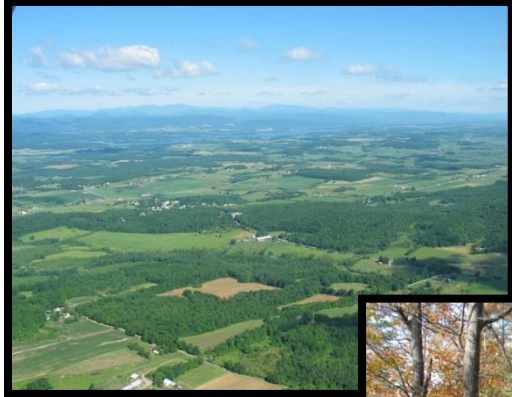


VERMONT CONSERVATION DESIGN

MAINTAINING AND ENHANCING AN ECOLOGICALLY FUNCTIONAL LANDSCAPE



***Summary Report for
Landscapes, Natural Communities, Habitats, and Species***

February 2018

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Acknowledgements

This document summarizes two technical reports of Vermont Conservation Design. Jens Hilke, Doug Morin, Keith Thompson, and Elizabeth Thompson coauthored these reports. Their expertise, insight, thoughtfulness, and commitment to a conservation vision made this work possible. Special thanks to the Vermont Land Trust for Liz's time in the Landscapes phase. We also greatly appreciate the time and expertise contributed by the steering committee and workgroup participants and their respective organizations listed below. They tackled tough questions and provided sound scientific input. We thank Commissioner Louis Porter, Mark Scott, Kim Royar, and John Austin (Vermont Fish and Wildlife Department), and Commissioner Michael Snyder and Deputy Commissioner Sam Lincoln (Vermont Department of Forests, Parks and Recreation) for their feedback, support, and encouragement. This project was funded by the U.S. Fish and Wildlife Service through State Wildlife Grants.



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For More Information

For data layers, technical reports, and additional information, please visit the Vermont Fish and Wildlife Department website: www.vtfishandwildlife.com, or contact the report authors.

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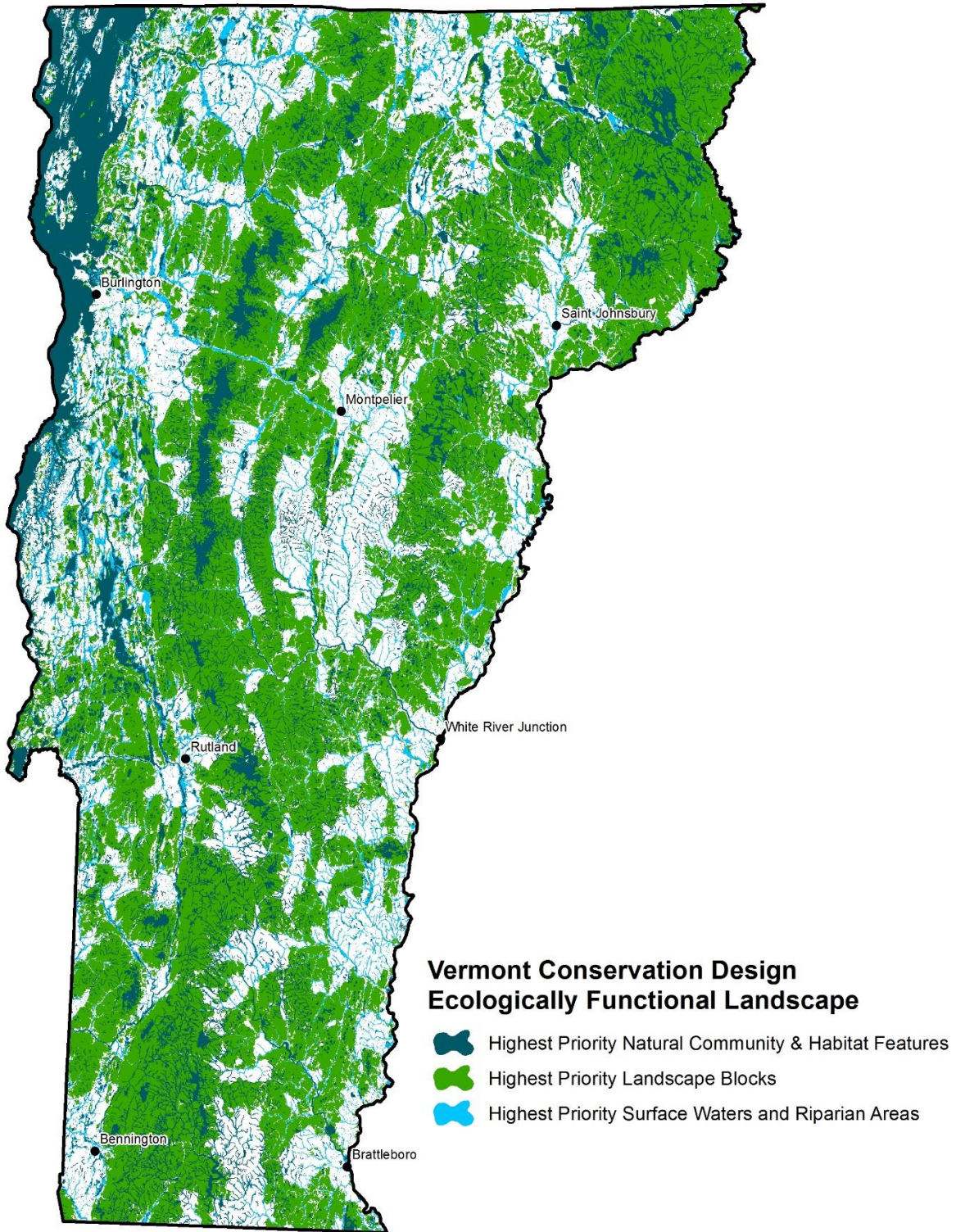
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Executive Summary

- Public surveys show strong support for conservation in Vermont. Vermonters value wildlife, nature, the state's rural character, and our working forests and farms. We depend on the natural landscape to support these and other values.
- Habitat loss and fragmentation, non-native species, and a rapidly changing climate all pose grave threats to species and ecosystems. The future of Vermont's forests, waters, and wildlife is uncertain.
- Vermont Conservation Design is a practical and efficient plan to address that uncertainty and sustain the state's valued natural areas, forests, waters, wildlife, and plants for future generations.
- Using our best scientific data, we identify easily understood and recognizable features that, when appropriately conserved or managed, collectively offer high confidence for the long-term continuation of an ecologically functional landscape.
- The foundation of Vermont Conservation Design is an intact, connected network of unfragmented Forest Blocks, Surface Waters, and Riparian Areas. These landscape features provide many functions, such as habitat for interior forest wildlife and clean air and water. They also allow species to move around the landscape. Landscape features occupy a relatively large area but offer wide latitude in management and conservation strategies.
- Natural community and habitat features are smaller, special places such as hemlock forests, rich fens, young forests, old forests, aquatic communities, grasslands, or caves. These all support particular species or ecological functions and are key components of this design. They occupy a relatively small area but often benefit from more specific management or conservation strategies.
- Together, these identified features represent a rigorous, science-based conservation design for Vermont. We have high confidence that they can keep Vermont's common plants and animals abundant and help prevent the disappearance of vulnerable species.
- Vermont Conservation Design maintains nature and the benefits it provides. The ecologically functional landscape it envisions sustains environmental services, like clean air and water, carbon sequestration, and flood protection. It provides resilience to climate change, allowing plants and animals to shift distributions. It supports numerous social and economic values, including outdoor recreation, the forest products economy, and the natural beauty that draws people to Vermont.
- Vermont Conservation Design is a vision to sustain the state's ecologically functional landscape based on our best science. Many tools can be used to achieve this vision. Thoughtful stewardship of private lands, with public support and incentives, will be essential to success. Other tools include conservation easements, regulations such as local planning and zoning, and ownership by a public agency or conservation organization. This document and these maps do not presume which of these tools are best suited to specific places or features.



Executive Summary Map: The Highest Priority Features identified by Vermont Conservation Design. A wide variety of management and conservation strategies can be used to maintain the ecological functions of each feature.

