functions.)

Ecological Function

Few natural systems have been studied as much for their ecological functions as have wetlands. Wetlands store large volumes of water and attenuate downstream flooding, a function that is likely to increase in importance in Vermont as climate change brings more frequent and larger storm events. Wetlands help maintain surface water quality by trapping sediments and removing nutrients and pollutants from surface waters before that water reaches streams or lakes. Vegetated wetlands along the shores of lakes and rivers can protect against erosion caused by waves along the shorelines during floods and storms. Many wetlands are associated with groundwater discharge and form the headwaters of many cold-water streams, another function that is likely to increase in importance with the expected warming and reduction in snowpack associated with climate change. Wetlands are well known for the critical wildlife habitat they provide for many species of birds, mammals, reptiles, amphibians, and insects, but some wetlands also provide critical spawning and nursery habitat for fish species. Although wetlands occupy only about five percent of the land area in Vermont, they provide necessary habitat for the survival of a disproportionately high percentage of the rare, threatened, and endangered species in the state. Examples of wetland dependent rare species include Calypso orchid, Virginia chain fern, marsh valerian, sedge wren, spotted turtle, and four-toed salamander.

Priority Target for an Ecologically Functional Landscape

All wetlands in Vermont with significant functions (Class 1 or 2). Note that vernal pools, a specific type of wetland, are treated separately.

Highest Priority: Any wetland that meets one or more of the following conditions:

- Is designated as a Class 1 wetland, or has characteristics and functions likely to meet the Class 1 standards (Potential Class 1)
- Is an exemplary (state-significant) wetland natural community occurrence, or is immediately adjacent to one
- Is wholly or partially within any of the highest priority landscape scale elements of Vermont Conservation Design

- Is wholly or partially within a small watershed with >50% of the land area developed
- Is wholly or partially within an important watershed for Lake Champlain water quality:
    - Missisqoui River watershed
    - South Lake A & B watersheds

Guidelines for Maintaining Ecological Function

Maintain or restore natural ecological processes, including unaltered soils and hydrology, native vegetation appropriate to the site, and suitable conditions for native fish and wildlife species. Effective conservation should include appropriate upland buffer zones, the ecological processes that support wetlands (especially hydrology), and a network of connected lands, waters, and riparian areas to allow ecological exchange between wetlands, including the ability of component species to shift over time in response to changing environmental conditions.

Restoration Needs

More than 35% of the original wetlands in Vermont have been lost to agriculture, development, and other land uses. Restoration of these wetlands is needed to achieve full ecological function.

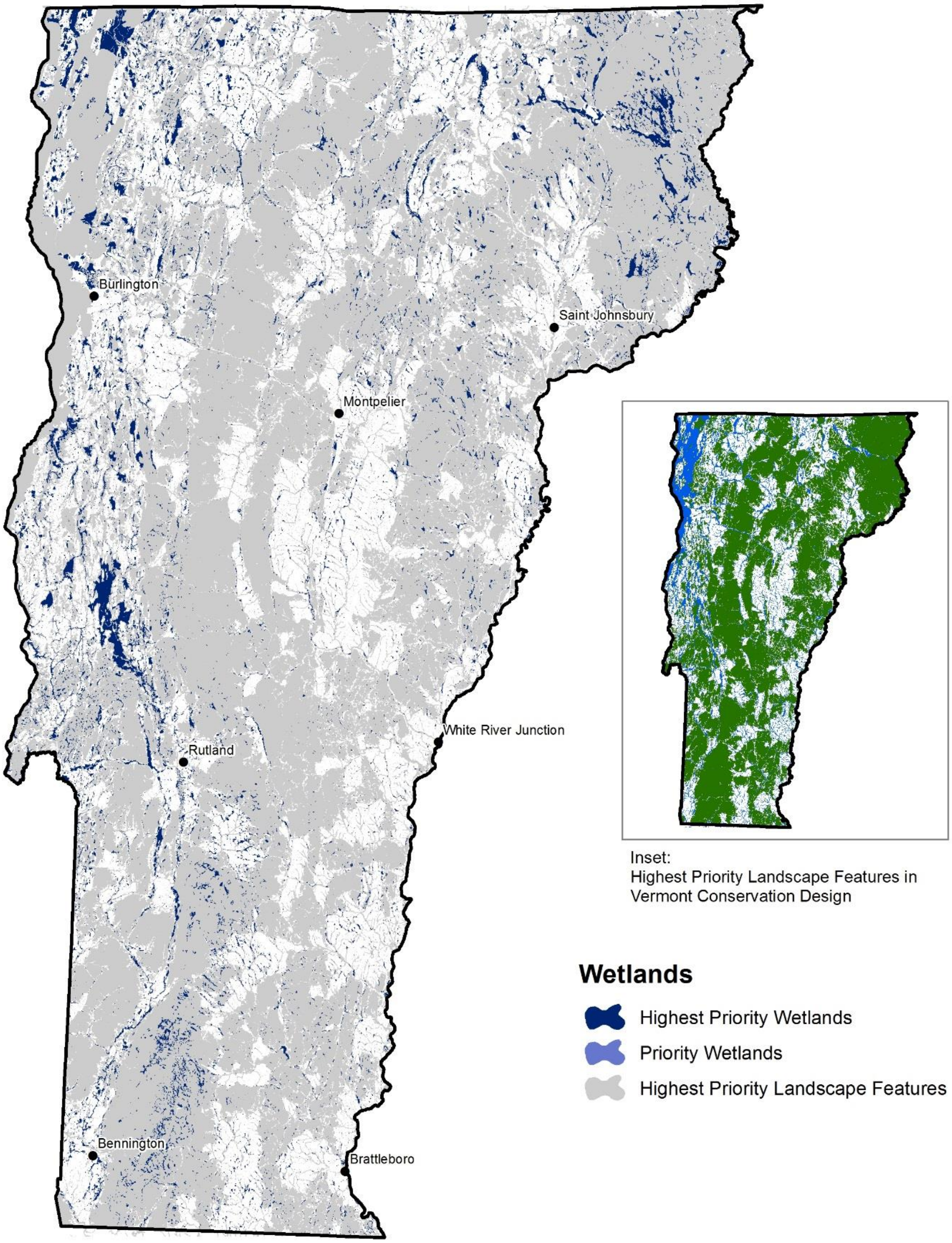
Methods and Rationale

Wetlands occupy a small portion of the Vermont landscape but contribute crucial ecological functions. Criteria for highest priority wetlands were selected in order to identify wetlands that make exceptional contributions to biological diversity or water quality, or which are inseparable from the functioning of the landscape scale elements of Vermont Conservation Design.

Mapping Comments

The map layer is an incomplete representation of the priority and highest priority targets. Mapping represents the best current knowledge of the location of targets on the ground. The approximate location of wetland targets is shown using VSWI, NWI, and Natural Heritage data sources. All polygons are approximate. Additional wetlands exist that are not represented in the map data. Field verification may be needed to confirm that any wetland meets the target criteria and provides appropriate ecological functions.

Map 6: Wetland Targets



Note that wetlands mapping is incomplete and there are additional wetlands that meet target criteria.

Vernal Pools

Definition

Vernal pools and their surrounding 650’ life zone. Vernal Pools are small (generally less than one acre), ephemeral pools that occur in natural basins within upland forests. They typically have no permanent inlet or outlet streams and have very small watersheds. Vernal pools are defined by the physical and hydrologic characteristics of the basin and by the animal species associated with the pool, including mole salamanders, wood frogs, and invertebrates.

Ecological Function

Vernal pools are best known as critical breeding habitat for mole salamanders (spotted salamander, blue-spotted salamander, and Jefferson salamander), eastern four-toed salamander, and wood frog. These species are considered vernal pool indicator species, meaning they cannot reproduce without access to a vernal pool. All these species migrate to vernal pools for spring breeding from adjacent upland forests where they spend the majority of their life cycles. Eggs are laid in the pools and amphibian larvae develop and mature there and then move to the adjacent forest. Studies indicate that the majority of the amphibians using a pool for breeding are found within 650 feet of the pool during the non-breeding season (Semlitsch 1998). Vernal pools are also important for other species, including fairy shrimp, fingernail clams, spring peepers, American toad, and several plant and wildlife species. Vernal pools and the species that rely on them are particularly vulnerable to hydrologic changes to their small watersheds. For example, development and climate driven changes in runoff volume and pool duration may render them less suitable amphibian breeding habitat.

Priority Target for Maintaining an Ecologically Functional Landscape

All vernal pools that are regularly used by spotted salamander, Jefferson salamander, blue-spotted salamander, or wood frog.

Highest Priority: All vernal pools within a VCD highest priority forest block or the VCD highest priority surface water and riparian areas, that are regularly used by spotted salamander, Jefferson salamander, blue-spotted salamander, or wood frog.

Guidelines for Maintaining Ecological Function

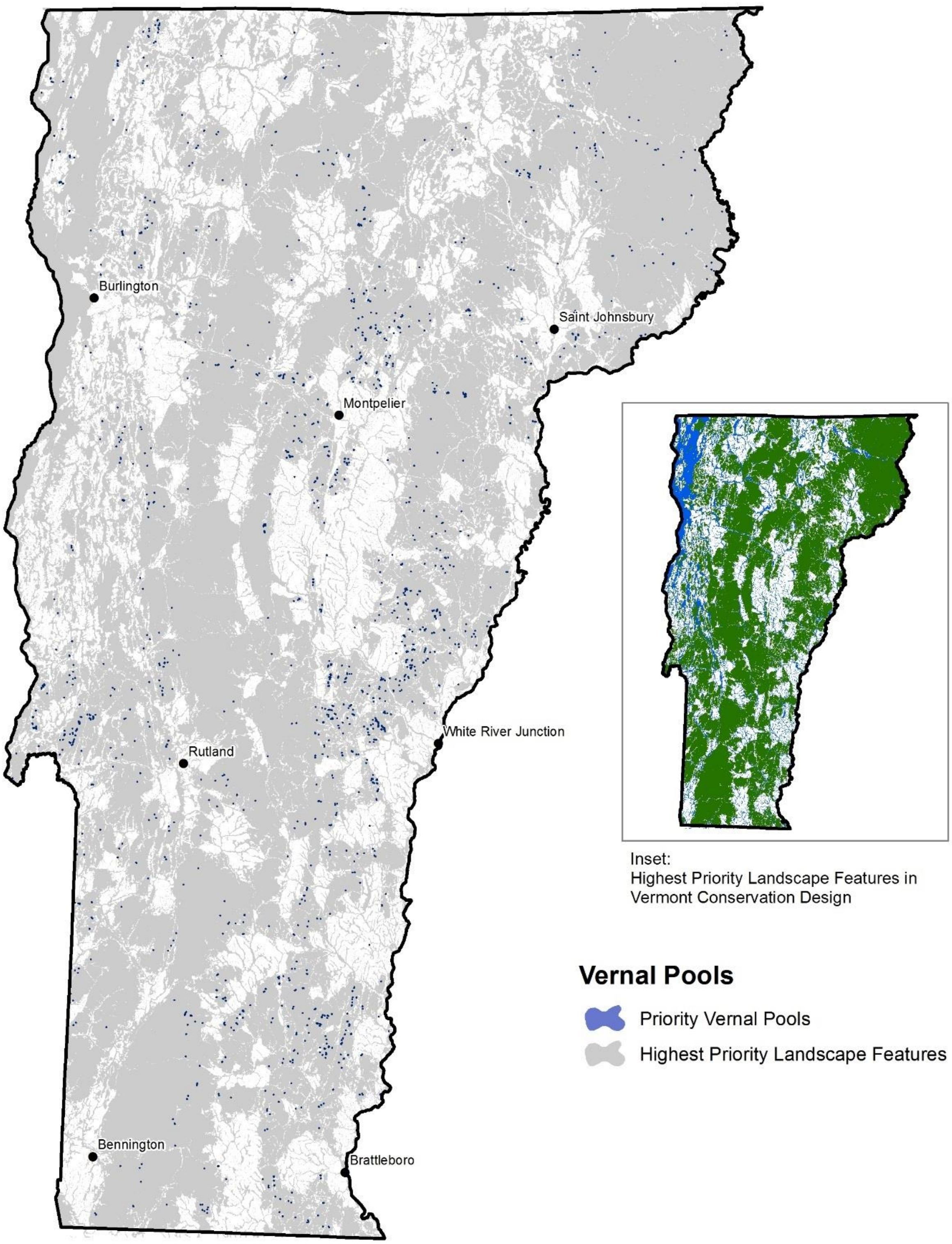
Maintain or enhance conditions in and around the pool for pool-breeding obligate species. The pool's small watershed should have little if any alteration to natural hydrology that would affect runoff volume, pool duration, or water quality. The pool structure should be unaltered by, or mostly recovered or restored from, past human disturbances. Maintain or restore a closed forest canopy with native species, abundant coarse woody debris, and a lack of artificial barriers to salamander movement in the 650 feet of forest adjacent to the vernal pool.

Restoration Needs
As with other wetland types, many of Vermont's original vernal pools have been lost to development or other land uses. Restoration of vernal pools may be beneficial in some parts of the state.

Methods and Rationale
Vernal pools contribute unique ecological functions. Those that occur within the highest priority landscape scale elements of Vermont Conservation Design are most likely to provide for the full life needs of pool obligate species.

Mapping Comments
The map layer is an incomplete representation of the priority and highest priority targets. Mapping represents the best current knowledge of the location of targets on the ground. Vernal pool mapping includes pool locations and the 650' upland forest zone. Mapped data include both confirmed pool locations and locations that have a very high likelihood of pool occurrence and are noted as such in attribute data. Field verification is needed to confirm that these likely pools meet the target criteria and provide appropriate ecological functions. Additional target pools exist that are not represented in the map data.

Map 7: Vernal Pool Targets



Note that vernal pool mapping is incomplete and there are additional wetlands that meet target criteria.

Valley Bottom Riparian Restoration Areas

Definition
These riparian restoration areas are portions of the valley bottom that are undeveloped but notably lacking in natural vegetation. Valley bottoms are a landform representing areas with active river processes and/or wetlands and associated relatively flat areas (Ferree and Thompson 2008). They are defined as areas through which rivers and streams migrate over time and where seasonal river or stream flooding is expected, and adjacent wetlands and areas with gentle slopes.

Ecological Function
The ecological integrity of an aquatic system is dependent on the condition of the watershed in which it occurs but is also critically tied to the condition of the riparian area adjacent to the stream or pond. For stability, rivers and streams must have access to their floodplains and freedom to meander within their valley bottoms or river corridors. Naturally vegetated riparian areas provide many significant ecological functions, including stabilizing shorelines against erosion, storage and slowing of flood waters, filtration and assimilation of sediments and nutrients, shading of adjacent surface waters to help moderate water temperatures, and direct contribution of organic matter to the surface water as food and habitat structure. Riparian areas are also very essential habitat for many species of wildlife that are closely associated with the terrestrial and aquatic interface, including mink, otter, beaver, kingfisher, spotted sandpiper, and wood turtle. The shorelines and riparian areas of rivers and lakes support floodplain forests, several other rare and uncommon natural communities, and many species of rare plants and animals. In addition to these ecological functions that are tied to aquatic systems, the linear network of riparian areas provides a crucial element of landscape connectivity for plant and animal movement in response to climate change (Beier 2012).

Priority Target for an Ecologically Functional Landscape
Valley bottom areas within small watersheds (NHD+ catchments) that have less than 50% natural vegetation within the watersheds' valley bottoms are priority restoration targets.

Highest Priority: All identified valley bottom riparian areas are highest priority.

Guidelines for Maintaining Ecological Function
Restore native, woody vegetation appropriate to the site and potential natural community until there is continuous natural vegetative cover along rivers, streams, lakes and wetlands in these priority watersheds, and then expand the naturally vegetated area further back from these features to encompass the broader valley bottom.

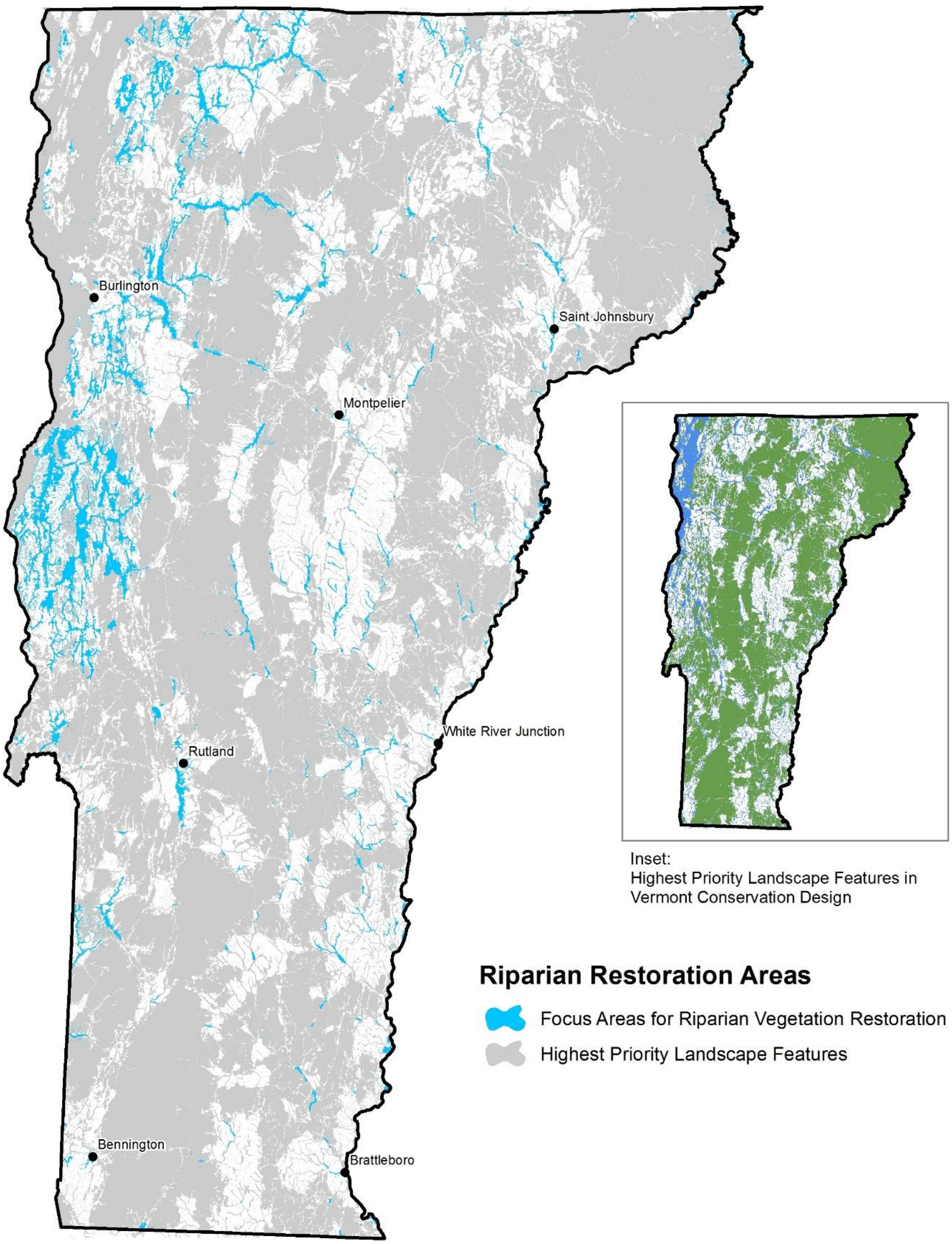
Methods and Rationale
The majority of the ecological functions of riparian areas depend on diverse and abundant natural vegetation. The 50% threshold is a compromise between targeting all riparian areas for restoration to natural vegetation, and current conditions. Small watersheds (NHD Plus) and the

National Land Cover Database 2011 data were used to identify segments of valley bottoms that lack abundant natural vegetation.

Mapping Comments

The map layer is a complete representation of the priority and highest priority targets. All valley bottom areas that are targeted for restoration are mapped. Field assessment may be needed to select restoration locations within each mapped valley bottom riparian area.

Map 8: Valley Bottom Riparian Restoration Area Targets



Grasslands – Refuges

Definition

Grasslands are anthropogenic areas dominated (>50%) by noninvasive (but often non-native) grass with a lesser abundance of forbs. They are typically cultivated for livestock forage, and do not include fields of cereal grains.

Ecological Function

The primary function of grasslands is as habitat for species of birds that require grassland for breeding and foraging, particularly Bobolink, Eastern Meadowlark, and Savannah Sparrow. This element seeks to provide a minimum area and configuration of productive breeding habitat capable of supporting numbers of bobolinks, meadowlarks, and savannah sparrows that would prevent state listing as Threatened or Endangered. These areas also provide habitat for plants and numerous other species of wildlife that use grasslands for their life requirements.