Introduction

Forests and fields, waters and wetlands, and their wildlife and plants, are central to Vermont's identity. Vermonters strongly value wildlife, nature, and the state's rural, sparsely developed landscape, including lands that support outdoor recreation, and working forests and farms. We depend on the natural landscape to support these values along with 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 forests, waters, and wildlife is uncertain.

Vermont Conservation Design is a practical and efficient plan to address that uncertainty, and sustain the state's valued natural areas, forests, waters, wildlife, and plants for future generations.

Vermont Conservation Design is a practical plan because it sets science-based quantitative and distributional goals for maintaining and restoring an ecologically functional landscape. For the first time, this plan provides a scientific 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 benefits to nature and to people, and they cannot be replaced once they are lost. Vermont Conservation Design is grounded in Vermont's tradition of responsible land stewardship.

Vermont Conservation Design is efficient because it specifically identifies or targets a minimum number of features to achieve conservation success. 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 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 require special conservation attention and Vermont Conservation Design helps us to focus on the species with the greatest needs.

In this report we identify four landscape features and six natural community and habitat features whose conservation and management is highest priority for maintaining ecological function. Landscape features—forest blocks and riparian areas—occupy large areas and are the foundation for intact and connected natural systems. Natural communities and habitats are the finer-scale pieces, such as hemlock forests, alder swamps, and grasslands that provide critical ecological functions and support our plants and animals. Together, these landscape and natural community-scale features form Vermont's ecologically functional landscape.

The results of this project represent a rigorous, science-based conservation design for Vermont. We have high confidence that if all these targeted features (forest blocks, surface waters and riparian areas, natural communities and habitats) can be conserved or managed appropriately, they will sustain nature and its benefits.

We present Vermont Conservation Design as a vision for Vermont’s future—a vision that maintains nature and all its complexities as defining characteristics of this small and diverse state. The densely populated areas of southern New England provide a clear story of how natural systems, wildlife habitat, ecological functions, and rural economies can be compromised or lost. Vermont Conservation Design provides a framework for us to carefully consider our choices for 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 land-use changes and climate changes, and the ability of 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 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 calcium-rich 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 to shift distributions and natural communities to rearrange themselves in response to a changing climate and other stressors.

Coarse-filter Conservation Approach

We used the coarse-filter approach to conservation (Noss 1987; Hunter et al. 1988). It would be overwhelming to identify and manage for the individual needs of the 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 features 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. By maintaining or enhancing these proxies, or coarse-filters, we can have high confidence that we can efficiently conserve the majority of Vermont’s native species.

The coarse-filter conservation approach can provide for the habitat needs of many—very likely the majority—of Vermont’s species, allowing for efficiency in conservation planning and design. This project focused on identifying coarse filters. We have high confidence that this conservation design identifies areas essential for the long-term functioning of Vermont’s landscape and the species it contains. However, coarse-filter conservation alone cannot adequately address the needs of all Vermont’s species. Very rare species, whose distributions on the landscape are infrequent and unpredictable, or species facing pests or diseases largely unrelated to habitat (e.g. moose and many bat species), cannot be conserved with coarse filters. Some species are simply vulnerable as a result of being in our human-dominated landscape and will always need conservation attention. A complementary “fine-filter” conservation approach is necessary, and Vermont Conservation Design has made it possible for the first time for us to identify many of those species in need.

Methods and Results

Vermont Conservation Design identifies landscape-level and natural community and habitat-level coarse filters—we refer to these as **landscape features** and **natural community and habitat features**. These features were selected using a repeatable process, our best scientific data, and professional judgement. The specific rationale and methods for these steps are described in the Vermont Conservation Design Technical Reports. Broadly, we listed potential features that could serve as coarse filters, and the finer-scale elements (species, communities, and ecological processes) that could be effectively conserved by each. This allowed us to select coarse filters that are the most efficient while still being readily understood and recognizable. We then compiled a final set of features that provides high confidence for the long-term conservation of ecological function in the state.

Based on these steps, we selected five landscape features and six natural community and habitat features as being the most effective and parsimonious for maintaining an ecologically functional landscape. These ten features are:

Landscape Features

- Interior Forest Blocks
- Connectivity Blocks
- Surface Waters and Riparian Areas
- Physical Landscapes

Natural Community and Habitat Features

- Natural Communities
- Young and Old Forests
- Aquatic Habitats
- Wetlands
- Grasslands and Shrublands
- Underground Habitats

In addition, we also identified Wildlife Road Crossings as a key element of the conservation design. Wildlife road crossings are road segments with suitable habitat on both sides of the road. Although not actually a coarse filter, wildlife road crossings are essential to the functions of the five chosen landscape features and therefore are a critical component of maintaining and enhancing Vermont’s ecologically functional landscape.

Once we had selected these features, we tested the overall design against a diverse list of more than 200 species. This list included common species, as well as rare and declining species of plants and animals that are Species of Greatest Conservation Need (SGCN) in the Vermont Wildlife Action Plan. The results of this analysis provide additional confidence in the overall functioning of the design.

When the ecological functions of each of these features are maintained and enhanced, and when each is conserved at the appropriate scale and distribution across the landscape, the majority of Vermont’s species and ecological processes are very likely to be conserved even as the climate changes.

While each feature in Vermont Conservation Design is important on its own, they cannot function in isolation. Maintaining or enhancing an ecologically functional landscape in Vermont depends on both the specific functions of each feature, and the ability of the pieces to function together. Interactions between features are what support Vermont’s environment and are essential for long-term conservation of Vermont’s biological diversity and natural heritage.



Each of these features is described below, and whenever possible, a map shows the areas identified as “highest priority” for each. In some cases, it is not possible to map features due to lack of spatial information.

The following descriptions and maps identify a large percentage of Vermont’s lands and waters for conservation priority. We are highly confident that these features and their ecological functions must be maintained if Vermont is to have an ecologically functional landscape into the future.

Conserving Ecological Function

The goal for each identified feature in the design 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. For example, the goal for Interior Forest Blocks is to maintain the unfragmented, interior forest of these areas that provides critical habitat for many species of plants and animals. There is considerable leeway on what can happen within a forest block and still maintain interior forest function. For example, most forest management activities are compatible with maintaining the long-term interior forest functions for these blocks, providing these activities are thoughtfully planned.

Conservation and management of natural communities and habitats is very specific to the individual feature. 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 habitat for nesting birds requires active management—the timing of field mowing is critical. Successfully implementing these targets will likely require the full range of conservation and management options available.

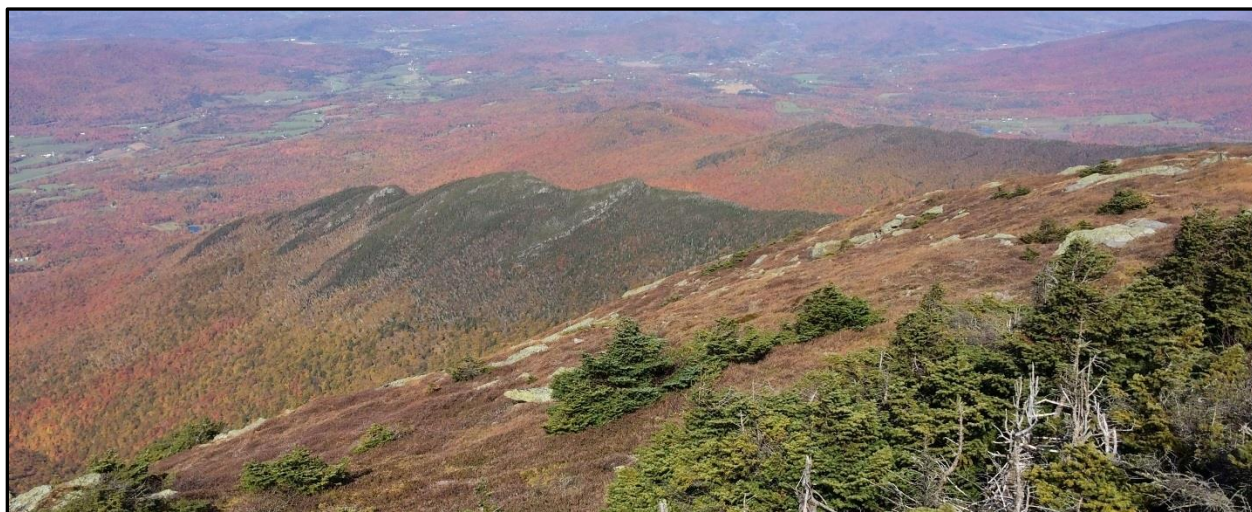
Many tools can be used to achieve the overall goal of retaining ecological function. With approximately 80% of Vermont’s land privately-owned, management and stewardship of private lands will be an essential path to success. Other potential tools include landowner incentives, conservation easements, regulations such as local planning and zoning, and ownership by a state or federal agency or a private conservation organization. This document and these maps do not provide suggestions as to which of these tools are best suited to specific places. The Vermont Conservation Design Technical Reports include recommendations for further prioritization filters that users can apply to help make these decisions.