Priority Target for an Ecologically Functional Landscape

Three Refuges, covering a total of 7,500 acres, managed specifically for grassland birds in Addison, Franklin, and Orleans Counties, and located outside highest-priority landscape-scale elements. In Orleans County, 500 acres of Refuge areas should be located within the Lake Memphramagog watershed, in minimum contiguous suitable habitat areas of 100 acres. In Addison and Franklin Counties, 7000 acres of Refuge areas should be divided between the two counties, in minimum contiguous suitable habitat areas of 250 acres. Fields should be adjacent or in as close proximity as possible. Patches of managed grassland that are smaller than the minimum size may provide habitat of a lower quality, but still have value, particularly if grouped near larger patches.

Highest Priority:
All reserve areas are Highest Priority

Guidelines for Maintaining Ecological Function

The management regime of grasslands is essential. Disturbance must be often enough to maintain quality grassland, and (optimally) remove thatch to allow vigorous growth. Management must not, however, destroy nests during the breeding season (generally, May to early August).

In grassland refuges, mowing or other management should take place after August 1. Grassland patches should be larger than 25 acres, which will meet the needs of bobolink and savannah sparrow and will contribute to the needs of other species. Patches that are blocky or circular have more interior grassland area and will support more birds. Trees within the grassland will generally lower the habitat use and should be absent or limited to a small number of individual trees (not a treeline or island). Mowing regimes should be designed to incorporate best management practices for birds and reptiles.

Mapping Comments

Inventory is needed to identify and assess suitable locations for achieving these targets. Grassland refuges are not mapped at this time.

Restoration Needs

Efforts on grassland should focus on maintaining and improving existing grassland areas and supporting grass-based agriculture over intensive row crops or other land uses.

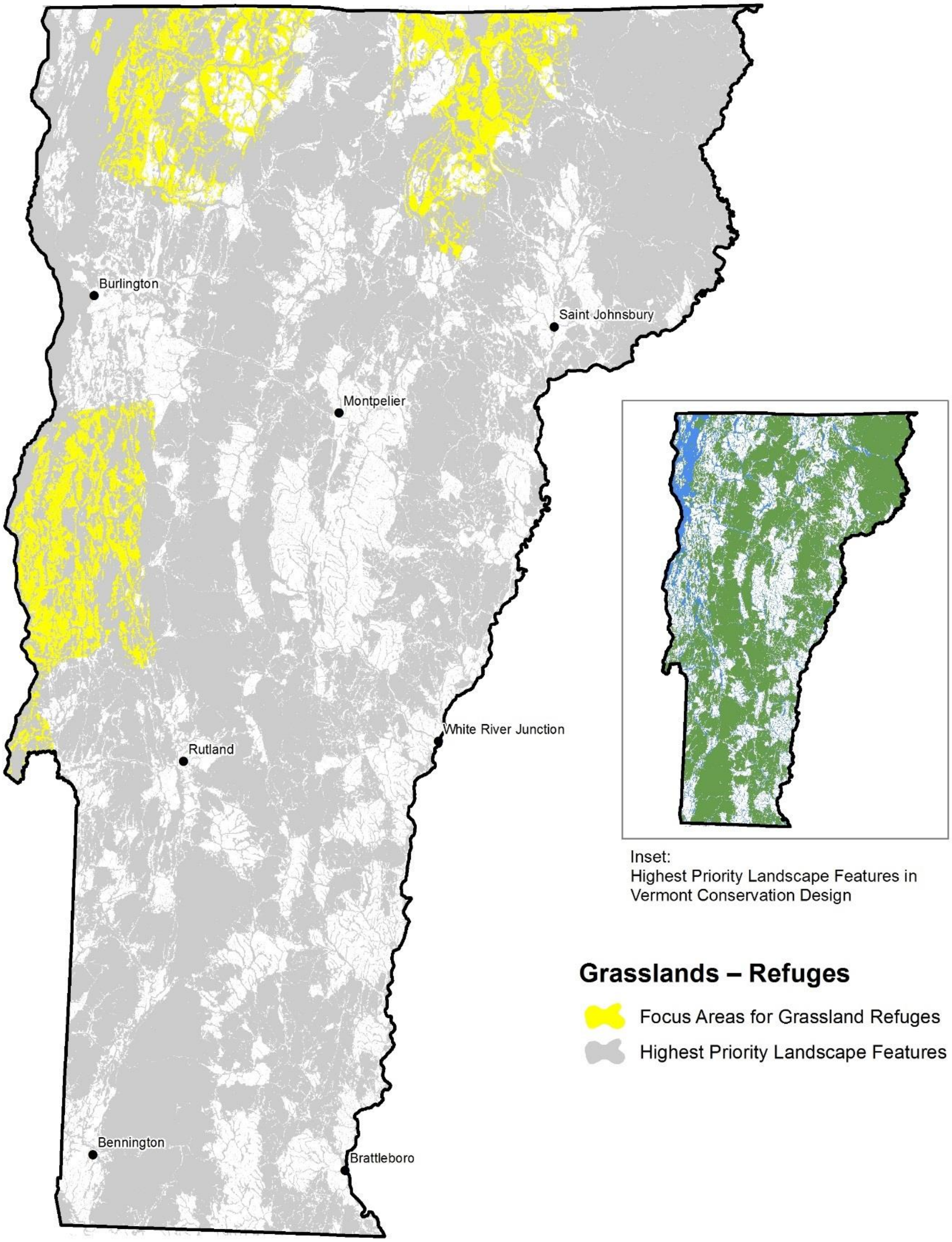
Methods and Rationale

The wildlife species that rely on grasslands are experiencing some of the gravest declines across the both the US and the northeast. Habitat loss from development and loss of functional habitat through agricultural intensification are the primary threats to these species in Vermont. Maintaining and enhancing grasslands of sufficient quality, size, and arrangement will enable populations of birds, plants, and other animals to persist in Vermont into the future.

Specifically, these targets were developed based on the habitat needs of three umbrella species: bobolink, eastern meadowlark, and savannah sparrow. These common grassland species and their biological needs are broad enough to reflect the needs of the majority of obligate and facultative grassland wildlife species, though they do not capture the needs of all grassland dependent species. Very rare species (e.g., vesper sparrow) and species with unique requirements (e.g. northern harrier, American kestrel) likely need fine filter consideration.

Long-term persistence of these three umbrella species is best achieved with dedicated habitat management. Acreages were derived by calculating the area needed to support a breeding population of at least 500 pairs. This ensures populations are above the threshold for listing as State Threatened or Endangered. Focus regions were chosen based on the presence of large areas of grassland and abundant grassland birds.

Map 9: Grassland Refuge Target Regions



Refuges are targeted outside of the highest priority landscape-scale elements.

Grasslands – Managed Agricultural Lands

Definition

Grasslands are anthropogenic areas dominated (>50%) by noninvasive (but often non-native) grass with a lesser abundance of forbs. They are typically cultivated for livestock forage, and do not include fields of cereal grains.

Ecological Function

The primary function of grasslands is as habitat for species of birds that require grassland for breeding and foraging, particularly Bobolink, Eastern Meadowlark, and Savannah Sparrow. This element seeks to improve the favorability of existing agricultural grassland management for grassland birds, particularly to reduce the incidence of breeding-season mowing that causes substantial mortality for nesting birds. These areas also provide habitat for plants and numerous other species of wildlife that use grasslands for their life requirements.

Priority Target for an Ecologically Functional Landscape

All anthropogenic grasslands in Vermont are targets for improving grassland bird survival and productivity for as long as the grassland field remains in active agricultural use.

Highest Priority:

Regions that currently have high concentrations of grasslands: Champlain Valley biophysical region, the Northern Vermont Piedmont biophysical region, the Connecticut River region (within approximately 10 miles of the Connecticut River).

Guidelines for Maintaining Ecological Function

The management regime of grasslands is essential. Disturbance must be often enough to maintain quality grassland, and (optimally) remove thatch to allow vigorous growth. Management must not, however, destroy nests during the breeding season (generally, May to early August).

In Grassland Management areas, mowing or other management should take place after August 1, or practice “deferred mowing” where management takes place early in the breeding season then is withheld until after the end of the breeding season, to allow a window between for successful breeding. Grassland patches should be larger than 10 acres, which will meet the needs of bobolink and savannah sparrow and will contribute to the needs of other species. Patches that are blocky or circular have more interior grassland area and will support more birds. Trees within the grassland will generally lower the habitat use and should be absent or limited to a small number of individual trees (not a treeline or island). Patches of managed grassland that are smaller than the minimum size may provide habitat of a lower quality, but still have value, particularly if grouped near larger patches.

Restoration Needs

There are no restoration needs at this time. Efforts should focus on maintaining and improving grassland areas in active agricultural use, and support grass-based agriculture over intensive row crops or other land uses.

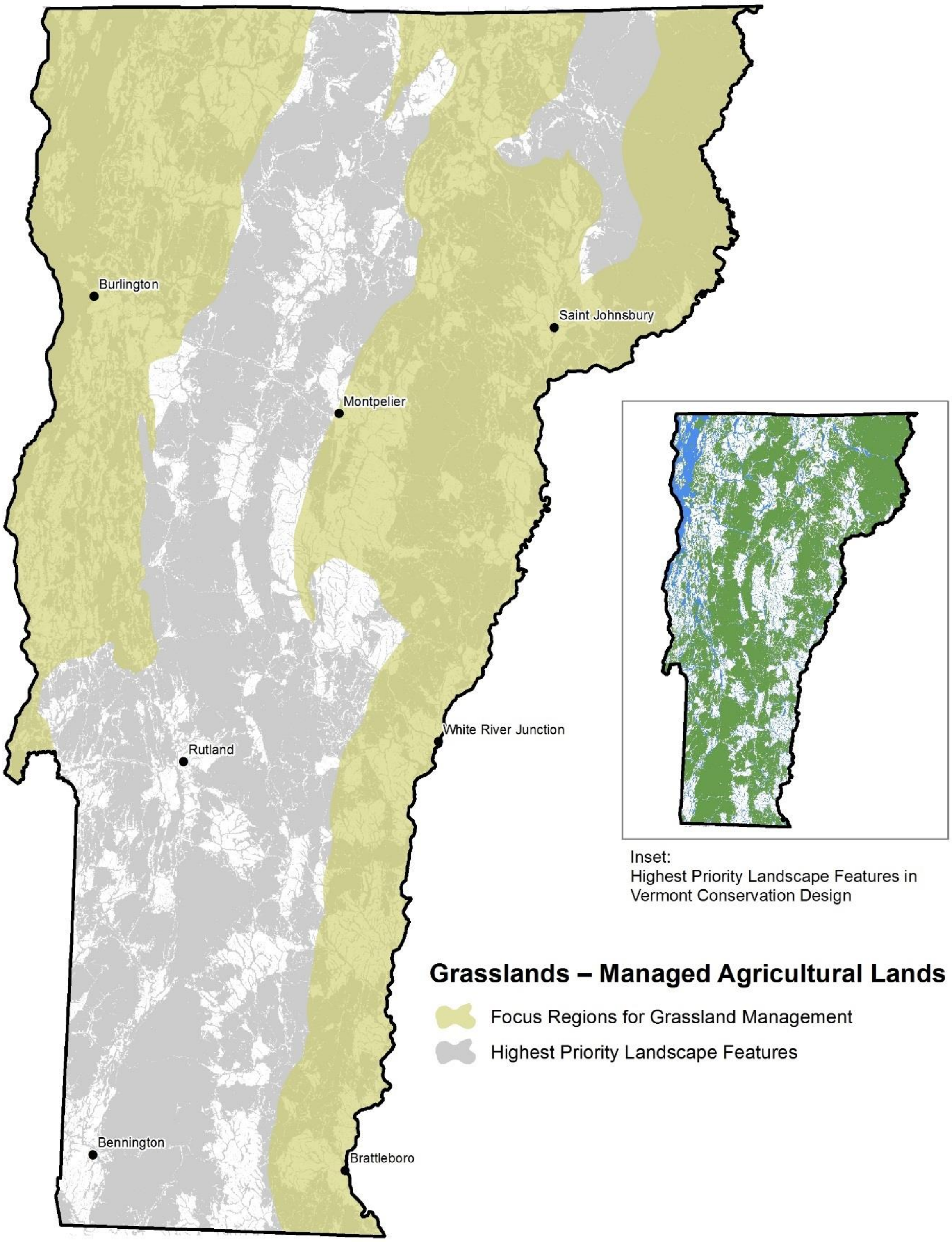
Mapping Comments

Grasslands are relatively widespread and may be ephemeral depending on agricultural activity. For this reason, grassland management targets are not mapped.

Methods and Rationale

The wildlife species that rely on grasslands are experiencing some of the gravest declines across the both the US and the northeast. Habitat loss and loss of functional habitat through agricultural intensification are primary threats to these species in Vermont. Maintaining and enhancing grasslands of sufficient quality, size, and arrangement will enable populations of birds, plants, and other animals to persist in Vermont into the future.

Map 10: Grassland Management Focus Areas



Management is targeted outside of the VCD Ecologically Functional Landscape.

Upland Shrub-Forb

Definition

These are upland sites dominated by forbs and shrubs, with at least 50% shrub canopy cover and few if any trees. Forb- and shrub-dominated areas are often variable and inter-mixed across space due to variable disturbance intensities and across time because disturbance drives areas to forbs which then develop into shrubs.

Ecological Function

Many wildlife species require shrub and forb meadows for breeding and foraging. These species include American woodcock, brown thrasher, prairie warbler, field sparrow, eastern bluebird, eastern kingbird, orchard oriole, northern shrike, eastern towhee, and eastern cottontail. This element seeks to complement naturally occurring shrubland (such as alder swamps) and young forest. Together these three elements should provide sufficient quantities and types of forb and shrubland, distributed across the state to support the many of the wildlife species the rely on forb and shrub habitat.

Priority Target for an Ecologically Functional Landscape

Forb-shrub targets are stated as percentages of undeveloped land area in each Biophysical Region:

- Northern Green Mountains, Southern Green Mountains, and Southern Vermont Piedmont: 0.5%
- Northeast Highlands, Taconic Mountains, Vermont Valley, Champlain Highlands, and Northern Vermont Piedmont: 1%
- Champlain Valley: 2-3%

Highest Priority:
Any forb- or shrubland dominated by noninvasive vegetation and near forest, wetland, open areas, or other non-developed habitats

Guidelines for Maintaining Ecological Function

Disturbance (mowing, grazing, burning, etc.) should occur outside the growing season (preferably April-early May or October-November) to minimize mortality to foraging and nesting birds, reptiles, and insects. Disturbance should be regular enough to prevent trees from gaining dominance. To allow successful breeding of many shrubland birds, patches should be at least 5 acres and should be blocky or circular in shape to maximize interior area. Forb and shrublands should be composed primarily of non-invasive vegetation.

Locations of shrub and forb patches should be carefully chosen to prevent impacts to other higher priority features. Small patches of shrub-forb (less than 5 acres) have the least impact to forest blocks, but in some situations larger patches can still be appropriately placed in large forest blocks. All shrub-forb areas should be in proximity with others to provide increased function for shrubland birds. Patches of managed forb-shrubland that are smaller than the minimum size may provide habitat of a lower quality, but still have value, particularly for reptiles.

Restoration Needs

Efforts should focus on maintaining and improving existing areas. Establishment of new shrubland should take place outside of the highest-priority landscape-scale elements, and in locations that avoid conflicts with other habitat and natural community-scale targets.

Mapping Comments

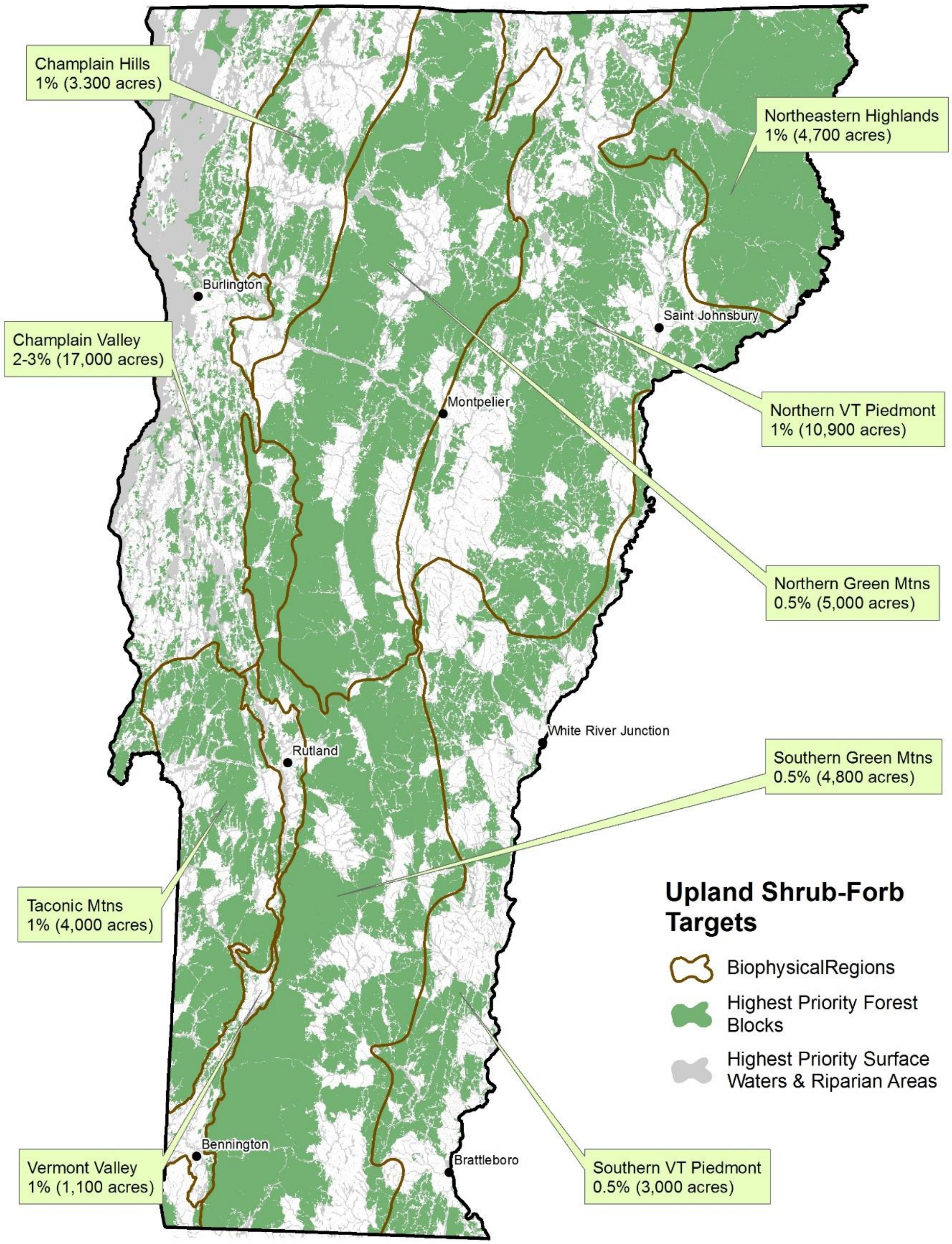
Spatial locations for upland shrub-forb targets are dynamic and expected to change as a result of land use and natural disturbance patterns over time. Upland shrub-forb targets are not mapped.

Methods and Rationale

The wildlife species that rely on shrublands are experiencing significant declines across the US and the northeast. Habitat loss is the primary threat to these species in Vermont. Maintaining and enhancing shrub- and forb-land of sufficient quality, size, and arrangement will enable populations of birds, plants, and other animals to persist in Vermont into the future.

Shrub-forb targets were selected to maintain the current levels (based on available data) of forb and shrubland in most of the state, while increasing the level in the Champlain Valley, the location of the greatest shrub-dependent bird diversity in the state. These targets complement those set for young forest and wetland shrub habitats. The variety of types is important both within and between these groups, as the range of species using these habitats prefer a variety of conditions.

Map 11: Upland Shrub-Forb Percentage Targets



Upland Shrub-Forb Targets as a percentage of undeveloped land in each biophysical region.

Caves

Definition
These are naturally occurring underground cavities that are large enough to have a different environment (temperature, humidity, etc.) than conditions outside the cave.

Ecological Function
Caves provide a very consistent environment of temperature, relative humidity, and air flow. Changes in structure and hydrology could greatly affect the habitat provided by subterranean areas. Bats are one of the better studied orders of wildlife species associated with subterranean areas and have been surveyed in caves going back into the 1930s. There are 6 species of bats known to hibernate in Vermont caves. Recent surveys indicate that caves may hold as few as less than 10 bats to as many as over 70,000. Bats use these sites for hibernation, but also spend a disproportionate amount of the year in the surrounding area (e.g., fall swarming).