Each section below provides guidelines on what is needed to maintain ecological functions for that feature.

Landscape Features

At the most basic level, an ecologically functional landscape must have intact and connected natural systems. The large, unfragmented forest blocks and the network of aquatic systems and their riparian areas identified in this section are the foundation for ecological function in the state. Minimizing fragmentation of these features, and maintaining or restoring connectivity across the landscape, is critical to the conservation of all of Vermont’s species and their habitats, and the ability of species to shift their distributions over time in response to ecological changes.

We identify the Highest Priority for each of the landscape features in this summary report. Additional Priority Areas are identified in Part 1 Vermont Conservation Design Technical Report. These Priority Areas form a second tier of importance for each feature. In addition, areas of Vermont that are not identified on any of the maps for landscape features may contain important forest blocks, habitats, natural communities, or other features. Although they are not identified as Highest Priority Landscapes, they too can be managed or conserved to contribute to an ecologically functional landscape.



Interior Forest Blocks

Forest blocks are areas of contiguous forest and other natural communities and habitats, such as wetlands, ponds, and cliffs, that are unfragmented by roads, development, or agriculture (Sorenson and Osborne 2014). Forests blocks are the first foundational unit of the Vermont Conservation Design.

Ecological Functions

Interior Forest Blocks provide many ecological and biological functions critical for protecting native species and the integrity of natural systems (Austin et al. 2004). These include: supporting natural ecological processes such as predator-prey interactions and natural disturbance regimes; helping to maintain air and water quality and flood resilience; supporting the biological needs of many plant and animal species, particularly those that are wide-ranging or sensitive to human encroachment; supporting viable populations of wide-ranging animals by allowing access to important feeding habitat, reproduction, and genetic exchange; and serving as habitat for source populations of dispersing animals for recolonization of nearby habitats that may have lost their original populations of those species.

In addition, large, topographically diverse forest blocks will allow many species of plants and animals to shift to suitable habitat within a forest block in response to climate change within the next century without having to cross developed areas to other forest blocks (Beier 2012).

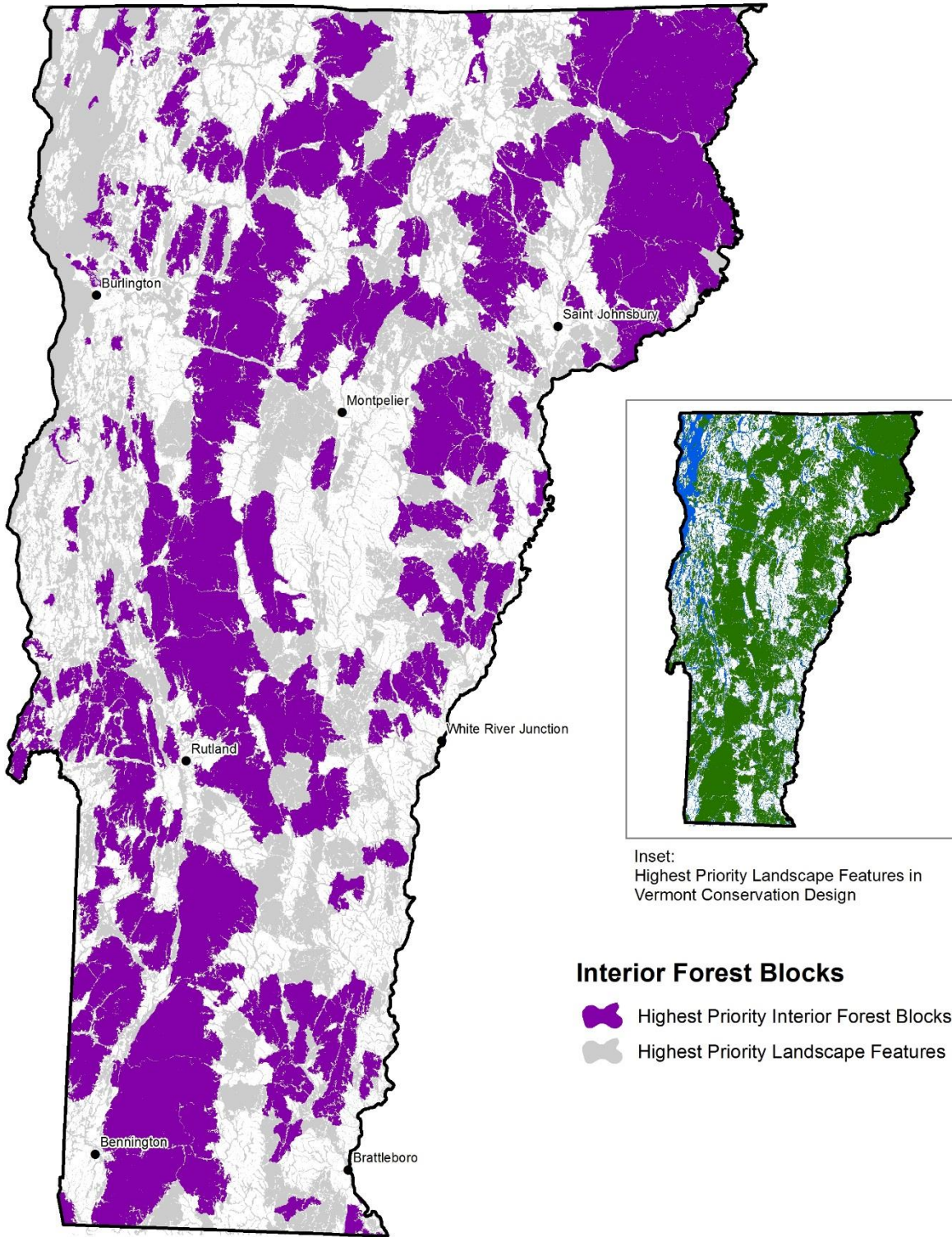
Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies a set of forest blocks across the state that are highest priority for maintaining interior forest. These are the largest and/or highest ranked forest blocks from all biophysical regions that provide the foundation for interior forest habitat and associated ecological functions. The primary goal for these areas is to maintain the interior forest condition by avoiding permanent fragmentation from development. Limited development on the margins of large forest blocks may not have a significant adverse effect, provided it does not reduce connectivity between blocks or encroach into the forest block interior. Forest management that maintains forest structure and results in a distribution of all ages classes is compatible with maintaining the ecological functions of these forest blocks.

For more information on interior forest blocks, see the following section in the Part 1 Vermont Conservation Design Technical Report:

- Interior Forest Blocks





Map 1. Highest Priority Interior Forest Blocks.

Connectivity Blocks

Landscape connectivity refers to the degree to which blocks of suitable habitat are connected to each other (Noss and Cooperrider 1994). Connectivity Blocks are the network of forest blocks that together provide terrestrial connectivity at the regional scale (across Vermont and to adjacent states and Québec) and connectivity between all Vermont biophysical regions. There is a high level of connectivity within individual forest blocks. The proximity of one forest block to another, the presence of riparian areas, and the characteristics of the intervening roads, agricultural lands, or development determine the effectiveness of the network of Connectivity Blocks in a particular area.