Interest and understanding in the invertebrate community associated with caves is just beginning. Little is known about the condition of the subterranean aquatic habitats. At the national and global scale, it is well-documented that caves provide habitat for specialized invertebrates (Peck 1998). Caves are expected to function as a coarse filter for these species which are poorly understood.

Priority Target for an Ecologically Functional Landscape
Fifty percent of known caves in Champlain Valley (CV) and Taconic Mountains/Vermont Valley (TM/VV), and all caves in all other biophysical regions, are targeted to maintain an ecologically functional landscape.

Currently, there is insufficient inventory of caves to identify specific numerical targets to achieve 50% representation of caves in the CV and TM/VV regions, and even less information to fully assess representation of bedrock and formation of targeted caves. Additional study is needed to refine these targets. In lieu of a numerical target, the highest priority list of caves below (next page) represents our current best knowledge of the caves most critical for ecological function and maintaining an ecologically functional landscape.

Highest Priority: All targeted caves. At this time, the following list of caves:

Cave	Biophysical Region
1867 Cave	TM/VV
Aeolus Cave	TM/VV
Barrel Cave	CV
Bear Bones Cave	TM/VV
Bristol Cave	CV
Calvin Cave	TM/VV
Carbide Cave	Other BPR
Chimney Cave	TM/VV
Easter Cave	Other BPR
Kent (Wyman's) Cave	TM/VV
Little Skinner Hollow Cave	TM/VV

Cave	Biophysical Region
Milton Cave	CV
Morris Cave	TM/VV
Nickwackett Cave	CV
Philadelphia Cave	CV
Plymouth Cave	Other BPR
Porcupine Caves	CV
Quarry Cave	TM/VV
Skinner Hollow Cave	TM/VV
Trap Spring Cave	CV
Vermonster Cave	TM/VV
Williams Cave	TM/VV

Guidelines for Maintaining Ecological Function

Subterranean areas should remain intact, with limited human alteration or influence from above-ground pollutants. Maintain natural processes, including temperature regime, airflow, humidity, and hydrology; natural vegetation conditions above the cave footprint and a 50m buffer to moderate air and temperature conditions; and natural groundwater sources. Recreational exploration of caves can pose a threat to physical conditions and cave species. Within a 0.25-mile zone around the cave entrance, maintain or restore a closed forest canopy with native species and abundant potential live or dead roost trees with cavities, cracks, crevices, and/or peeling bark.

Restoration Needs

For some caves, restoration of natural vegetation around cave entrances and the cave footprint is needed to achieve full ecological function.

Mapping Comments

Cave locations are not mapped or described to protect sensitive species from disturbance. Locations of caves are provided to landowners and may be available upon request for conservation purposes.

Methods and Rationale

Cave targets were selected in an effort to represent all cave types (e.g. solutional, non-solutional) and bedrock types across all biophysical regions. Unfortunately, there is no classification or comprehensive inventory of caves in Vermont. Specific cave targets were selected because they are known sites with documented use by bats and/or invertebrates.

Abandoned Mines

Definition

Abandoned mines that provide suitable habitat used by hibernating bats, and the mines' surrounding naturally vegetated zone necessary for full ecological function. These targeted abandoned mines are large enough to have a different environment (temperature, humidity, etc.) than conditions outside the mine.

Ecological Function

Abandoned mines may provide many or all of the habitat qualities of natural caves and can even provide better habitat in some instances. These human-created cultural habitats are found statewide due to the history of Vermont. Although not of natural origin, they augment the natural habitats available to wildlife. In particular, bats are known to use some mine sites as hibernacula, and some mines support large bat populations. It is also possible that mines also support subterranean invertebrates, but this needs additional study.

Priority Target for an Ecologically Functional Landscape

All abandoned mines used (or formerly used, prior to white-nose syndrome) as bat hibernacula are targeted. At present, 19 known abandoned mines are targeted.

Highest Priority: All abandoned mines used (or formerly used, prior to white-nose syndrome) as bat hibernacula. Currently, 19 abandoned mines:

Cave	Biophysical Region
Brandon Silver Mine	SGM
Bridgewater Mine #1	SGM
Bridgewater Mine #2	SGM
Camp Brook Mine	NGM
Clifton Adit Mine	SGM
Dover Iron Mine	SGM
Elizabeth Mine	SVP
Ely Copper Mine	NVP
Fox Gold Mine (Rook's)	SGM
Greely 2 Mine	NGM

Cave	Biophysical Region
Greely Talc Mine	NGM
Hammondsville Mine	SGM
Johnson Talc Mine	NGM
Luzenac Mine - Frostbite	SGM
Luzenac Mine - Yager	SGM
Moretown (Eastern Magnesia) Talc Mine	NGM
Pike Hill Mine	NVP
Rochester Iron Mine	NGM
Rousseau Talc Mine	NGM

Guidelines for Maintaining Ecological Function

Subterranean areas should remain intact, with limited human alteration or influence from above-ground pollutants. Maintain natural processes, including temperature regime, airflow, humidity, and hydrology; natural vegetation conditions above the mine footprint and a 50m buffer to moderate air and temperature conditions; and natural groundwater sources. Recreational exploration of mines can pose a threat to physical conditions and mine species. Within a 0.25-mile zone around the mine entrance, maintain or restore a closed forest canopy with native species and abundant potential live or dead roost trees with cavities, cracks, crevices, and/or peeling bark.

Restoration Needs

There may be opportunities to restore natural vegetation around mine entrances and the mine footprint.

Mapping Comments

Abandoned mine locations are not mapped or described to protect sensitive species from disturbance. Locations of abandoned mines may be available upon request for conservation purposes.

Methods and Rationale

Abandoned mines provide unique habitat conditions. Those known to be used as bat hibernacula make important contributions to Vermont's ecologically functional landscape.

Coarse/Fine Filter Assessment

We tested our targets, along with the landscape-scale elements, to determine which species are expected to be conserved using coarse filters, and which species are expected to be fine-filter elements. We developed a list 74 common birds, mammals, herps, fish, invertebrates, and plants to test against the design. We have also tested 125 different species of bird, mammal, herp, and fish Species of Greatest Conservation Need (SGCN), and a subset of invertebrate and plant SGCN. In total, we have so far assessed more than 200 species. For each one, we identified which elements contributed to the species conservation, and then whether those elements were sufficient to conserve the species in Vermont.

We found that all of the common species are effectively conserved in Vermont using the coarse-filter targets. Some, such as migratory birds, cannot have their life needs met solely in Vermont. Thus, the persistence of these species in Vermont depends not only on maintaining their habitat needs here, but on conservation actions elsewhere. Approximately 50% of the SGCN are likely to have their habitat needs met in Vermont by this conservation design. Again, some species are migratory and may face threats outside the state. The remaining species are considered fine-filter species—those that face additional needs or threats that can not be addressed in this design. Moose, for example, will have their habitat needs well met by Vermont Conservation Design. The threats from parasites and heat stress, however, will require additional efforts.

Not all species that require a fine-filter approach need to be conservation targets. Climate and land use changes may simply make it impossible to maintain some species, despite our best efforts. Devoting our efforts to allowing species to rearrange, and letting nature adapt to new conditions, may be a more productive use of conservation effort. These will always be tough choices, but we hope this work can help inform that decision-making.

Overall, these results provide strong support for the effectiveness of Vermont Conservation Design, and the selected targets. This analysis supports our confidence that the targets presented here will effectively conserve many other species – including cryptic and poorly understood species. It also identifies those species most in need of additional, specific actions, and helps focus our species conservation efforts. Ensuring that these fine-filter species are included in a long-term effort to maintain ecological function is a key component of Vermont Conservation Design.

A subset of the results of this coarse/fine filter assessment is included in Appendix D. The full table, which includes the full accounting of species/design element relationships is available from the authors upon request. We intend to continue to expand this table over time.

We hope that this table will be of use to scientists and conservation planners, and that it will continue to be refined as it is used by species experts, and as new information becomes available.

Putting it All Together: The Ecologically Functional Landscape

All the features described in this report: Natural Communities; Young and Old Forests; Aquatic and Riparian Habitats; Wetlands; Grassland and Shrublands; and Undergrounds Habitats, are needed to maintain and enhance an ecologically functional landscape in Vermont. The specific functions of these features, and their interactions, are critical for long term conservation of much of Vermont's biological diversity and natural heritage.

But these natural community and habitat elements described in this report cannot be conserved in isolation. They depend on the foundation of an intact, interconnected landscape – the highest priority landscape scale features described in the Part 1 Technical Report (Sorenson et. al. 2015). Conserving an ecologically functional landscape requires that all the components, and their ecological functions, described in both parts of Vermont Conservation Design be successfully conserved. It is also important to remember that some species cannot be conserved using coarse filter conservation, and that these species will always need special attention. These actions, too, are a crucial part of maintaining an ecological functional landscape.

The following map shows the Vermont Conservation Design ecologically functional landscape, with all the highest priority landscape features and all of the mapped natural community and habitat features included.

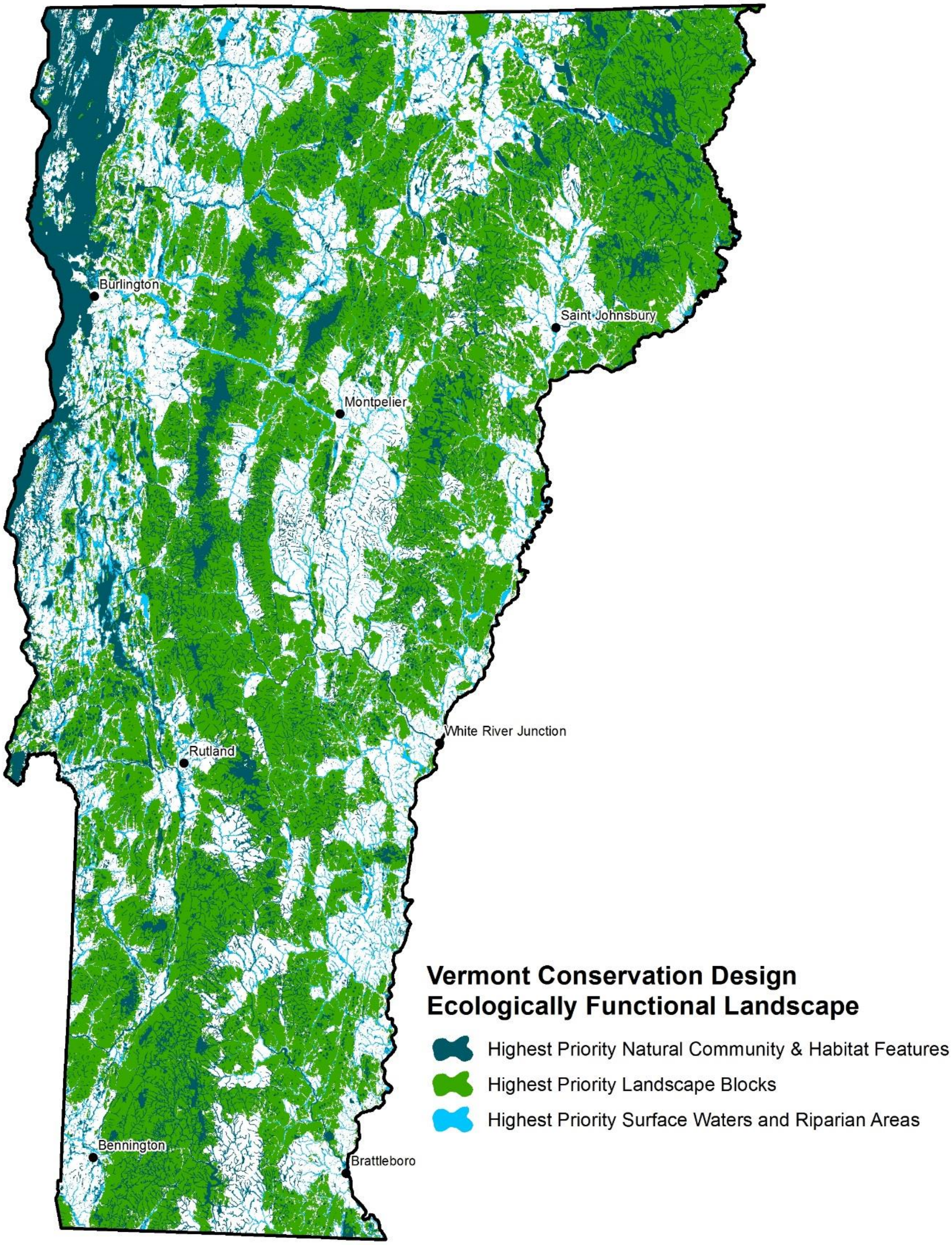
It is our hope that this information will inform land management, local planning, and land conservation decisions throughout Vermont. Private landowners, municipalities, state agencies, and conservation organizations should find this information helpful as we all work together for a vibrant and healthy Vermont, now and into the future.

Further Information

Additional information on Vermont Conservation Design, its data layers, and potential applications can be found on the Vermont Agency of Natural Resources BioFinder website: http://biofinder.vermont.gov. As of February 2018, BioFinder includes mapping of all landscape features identified in Vermont Conservation Design. We anticipate updating BioFinder over the next several months to incorporate the prioritized features described in this report. For more information on Vermont Conservation Design in BioFinder, please contact Jens Hilke (jens.hilke@vermont.gov).

Any of the authors of this report can also help with interpretation of the information.

Map 12: The Vermont Conservation Design Ecologically Functional Landscape



Note that some Highest Priority Natural Community and Habitat Features overlay Highest Priority Landscape Blocks and Highest Priority Surface Waters and Riparian Areas.

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Appendix A: Targets for Natural Community Types

			ESTIMATE OF EXPECTED OCCURRENCES		TARGET	*SUCCESS - known EOs contributing to target*	
	S-Rank	TOTAL # KNOWN EOs TARGETED	Midpoint Estimate	Target %	Midpoint Target	*% of Midpoint*	Confidence in Estimate of EO #
Spruce-Fir-Northern Hardwood Forest Formation							
Subalpine Krummholz	S1	**8**	7	1.0	7	***114%***	H
Montane Spruce-Fir Forest	S3	**46**	46	1.0	46	***100%***	H
Lowland Spruce-Fir Forest	S3	**18**	36	0.5	18	***50%***	M
Montane Yellow Birch-Red Spruce Forest	S3	**38**	75	0.5	38	***51%***	
Red Spruce-Northern Hardwood Forest	S5	**0**	*matrix*				
Red Spruce-Heath Rocky Ridge Forest	S3	**19**	38	0.5	19	***100%***	H
Boreal Talus Woodland	S3	**19**	75	0.5	38	***51%***	M
Cold-Air Talus Woodland	S1	**3**	4	1.0	4	***75%***	H
Northern Hardwood Forest Formation							
Northern Hardwood Forest	S5	**0**	*matrix*				H
Rich Northern Hardwood Forest	S4	**54**	300	0.5	150	***36%***	H
Mesic Red Oak-Northern Hardwood Forest	S4	**42**	175	0.5	88	***48%***	H
Hemlock Forest	S4	**46**	300	0.5	150	***31%***	H
Hemlock-Northern Hardwood Forest	S5	**0**	*matrix*				H
Northern Hardwood Talus Woodland	S3	**19**	75	0.5	38	***51%***	M
Oak-Pine-Northern Hardwood Forest Formation							
Temperate Hemlock Forest	S4	**26**	75	0.5	38	***69%***	M
Temperate Hemlock-Hardwood Forest	S3	**5**	75	0.5	38	***13%***	L
Red Pine Forest or Woodland	S2	**34**	42	1.0	42	***81%***	H
Pitch Pine-Oak-Heath Rocky Summit	S1	**7**	14	1.0	14	***52%***	H
Limestone Bluff Cedar-Pine Forest	S2	**27**	27	1.0	27	***100%***	H
Red Cedar Woodland	S1	**12**	16	1.0	16	***75%***	H
Dry Oak Woodland	S2	**23**	37	1.0	37	***63%***	H
Dry Oak Forest	S3	**26**	51	0.5	26	***102%***	H
Dry Red Oak-White Pine Forest	S3	**28**	75	0.5	38	***75%***	M
Dry Oak-Hickory-Hophornbeam Forest	S3	**42**	84	0.5	42	***101%***	H
Mesic Maple-Ash-Hickory-Oak Forest	S3	**32**	75	0.5	38	***85%***	L

			ESTIMATE OF EXPECTED OCCURRENCES		TARGET	*SUCCESS - known EOs contributing to target*	
	S-Rank	TOTAL # KNOWN EOs TARGETED	Midpoint Estimate	Target %	Midpoint Target	*% of Midpoint*	Confidence in Estimate of EO #
Transition Hardwood Limestone Forest	S3	**16**	35	1.0	35	***46%***	M
Mesic Clayplain Forest	S2	**50**	63	1.0	63	***80%***	H
Sand-Over-Clay Forest	S2	**11**	16	1.0	16	***71%***	H
White Pine-Red Oak-Black Oak Forest	S2	**5**	15	1.0	15	***33%***	L
Pine-Oak-Heath Sandplain Forest	S1	**14**	18	1.0	18	***80%***	H
Transition Hardwood Talus Woodland	S3	**11**	35	0.5	18	***63%***	H
Transition Hardwood Limestone Talus Woodland	S3	**19**	37	0.5	19	***103%***	
Upland Shores							
Acidic Riverside Outcrop	S3	**0**	125	0.5	63	***0%***	M
Calcareous Riverside Outcrop	S2	**9**	125	0.5	63	***14%***	M
Erosional River Bluff	S2	**4**	38	1.0	38	***11%***	M
Lake Shale or Cobble Beach	S3	**9**	30	1.0	30	***30%***	H
Lake Sand Beach	S2	**15**	16	1.0	16	***94%***	H
Sand Dune	S1	**2**	2	1.0	2	***100%***	H
Outcrops and Upland Meadows							
Alpine Meadow	S1	**2**	2	1.0	2	***100%***	
Boreal Outcrop	S4	**20**	200	0.5	100	***20%***	M
Serpentine Outcrop	S1	**6**	6	1.0	6	***100%***	H
Temperate Acidic Outcrop	S4	**32**	150	0.5	75	***43%***	M
Temperate Calcareous Outcrop	S3	**23**	75	0.5	38	***61%***	H
Cliffs and Talus							
Boreal Acidic Cliff	S4	**22**	63	0.5	31	***70%***	H
Boreal Calcareous Cliff	S2	**11**	25	1.0	25	***44%***	M
Temperate Acidic Cliff	S4	**15**	125	0.5	63	***24%***	M
Temperate Calcareous Cliff	S3	**31**	63	0.5	31	***99%***	H
Open Talus	S2	**15**	20	1.0	20	***75%***	H
Floodplain Forests							
Silver Maple-Ostrich Fern Riverine Floodplain Forest	S3	**38**	75	0.5	38	***101%***	H
Northern Conifer Floodplain Forest	S2	**7**	25	1.0	25	***28%***	M
Silver Maple-Sensitive Fern Riverine Floodplain Forest	S3	**18**	75	0.5	38	***48%***	H
Sugar Maple-Ostrich Fern Riverine Floodplain Forest	S2	**32**	63	1.0	63	***51%***	H

			ESTIMATE OF EXPECTED OCCURRENCES		TARGET	*SUCCESS - known EOs contributing to target*	
	S-Rank	TOTAL # KNOWN EOs TARGETED	Midpoint Estimate	Target %	Midpoint Target	*% of Midpoint*	Confidence in Estimate of EO #
Lakeside Floodplain Forest	S3	**26**	34	1.0	34	***78%***	H
Hardwood Swamps							
Red Maple-Black Ash Seepage Swamp	S4	**71**	250	0.5	125	***57%***	H
Red Maple-Sphagnum Acidic Basin Swamp	S3	**19**	38	0.5	19	***101%***	H
Red or Silver Maple-Green Ash Swamp	S3	**20**	40	0.5	20	***101%***	H
Calcareous Red Maple-Tamarack Swamp	S2	**23**	32	1.0	32	***73%***	H
Red Maple-Black Gum Swamp	S2	**17**	24	1.0	24	***72%***	H
Red Maple-Northern White Cedar Swamp	S3	**21**	41	0.5	21	***102%***	H
Wet Clayplain Forest	S2	**36**	43	1.0	43	***84%***	H
Wet Sand-Over-Clay Forest	S2	**13**	17	1.0	17	***79%***	H
Red Maple-White Pine-Huckleberry Swamp	S1	**4**	4	1.0	4	***100%***	H
Seepage Forest	S3	**0**	100	0.5	50	***0%***	
Softwood Swamps							
Northern White Cedar Swamp	S3	**88**	175	0.5	88	***101%***	H
Boreal Acidic Northern White Cedar Swamp	S3	**1**	16	1.0	16	***6%***	H
Northern White Cedar Sloping Seepage Forest	S3	**10**	30	0.5	15	***67%***	H
Spruce-Fir-Tamarack Swamp	S3	**39**	79	0.5	39	***99%***	H
Red Spruce-Cinnamon Fern Swamp	S3	**36**	75	0.5	38	***96%***	M
Black Spruce Swamp	S2	**44**	63	1.0	63	***70%***	H
Hemlock-Sphagnum Acidic Basin Swamp	S2	**19**	30	1.0	30	***63%***	H
Hemlock-Balsam Fir-Black Ash Seepage Swamp	S4	**69**	250	0.5	125	***55%***	H
Seeps and Vernal Pools							
Seep	S4	**0**			0	***#DIV/0!***	H
Vernal Pool	S3	**0**			0	***#DIV/0!***	H
Open Peatlands							
Dwarf Shrub Bog	S2	**59**	58	1.0	58	***103%***	H
Black Spruce Woodland Bog	S2	**49**	63	1.0	63	***78%***	H
Pitch Pine Woodland Bog	S1	**2**	2	1.0	2	***100%***	H