Ecological Functions

A network of Connectivity Blocks allows wide-ranging animals to move across their range, allows animals to find suitable habitat for their daily and annual life needs, allows young animals to disperse, allows plant and animal species to colonize new and appropriate habitat as climate and land uses change, and contributes to ecological processes, especially genetic exchange between populations (Austin et al. 2004). Maintaining the landscape connectivity function requires both Connectivity Blocks and Riparian Corridors, especially in highly fragmented areas of Vermont. There is general agreement among conservation biologists that landscape connectivity and wildlife corridors can mitigate some of the adverse effects of habitat fragmentation on wildlife populations and biological diversity (Beier and Noss 1998; Noss and Cooperrider 1994; Haddad et al. 2003; Damschen et al. 2006). Specifically, climate change adaptation is enhanced if the long-distance movements of plants and animals is supported by a combination of short movements within large, topographically diverse forest blocks and short corridor movements between forest blocks (Beier 2012).



Highest Priority Features and Guidelines for Maintaining Ecological Function

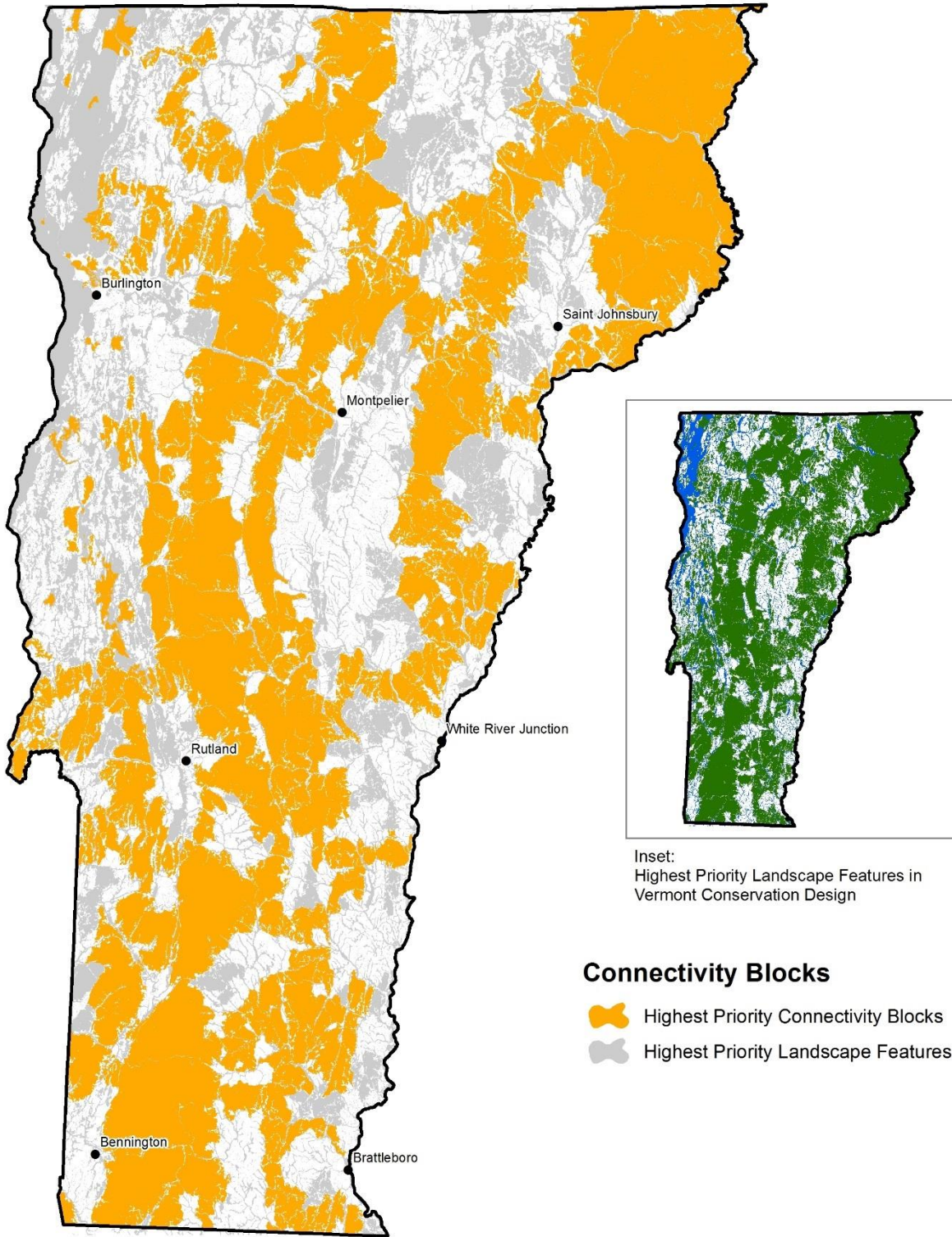
Vermont Conservation Design identifies a highest priority network, or “backbone” of connectivity blocks.

This “backbone” incorporates the spines of the major mountain ranges, connections outside Vermont to unfragmented habitat, and anchor blocks in fragmented biophysical regions based on abundant known occurrences of rare species and significant natural communities. Small forest blocks are included at pinch-points in the connectivity network as they are critical stepping stones.

Similar to Interior Forest Blocks, it is important to maintain the interior forest conditions in Connectivity Blocks by avoiding permanent interior forest fragmentation resulting from development. Connectivity within forest blocks will remain high if they remain unfragmented. For Connectivity Blocks it is also critically important to maintain or enhance the structural and functional connectivity that occurs on the margins of these blocks where they border other blocks. This can be accomplished by maintaining forest cover along the margins and by limiting development in these areas of block-to-block connectivity.

For more information on connectivity blocks, see the following section in the Part 1 Vermont Conservation Design Technical Report:

- Connectivity Blocks



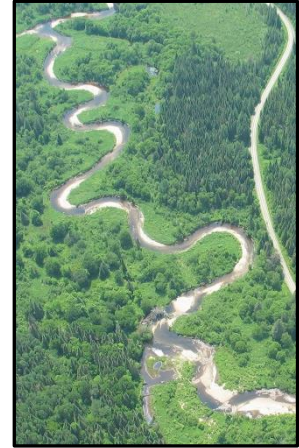
Map 2. Highest Priority Connectivity Blocks.

Surface Waters and Riparian Areas

Vermont's network of lakes, ponds, rivers and streams, and their associated riparian zones, valley bottoms, and river corridors are the second foundational unit of Vermont Conservation Design.

Ecological Functions

Aquatic systems provide vital habitat for a rich assemblage of aquatic species, including fish, amphibians, reptiles, invertebrates (e.g., insects, mussels, snails, worms, freshwater sponges), and plants. Naturally vegetated riparian areas provide many functions, including stabilizing shorelines, storage of flood waters, filtration 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, 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.