			ESTIMATE OF EXPECTED OCCURRENCES		**TARGET**	***SUCCESS - known EOs contributing to target***	
	S-Rank	**TOTAL # KNOWN EOs TARGETED**	**Midpoint Estimate**	**Target %**	**Midpoint Target**	***% of Midpoint***	**Confidence in Estimate of EO #**
Alpine Peatland	S1	**1**	1	1.0	1	***100%***	H
Poor Fen	S2	**80**	110	1.0	110	***73%***	H
Intermediate Fen	S2	**53**	64	1.0	64	***83%***	H
Rich Fen	S2	**74**	87	1.0	87	***85%***	H
Marshes and Sedge Meadows							
Shallow Emergent Marsh	S4	**11**	200	0.5	100	***11%***	H
Sedge Meadow	S4	**8**	200	0.5	100	***8%***	L
Cattail Marsh	S4	**11**	200	0.5	100	***11%***	L
Deep Broadleaf Marsh	S4	**5**	200	0.5	100	***5%***	L
Wild Rice Marsh	S3	**2**	13	1.0	13	***16%***	L
Deep Bulrush Marsh	S4	**22**	63	0.5	31	***70%***	M
Wet Shores							
Outwash Plain Pondshore	S1	**1**	1	1.0	1	***100%***	H
River Mud Shore	S3	**4**	300	0.5	150	***3%***	H
River Sand or Gravel Shore	S3	**5**	300	0.5	150	***3%***	H
River Cobble Shore	S2	**16**	150	1.0	150	***11%***	M
Calcareous Riverside Seep	S1	**11**	16	1.0	16	***71%***	H
Rivershore Grassland	S3	**14**	150	0.5	75	***19%***	H
Lakeshore Grassland	S2	**6**	16	1.0	16	***39%***	H
Shrub Swamps							
Alluvial Shrub Swamp	S3	**17**	63	0.5	31	***54%***	M
Alder Swamp	S5	**18**	200	0.5	100	***18%***	M
Sweet Gale Shoreline Swamp	S3	**28**	63	0.5	31	***90%***	H
Buttonbush Swamp	S2	**23**	30	1.0	30	***77%***	H

Appendix B: Old Forest Acres by Natural Community Type

Old forest targets are capture approximately 15% of the matrix forest area in all Highest Priority Blocks, stratified by biophysical region. These are minimum targets necessary for long-term ecological function on the landscape. So long as it does not conflict with other identified conservation targets, additional acreage of old forest would continue to increase ecological functions of Vermont's landscape.

To the extent possible, we then further refined these to show proportionality of each natural community type. Individual NC percentages are based off all matrix forest distribution in the entire biophysical region – not just blocks. These breakdowns by community type should be treated as guidelines. Descriptions of methods can be found after the targets.

OVERALL: Old forest at 15% target of Highest Priority Blocks = 419,000 acres

<u>Champlain Hills</u>
13,000 acres old forest
Estimated breakdown by natural community types:
HNHF: 7,000
NHF: 6,000
Minimum patch size = 1,000

<u>Champlain Valley</u>
15,000 acres old forest
Estimated breakdown by natural community types:
MMAHOF, THHF, THF, MRONHF, MCF: 15,000
Minimum patch size = 500 (100-acre minimum for MCF)

<u>Northeastern Highlands</u>
59,000 acres old forest
Estimated breakdown by natural community types:
NHF, RSNHF, (HNHF): 41,000
LSFF: 12,000
MYBRSF: 5,000
MSFF: 1,000
Minimum patch size = 4,000

<u>Northern Green Mountains</u>
95,000 acres old forest
Estimated breakdown by natural community types:
NHF, RSNHF: 71,000
HNHF: 14,000
MSFF: 5,000
MYBRSF: 5,000
Minimum patch size = 4,000

Northern Vermont Piedmont

78,000 acres old forest

Estimated breakdown by natural community types:
NHF: 39,000
HNHF: 20,000
MYBRSF, RSNHF: 12,000
LSFF: 7,000

Minimum patch size = 1,000

Notes: LSFF seems really overrepresented in habitat mapping (18%) and lowered; MYBRSF and RSNHF seem underrepresented and increased. These still seem rough.

Southern Green Mountains

91,000 acres old forest

Estimated breakdown by natural community types:
NHF, RSNHF: 64,000
HNHF: 22,000
MSFF, MYBRSF: 5,000

Minimum patch size = 4,000

Notes: Montane communities underrepresented in habitat mapping? Increased in targets.

Southern Vermont Piedmont

31,000 acres old forest

Estimated breakdown by natural community types:
THHF, THF: 17,000
NHF, HNHF, (MRONHF): 14,000

Minimum patch size = 1,000

Notes: Fine scale interspersion of natural communities in this region.

Taconic Mountains

33,000 acres old forest

Estimated breakdown by natural community types:
MMAHOF, THHF, THF: 20,000
NHF, RNHF, HNHF: 13,000

Minimum patch size = 1,000

Notes: Breakdown of Appalachian (Hemlock)-Northern Hardwood between HNHF and warm types is tough to estimate.

Vermont Valley

4,000 acres old forest

Estimated breakdown by natural community types:
MMAHOF, THHF, THF: 3,500
NHF, HNHF: 500

Minimum patch size = 500

Notes: NHF & HNHF are lower than habitat mapping, but seem high relative to observations in region.

Methods for Matrix Forest Calculations

Estimates of matrix occurrence and abundance by biophysical region were derived from TNC Terrestrial Habitat Map using ecosystem macrogroups. Six macrogroups were used as proxy for matrix natural communities. These six do not perfectly map to VT's natural community classification so professional judgement was used in translating these data into estimated community distributions. In some cases it was not possible to set a proportional target for a specific natural community type, so several types are lumped together. The six macrogroups and their associated natural communities are noted below:

- Acadian Low Elevation Spruce-Fir-Hardwood Forest
  - *Lowland Spruce-Fir Forest*
  - *Red Spruce-Northern Hardwood Forest*
- Acadian Sub-boreal Spruce Flat
  - *Lowland Spruce-Fir Forest*
- Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
  - *Montane Spruce-Fir Forest*
  - *Montane Yellow Birch-Red Spruce Forest*
- Appalachian (Hemlock)-Northern Hardwood Forest
  - *Hemlock-Northern Hardwood Forest*
  - *Mesic Maple-Ash-Hickory-Oak Forest*
  - *Temperate Hemlock-Hardwood Forest*
  - *Temperate Hemlock Forest*
  - *Mesic Red Oak-Northern Hardwood Forest*
- Laurentian-Acadian Northern Hardwood Forest
  - *Northern Hardwood Forest*
  - *Red Spruce-Northern Hardwood Forest*
  - *Montane Yellow Birch-Red Spruce Forest*
- Laurentian-Acadian Pine-Hemlock-Hardwood Forest
  - *Hemlock-Northern Hardwood Forest*

Appendix C: Ecological Functions of Forest Structure Conditions

Function	Upland persistent shrubland	Wetland Shrubland	Young Forest	"Middle Aged" Forest	Old Forest (Late Successional)
Wildlife Habitat Values (Obligate species)	x	x	x		x
Riparian habitat		x			xx
Water Temperature (for habitat)				x	xx
Nutrient Filtration and sediment storage		x		x	xx
Coarse Woody Material				x	xx
Complex Structure				x	xx
Micro Topography				x	xx
Pollinator Food	xx	xx	xx	x	xx
Pollinator Habitat	xx	xx	x	x	xx
Age class diversity					x
Plant habitat values (obligates)	x	x	x		x
Food and cover for non-obligates	xx	xx	xx	x	xx
Fungal Diversity				x	xx
Soil Development/Health		x		x	xx
Carbon Storage		x		x	xx
Air Filtration				x	xx
Forest Temperature Moderation			x	xx	xx
Input of fine material in to water systems (base of food chain)		x		x	xx
Accumulation of live Biomass/Productivity				x	xx
Persistence of habitat elements and structural legacies (resilience)					xx
Snags/Cavities/Perches				x	xx
Ecological benchmark		xx			xx
"x" indicates the function is provided by the indicated structural condition "xx" indicates the function is strongly provided by the indicated structural condition					

Appendix D: Coarse/Fine Filter Assessment

This table is an abridged subset of the full assessment of over 200 Species of Greatest Conservation Need (SGCN) and common species. The full table is available from the Vermont Fish and Wildlife Department. This table will continue to be an ongoing effort, with the ultimate goal to assess all SGCN.