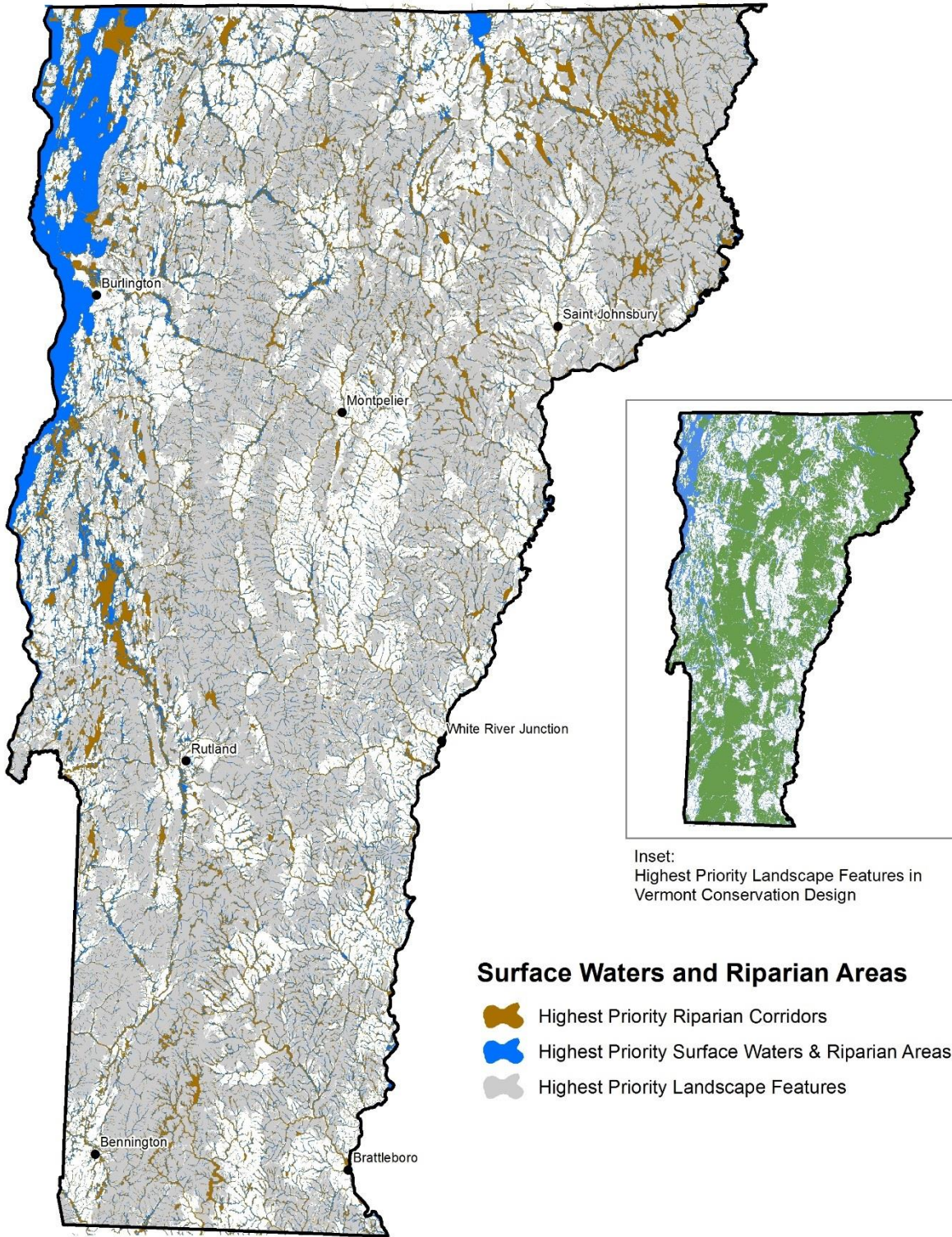
The linear network of riparian areas provides a crucial element of landscape connectivity. Many wildlife species use riparian corridors for travel to find suitable habitat to meet their life requisites, but certain species are almost entirely restricted to riparian areas, including mink, otter, beaver, and wood turtle. The combination of Riparian Areas for Connectivity, and Connectivity Blocks, provide the best available paths across the landscape, especially in highly fragmented regions like the Champlain Valley. Riparian connections also allow for long-term plant and animal movement in response to climate change (Beier 2012). Although many riparian areas and river corridors are highly altered by agriculture, roads, and urbanization, the risk of flooding serves as a natural deterrent for future development. Riparian areas also respond rapidly to restoration efforts (Beier 2012).

Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies the entire undeveloped network of surface waters and riparian areas as highest priority for maintaining an ecologically functional landscape. The ecological integrity of an aquatic system is critically tied to the condition of the riparian area adjacent to the stream or pond. Rivers and streams must have access to their floodplains and freedom to meander. Maintaining or restoring river channel equilibriums, the unimpeded movement of aquatic organisms, and natural riparian vegetation is essential to protecting water quality and providing high-quality habitat for terrestrial and aquatic species. The width of naturally vegetated riparian areas needed to provide terrestrial riparian connectivity varies from 100 feet or less on some small streams (50 feet each side) to 600 feet or more (300 feet on each side) for larger rivers or riparian areas that span long distances of otherwise unsuitable habitat.

For more information on surface waters and riparian areas, see the following sections in the Part 1 Vermont Conservation Design Technical Report:

- Surface Waters and Riparian Areas
- Riparian Areas for Connectivity (Riparian Corridors)



Map 3. Highest Priority Surface Waters and Riparian Areas (blue). Highest Priority Riparian Corridors (brown) are the naturally vegetated portions of the network that facilitate wildlife travel.

Physical Landscapes

Physical landscapes (often referred to as enduring features) are the parts of the landscape that resist change. They are the hills and valleys, the underlying bedrock, and the deposits left behind by glaciers. They remain largely unchanged when changes in land cover and wildlife occur, as plants and animals move, and even as the climate changes.

Ecological Functions

If nature is likened to a dramatic play, it's possible to think of the physical features as the stage and the individual species as the actors. The play is the natural communities, habitats and species that occur in a given place at a given time, but regardless of the action, the stage does not change. The importance of “conserving nature’s stage” is that we can be much more confident in our ability to conserve biological diversity and maintain a functional landscape into the future, with the capacity to adapt and be resilient to climate change, if all elements of physical landscape diversity are represented in the conservation design (Anderson & Ferree 2010; Beier and Brost 2010; Beier et al. 2015).

Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies conservation of a representative selection of all physical landscapes as highest priority for maintaining ecological function. To do this, the entire landscape design includes all of Vermont’s physical settings roughly proportional to their occurrence in the state. To do so, additional blocks—Physical Landscape Blocks—were added to the highest priority Surface Waters and Riparian Area network and the highest priority Interior

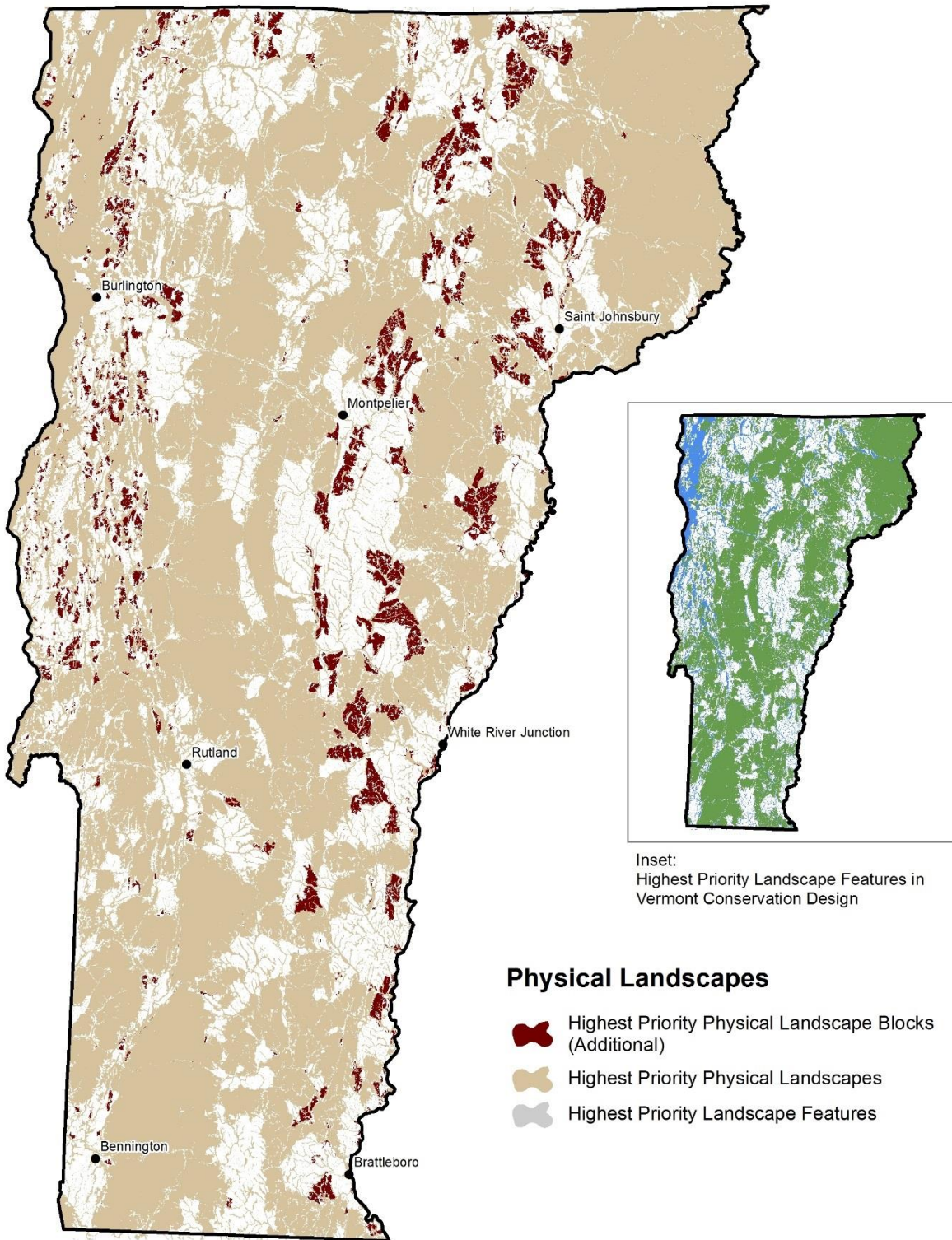


Forest Blocks and Connectivity Blocks in order to reach an overall design that includes the full range of physical diversity found in Vermont. We highlight these Physical Landscape Blocks in Map 4, but stress that the conservation of the entire design is necessary to provide the coarse-filter and climate resilience functions provided by the full range of physical landscapes.

Similar to the Interior Forest Blocks, maintaining and restoring natural vegetation and limiting development within these areas will protect the functions of these physical landscapes. Forest management that maintains forest structure and results in a distribution of all age classes is very compatible with maintaining the physical landscape diversity functions.

For more information on physical landscapes, see the following section in the Part 1 Vermont Conservation Design Technical Report:

- Physical Landscape Diversity Areas



Map 4. Highest Priority Physical Landscapes. Blocks shown in dark red were added to the design specifically to increase representation of rare and important physical settings. Note that Highest Priority Physical Landscapes overlap all of the Highest Priority Landscape Features.

Wildlife Road Crossings

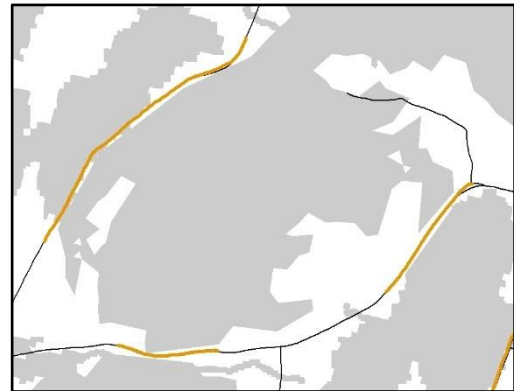
Landscape-scale connectivity and the ecological functions it provides depend on the ability of species to travel between forest blocks or along riparian corridors. Roads represent a barrier to wildlife movement and dispersal of many other species, including some plants.

Ecological Functions

Sections of roads that have suitable habitat on both sides are more likely to allow wildlife movement and dispersal of other species and, therefore, these sections of roads are critical components of maintaining or enhancing an interconnected, ecologically functional landscape. Wildlife road crossings that provide connectivity over or under roads are critically important between adjacent forest blocks and along linear riparian area networks. In addition, allowing for the passage of aquatic organisms through bridges or culverts is critical for the functioning of the network of rivers and streams.

Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies a set of wildlife road crossings that are highest priority for maintaining connections between highest priority forest blocks, and that are highest priority for maintaining permeable riparian corridors.



Map 5. Highest Priority Wildlife Road Crossings connect forest blocks and riparian areas.



Structural connectivity across identified wildlife road crossings is provided by the presence of forest cover, wetlands, or other natural habitats. Maintaining or restoring natural vegetation on both sides of identified road crossing segments will maximize the effectiveness of the road crossing for connectivity.

Forest management that maintains forest cover

adjacent to the road is compatible with this function. Roadside development that further restricts animal movement is detrimental to connectivity. Road and highway structures that allow or promote fish and wildlife movement, such as bridges and oversized culverts, and limiting the use of fences and roadside barriers that impede movement, are all effective in promoting wildlife passage.

For more information on wildlife road crossings in Vermont Conservation Design, see the following sections in the Part 1 Vermont Conservation Design Technical Report:

- Wildlife Road Crossings
- Connectivity Blocks
- Riparian Areas for Connectivity (Riparian Corridors)

Natural Community and Habitat Features

While landscape features such as forest blocks and riparian areas are foundational for ecological function, they are greatly enhanced when combined with finer scale features. In this section, we identify the highest priority natural communities and habitats that—when conserved in conjunction with the landscape features—are necessary to maintain and enhance an ecologically functional landscape in Vermont. These finer-scale features together occupy a much smaller land area than the landscape features. However, they are closely associated with more specific environmental settings or ecological conditions that are not fully reflected by the landscape features. Many plant and animal species depend on the combination of the landscape features and these specific natural communities and habitats.

We can fully describe the natural communities and habitats that are needed for an ecologically functional landscape, but we cannot necessarily map them all. Some, such as young forests or shrublands are temporary on the landscape, and shift locations over time. Others, such as natural communities and wetlands have incomplete inventory across the state, and mapping reflects the best current knowledge. The descriptions provided here should help planners and land managers determine if an unmapped, unassessed feature meets the criteria of being highest priority.



Natural Communities

Natural communities are interacting assemblages of organisms and their environment, and they are classified into types, such as Northern Hardwood Forest, Hemlock Forest, Red Maple-Black Gum Swamp, and Cattail Marsh, that repeat across the landscape wherever similar conditions are found.

Ecological Functions

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. Collectively, these 97 types in Vermont encompass the full range of habitat conditions that native flora and fauna evolved with and are adapted to. Therefore, conserving high-quality examples of all the natural community types is an efficient way to conserve most species.

Natural communities are relatively stable in a human timeframe, but their species assemblages 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 places that are expected to continue to support important natural communities, and associated species, into the future.