** - high confidence that the design will capture the finer scale element. Protecting the coarse-scale element will also protect functioning examples of the finer-scale element. * - moderate confidence that the design will capture the finer scale element. Protecting the coarse-scale element will also protect functioning examples of the finer-scale element. 0 = neither of the above	**Confidence that habitat needs captured by landscape level design (** or * or 0)**	**Confidence that habitat needs Captured by habitat and natural community targets (** or * or 0)**	**Confidence that all the checked coarse filters provide suitable habitat in VT for long-term persistence (excluding external threats) (HIGH MED LOW)**	**Is coarse filter conservation in VT currently sufficient for this species to persist into the future?**	**Recommend that this species be managed in VT using the fine filter approach? ("Fine Filter" or blank)**
BIRDS - COMMON					
Wood duck	**	**	HIGH	No	
Barred Owl	**	*	HIGH	Yes	
Alder Flycatcher	**	**	HIGH	No	
Black-throated Blue Warbler	**	**	HIGH	No	
Blackburnian Warbler	**	**	HIGH	No	
Red-winged Blackbird	**	**	HIGH	Yes	
Scarlet Tanager	**	**	HIGH	No	
MAMMALS - COMMON					
North American Porcupine	**	*	HIGH	Yes	
American Beaver	**	*	HIGH	Yes	
Snowshoe Hare	**	**	HIGH	Yes	
Red Fox	**	**	HIGH	Yes	
Fisher	**	**	HIGH	Yes	
White-tailed Deer	**	**	HIGH	Yes	

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HERPS - COMMON					
Snapping Turtle	**	*	HIGH	Yes	
Ring-necked snake	*	**	HIGH	Yes	
Spring peeper	*	**	HIGH	Yes	
Wood Frog	*	**	HIGH	Yes	
Northern Two-lined Salamander	**	*	HIGH	Yes	
Eastern Red-backed Salamander	**	*	HIGH	Yes	
FISH - COMMON					
Brook Trout	**	**	High	Yes	
Northern Pike	**	**	High	Yes	
PLANTS - COMMON					
Sugar Maple	**	**	HIGH	Yes	
Basswood	**	**	HIGH	Yes	
Shrubby Cinquefoil (*Dasiphora floribunda*)	*	**	HIGH	Yes	
Hairgrass (*Deschampsia flexuosa*)	*	**	HIGH	Yes	
White Water Lily (*Nymphea odorata*)	**	*	HIGH	Yes	
Stairstep Moss (*Hylocomnium splendens*)	*	**	HIGH	Yes	
INVERTEBRATES - COMMON					
Orange-belted Bumblebee (*Bombus ternarius*)	*	**	High	Yes	
Common Eastern Bumblebee (*Bombus impatiens*)	*	**	High	Yes	

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Baltimore Checkerspot (*Euphydryas phaeton*)	0	**	High	Yes	
Question Mark (*Polygonia interrogationis*)	**	**	High	Yes	
Common Shore Tiger Beetle (*Cicindela ripanda*)	**		High	Yes	
Six-spotted Tiger Beetle (*Cicindela sexguttata*)	**	**	High	Yes	
Petite Emerald (*Dorochordulia lepida*)	**	**	High	Yes	
Twelve-spotted Skimmer (Libellula pulchella)	**	**	High	Yes	
BIRDS - HIGH SGCN					
Gray Jay	0	**	HIGH	Yes	
Brown Thrasher	*	**	HIGH	Yes	
Sedge Wren	*	*	LOW	No	Fine Filter
Eastern Towhee	*	**	HIGH	Yes	
Least Bittern	*	**	HIGH	Yes	
Spruce Grouse	0	*	HIGH	No	Fine Filter
Olive-sided Flycatcher	**	**	HIGH	Yes	
Grasshopper Sparrow	0	*	LOW	No	Fine Filter
Bicknell's Thrush	*	**	HIGH	No	
Northern Harrier	0	**	HIGH	Yes	
Vesper Sparrow	0	*	LOW	No	Fine Filter
Wood Thrush	**	*	HIGH	No	
Common Tern	0	*	LOW	No	Fine Filter

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Upland Sandpiper	0	*	LOW	No	Fine Filter
Pied-billed Grebe	*	*	MED	Yes	
BIRDS - MED SGCN					
Black-billed Cuckoo	*	**	HIGH	Yes	
Black-throated Blue Warbler	**	**	HIGH	no	
Field Sparrow	0	**	HIGH	no	
Northern Goshawk	**	*	HIGH	no	
Bobolink	0	**	HIGH	no	
Bay-breasted Warbler	*	*	LOW	No	Fine Filter
Lesser Yellowlegs	*	**	HIGH	no	
Cerulean Warbler	*	*	LOW	no	Fine Filter
Chestnut-sided Warbler	*	**	HIGH	no	
Black-backed Woodpecker	*	**	HIGH	Yes	
American Woodcock	*	**	HIGH	no	
FISH - HIGH SGCN					
American Brook Lamprey	**	**	HIGH	no	Fine Filter
Sauger	**	**	HIGH	no	Fine Filter
Stonecat	**	**	Med	no	Fine Filter
Blacknose Shiner	**	**	High	yes	
Northern Brook Lamprey	**	**	High	no	Fine Filter
Greater Redhorse	*	**	High	no	Fine Filter

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Lake Sturgeon	*	**	HIGH	no	Fine Filter
FISH - MED SGCN					
Redbreast Sunfish	**	**	High	yes	
Shorthead Redhorse	*	**	High	yes	
American Eel (CT River)	**	*	High	no	
Mottled Sculpin	*	**	High	yes	
American Shad	**	*	High	no	
Mooneye	**	**	Low	no	Fine Filter
Atlantic Salmon-Lake Champlain & Memphremagog basins naturally reproducing populations	**	**	Low	no	Fine Filter
Blueback Herring (CT River)	**	*	High	no	
American Eel (Lake Champlain)	*	**	High	no	
HERP - HIGH SGCN					
Jefferson Salamander	*	**	High	Yes	
Timber Rattlesnake	*	**	High	No	Fine Filter
Spotted Turtle	0	*	Low	No	Fine Filter
Boreal Chorus Frog	0	0	Low	no	Fine Filter
Mudpuppy	*	**	High	no	Fine Filter
HERP - MED SGCN					
Wood Turtle	**	*	High	no	Fine Filter
Four-toed Salamander	*	**	High	yes	

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Smooth Greensnake	*	**	High	yes	
Common Watersnake	**	**	High	yes	
Common Musk Turtle	*	**	High	yes	
MAMMALS - HIGH SGCN					
Water Shrew	**	*	High	Yes	
Eastern Red Bat	**	*	High	Yes	
Long-tailed or Rock Shrew	*	**	High	Yes	
American Marten	**	**	High	Yes	
New England Cottontail	0	0	Low	No	Fine Filter
Canada Lynx	**	**	High	no	
Rock Vole	*	**	high	yes	
Woodland Vole	*	**	High	Yes	
Indiana Bat	**	**	High	No	Fine Filter
MAMMALS - MED SGCN					
Northern Flying Squirrel	**	**	High	yes	
Gray Fox	**	**	High	yes	
Moose	**	*	High	No	Fine Filter
Southern Flying Squirrel	**	**	High	Yes	
Hairy-tailed Mole	**	**	High	Yes	
Big Brown Bat	**	**	High	No	Fine Filter
Southern Bog Lemming	*	**	High	yes	

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Smoky Shrew	*	**	High	yes	
INVERTEBRATE GROUPS SGCN					
Ant (Temnothorax pilagens)	0	0	Low	no	Fine Filter
Ant (Myrmica lobifrons)	0	**	High	yes	
Early Hairstreak (Erora laeta)	**	**	High	no	Fine Filter
Boulder-beach Tiger Beetle (Cicindela ancocisconensis)	**	**	High	yes	
Cobblestone Tiger Beetle (Cicindela marginipennis)	**	**	High	no	Fine Filter
Boreal marstonia (Marstonia lustrica)	**	**	High	yes	
Star gyro (Gyraulus crista)	**	**	High	yes	
American Rubyspot (Hetaerina americana)	**	**	High	yes	
Maine Snaketail (Ophiogomphus mainensis)	**	*	High	yes	
Dwarf wedgemussel (Alasmidonta heterodon)	**	*	High	no	Fine Filter
Creek heelsplitter (Lasmigona compressa)	**	*	High	yes	
A Mayfly (Ameletus browni)	*	*	Low	no	Fine Filter
Roaring Brook Mayfly (Epeorus frisoni)	*	*	Low	no	Fine Filter
Bumblebee (Bombus terricola)	0	0	Low	no	Fine Filter
Bumblebee (Bombus pensylvanicus)	0	0	Low	no	Fine Filter
PLANTS - HIGH SGCN					
Carex atherodes	0	0	Low	No	Fine Filter
Cypripedium arietinum	0	*	Medium	No	Fine Filter

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Hudsonia tomentosa	0	*	Medium	No	Fine Filter
Poa pratensis ssp. agassizensis	0	0	Low	No	Fine Filter
Calystegia silvatica ssp. fraterniflora	0	0	Low	No	Fine Filter
Carex bicknellii	0	0	Low	No	Fine Filter
Botrychium rugulosum	0	0	Low	No	Fine Filter
Cypripedium parviflorum var. makasin	0	**	High	Yes	
Ludwigia polycarpa	*	*	Low	No	Fine Filter
Callitriche hermaphroditica	0	*	Low	No	Fine Filter
Castilleja septentrionalis	0	**	High	Yes	
Stuckenia filiformis	*	*	Low	No	Fine Filter
PLANTS (vascular only) - LOW SGCN					
Pycnanthemum muticum	0	*	Low	No	Fine Filter
Arceuthobium pusillum	0	**	High	Yes	
Scheuchzeria palustris	0	**	High	Yes	
Arabidopsis lyrata	0	**	High	No	Fine Filter
Agrostis mertensii	*	*	Medium	Yes	
Carex muehlenbergii var. muehlenbergii	*	*	Low	No	Fine Filter
Malaxis unifolia	0	*	Medium	No	Fine Filter
Dryopteris fragrans	0	**	High	Yes	
Sanguisorba canadensis	0	**	High	Yes	
Quercus ilicifolia	*	**	High	Yes	

** - high confidence that the design will capture the finer scale element. Protecting the coarse-scale element will also protect functioning examples of the finer-scale element. * - moderate confidence that the design will capture the finer scale element. Protecting the coarse-scale element will also protect functioning examples of the finer-scale element. 0 = neither of the above	**Confidence that habitat needs captured by landscape level design (** or * or 0)**	**Confidence that habitat needs Captured by habitat and natural community targets (** or * or 0)**	**Confidence that all the checked coarse filters provide suitable habitat in VT for long-term persistence (excluding external threats) (HIGH MED LOW)**	**Is coarse filter conservation in VT currently sufficient for this species to persist into the future?**	**Recommend that this species be managed in VT using the fine filter approach? ("Fine Filter" or blank)**
Isoetes engelmannii	0	*	Medium	No	Fine Filter
Polygonatum biflorum	0	*	Medium	No	Fine Filter
Sisyrinchium atlanticum	0	0	Low	No	Fine Filter