Highest Priority Features and Guidelines for Maintaining Ecological Function

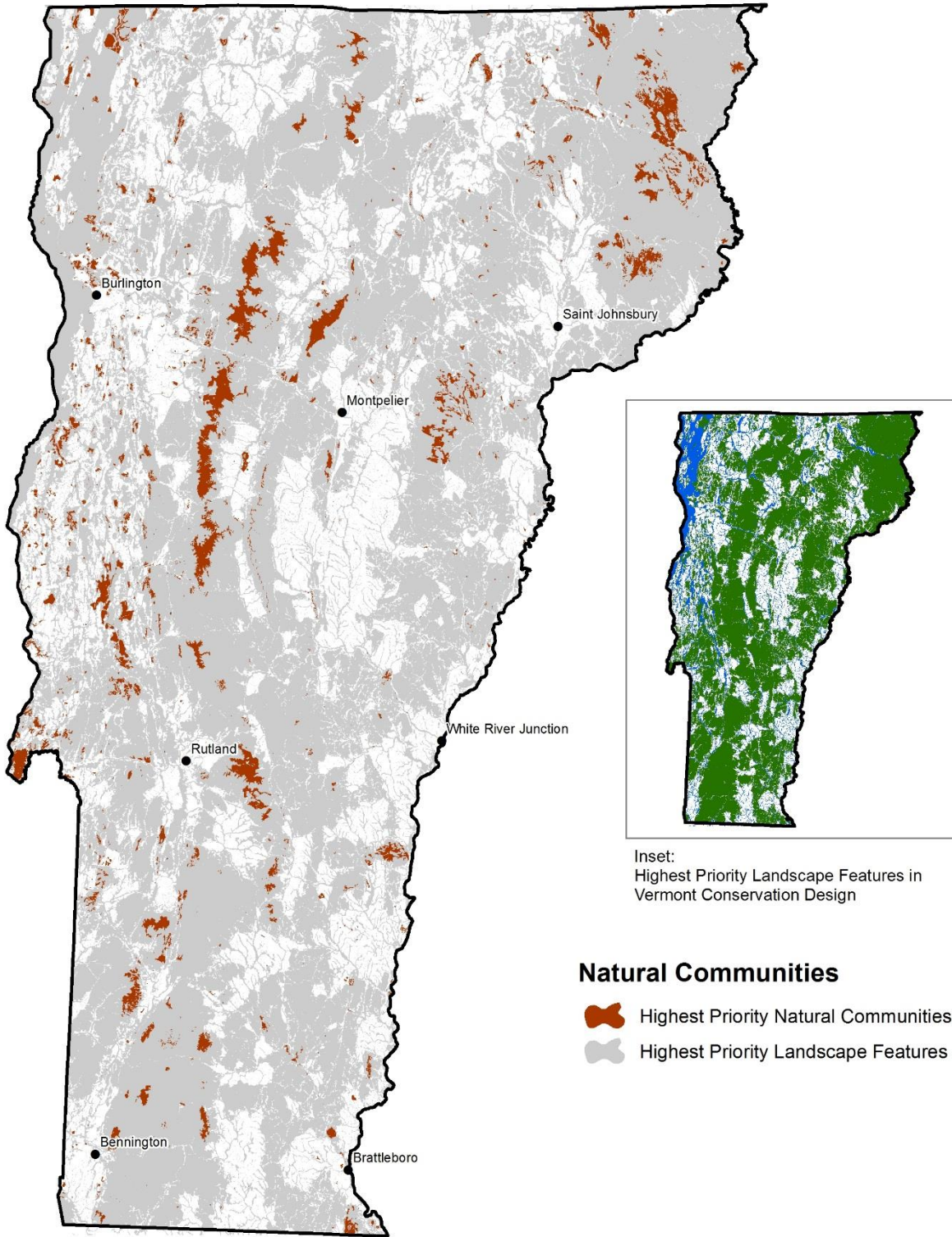
Vermont Conservation Design identifies conserving state-significant examples of each of the natural community types as a highest priority for maintaining ecological function. Specifically, this means conserving all significant examples of rare natural community types, and 50% of the significant examples of more common types, distributed across biophysical regions, and within an intact and connected natural landscape whenever possible. Some community types can be effectively conserved by other coarse filters. Matrix community types, such as Northern Hardwood Forest, are effectively captured by forest blocks and old forests. Seeps and vernal pools are captured by forest blocks and wetlands, respectively.



These natural communities should be maintained in, or restored to, a state of high ecological integrity. This translates into several measurable characteristics. Each natural community should be dominated by the native species characteristic of that community type. The species composition and physical conditions (soils, hydrology, etc.) should be largely unaltered by, or mostly recovered from, human disturbances. Natural disturbance processes should 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.

For more information on natural communities, see the following section in the Part 2 Vermont Conservation Design Technical Report:

- Natural Communities



Map 6. Highest Priority Natural Communities. Mapping represents the best current knowledge; additional highest priority natural communities exist that are not yet mapped.

Young and Old Forests

Young forests are regenerating forests dominated by dense seedlings and saplings less than 15-20 years old. Old forests are biologically mature forests, generally with trees exceeding 150 years in age.

Ecological Functions

The vast majority of Vermont’s native plants and animals are adapted to the forest conditions that preceded European settlement. Because approximately 80% of Vermont’s forest was cleared in the 19th century, today the forest composition and structure is very different than the conditions in which these species evolved. Old forests with large trees, abundant dead and downed wood, and natural canopy gaps, are essentially absent on the landscape. The complex structure of these forests creates diverse habitats, many of which are not present in younger forests. These complex structures also make these forests remarkably resilient. Old forests will be important “life-boats” that allow species and ecological processes to adapt to a changing climate.



At the same time, in most regions of Vermont young forest is less abundant today than it was before European settlement when natural disturbance created gaps and openings in the widespread forest. Young forests support a suite of wildlife species, many of which are in regional decline. Young forests also support many common species. Prior to European settlement almost all young forest was created by natural disturbance. Currently, forest management creates the majority of young forest in the state.

Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies increasing the amount of both young and old forest in the state as highest priority for maintaining an ecologically functional landscape. A return to the pre-European abundance of young forest (approximately 3-5% of the forest) is needed to reverse a declining trend and reach a level that at one time supported all of Vermont’s native species that require young forest. While it is not practical or possible to return to a landscape dominated by old forest, allowing about 9% of Vermont’s forest (specifically, 15% of the matrix forest within the highest priority forest blocks) to become old forest will bring this missing component back to Vermont’s landscape and offer confidence that species that benefit from or depend on this condition can persist.

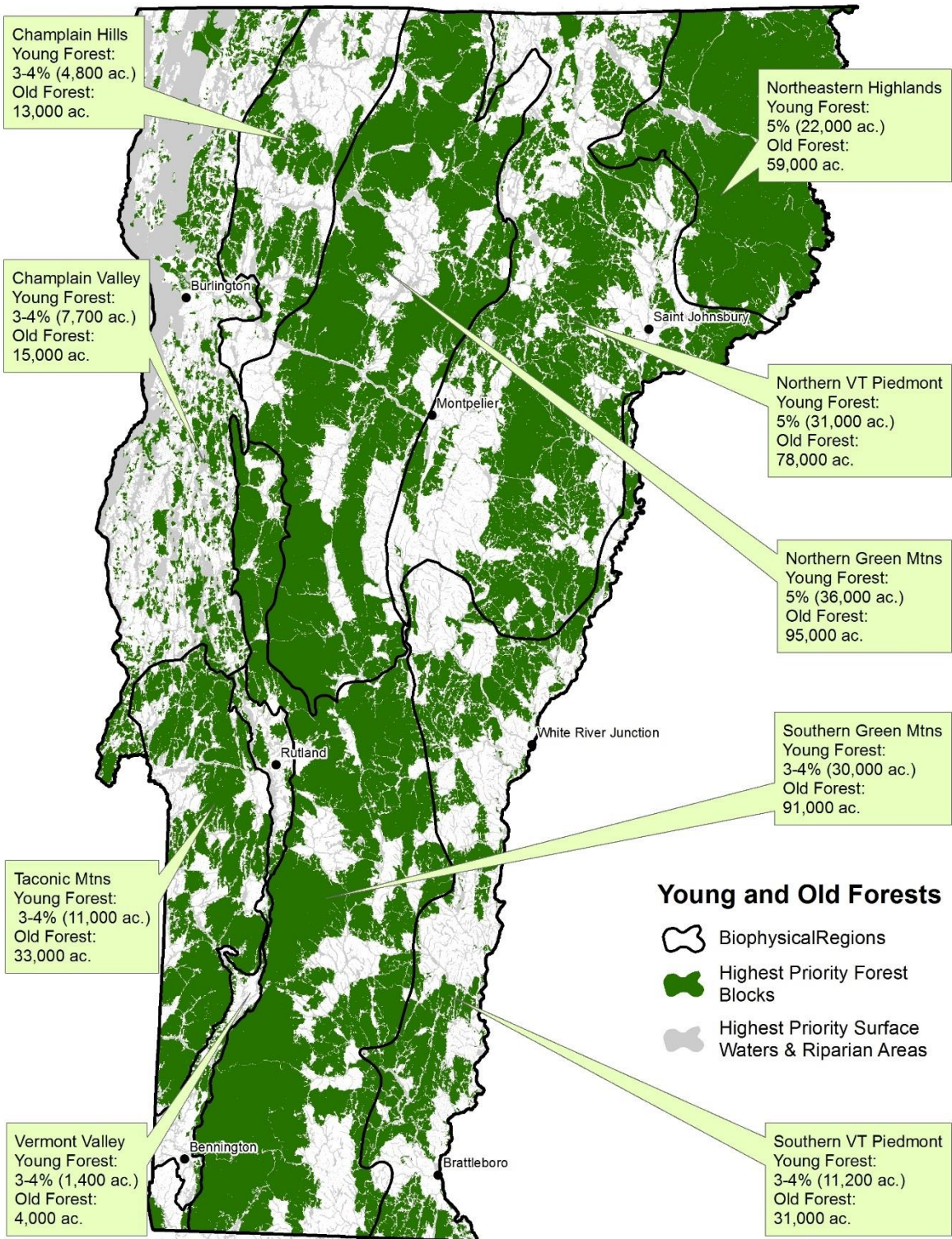
Young forest patches should be large enough to meet the needs of obligate species (generally 5 acres or larger), without compromising the ecological functions of other highest priority features. Old forests



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. In most forests, passive restoration will result in old forest. In some cases, active forest management may promote forest composition and structure suitable for subsequent passive restoration.

For more information on young and old forests, see the following sections in the Part 2 Vermont Conservation Design Technical Report:

- Young Forest
- Old Forest



Map 7: Highest Priority Young and Old Forest acreages within the highest priority forests blocks in each biophysical region.

Aquatic Habitats

Aquatic habitats are those found in rivers, streams, lakes, and ponds. These places are a vital subset of the Surface Waters and Riparian Areas network, but they still depend on the successful functioning of the entire aquatic network.

Ecological Functions

Aquatic habitats are essential for many species, including fish, amphibians, reptiles, invertebrates, and plants. Particular lakes and ponds, and segments of rivers and streams, make exceptional contributions



to Vermont's biological diversity because of their unique physical characteristics arising from geology or topography, because they are good examples of aquatic habitats, or because they have concentrations of rare species and/or important species assemblages.

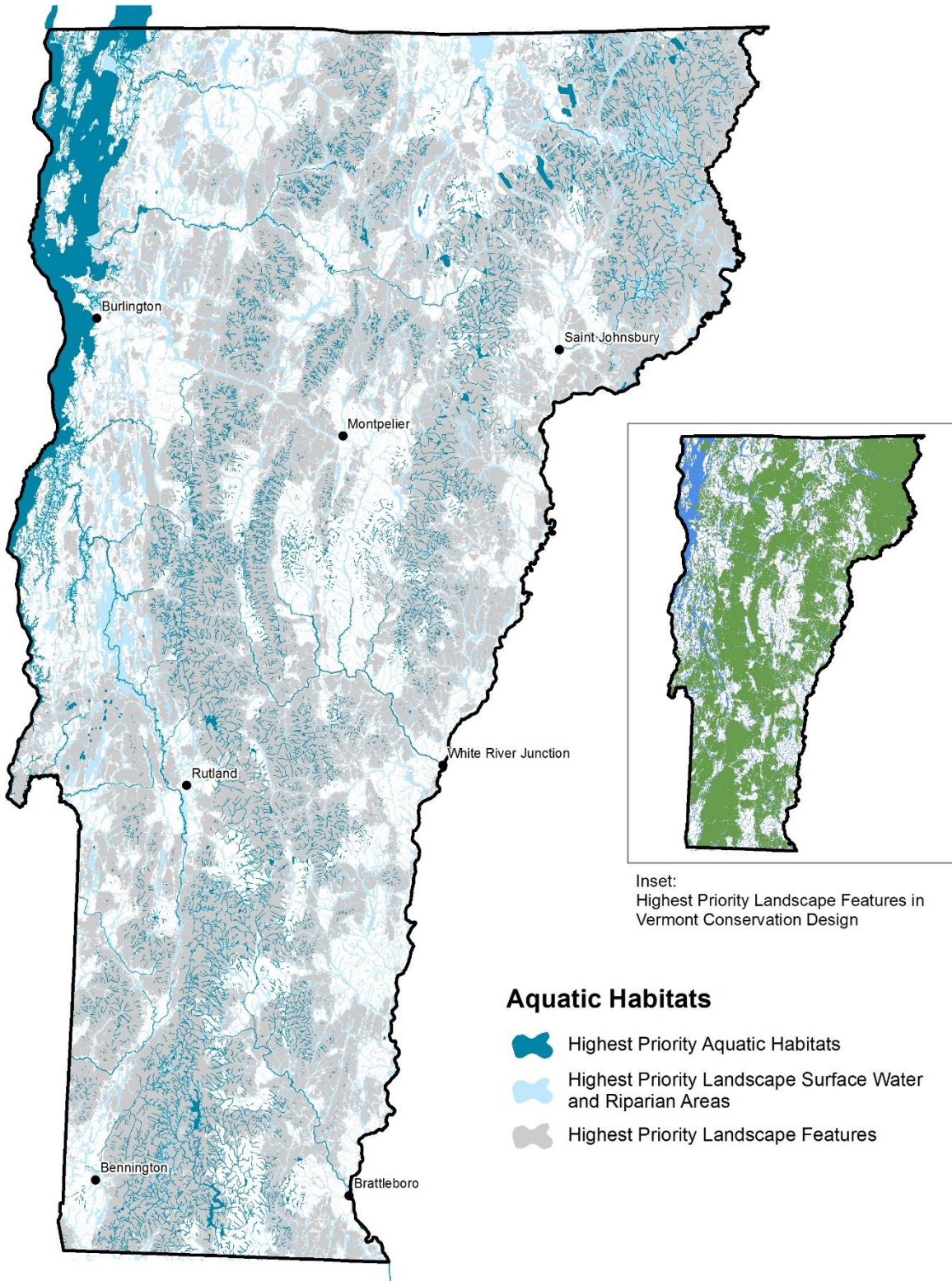
Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies a set of aquatic habitats that are highest priority for maintaining ecological function. These are lakes and ponds, and segments of rivers and streams with known concentrations of rare species, exceptional species diversity, or which are examples of high-quality habitat. Collectively these features are representative of physical aquatic conditions. The river and stream segments include the full range of stream sizes, gradients, and temperature conditions in Vermont as identified by Anderson et al. (2013). Lakes and ponds include full representation of trophic status, depth, and alkalinity, which are generally the main factors that shape biological communities in lakes (Wetzel 2001). These highest priority aquatic habitats must be part of a fully functioning network of surface waters and riparian areas. Although areas with exceptional biological contributions can be identified, they cannot function independently.

An aquatic system's ecological integrity depends on the condition of the watershed in which it occurs, but it is 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 vegetation should be maintained or restored along shorelines, and should have adequate width to maintain water quality, stabilize shorelines, and provide shade and the recruitment of downed wood and other natural organic matter. Runoff and erosion should be minimized along developed shorelines. Underwater habitat and vegetation should be maintained or restored to provide suitable conditions for foraging, shelter, and reproduction of aquatic organisms. The spread of aquatic invasive species and pathogens should be prevented and controlled where possible.

For more information on aquatic habitats, see the following sections in the Part 2 Vermont Conservation Design Technical Report:

- Important Aquatic Habitats and Species Assemblages – Rivers and Streams
- Important Aquatic Habitats and Species Assemblages – Lakes and Ponds
- Representative Lakes and Ponds



Map 8. Highest Priority Aquatic Habitats (dark blue). These features are a subset of the landscape-scale Surface Waters and Riparian Areas (light blue). Aquatic habitats depend on the ecological functioning of the entire aquatic network.

Wetlands

Wetlands are vegetated ecosystems characterized by abundant water. Vermont's wetlands range from small vernal pools and seeps to vast swamps and marshes covering thousands of acres.

Ecological Functions

Wetlands store water and attenuate downstream flooding. They maintain water quality by trapping sediments and removing nutrients and pollutants. Shoreline wetlands protect against erosion during floods and storms. Many wetlands are associated with groundwater discharge and form the headwaters of many cold-water streams. Wetlands provide important wildlife habitat and spawning and nursery habitat for fish species. Wetlands in Vermont provide habitat for a disproportionately high percentage of rare species. As climate change brings more frequent and larger storm events, and results in warmer surface waters, wetland functions will become even more important.

Vernal pools are a special type of wetland that provides critical breeding habitat for wood frogs and several salamander species, including spotted salamanders. These species migrate to vernal pools for spring breeding from the 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. The mature amphibians then move to the adjacent forest for the fall and winter.

Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation identifies a set of wetlands and vernal pools that are highest priority for maintaining ecological function. These are primarily wetlands and vernal pools associated with the landscape-scale forest blocks and riparian areas. It also includes wetlands in degraded watersheds where wetland functions are especially critical for water quality, water storage, and erosion control.

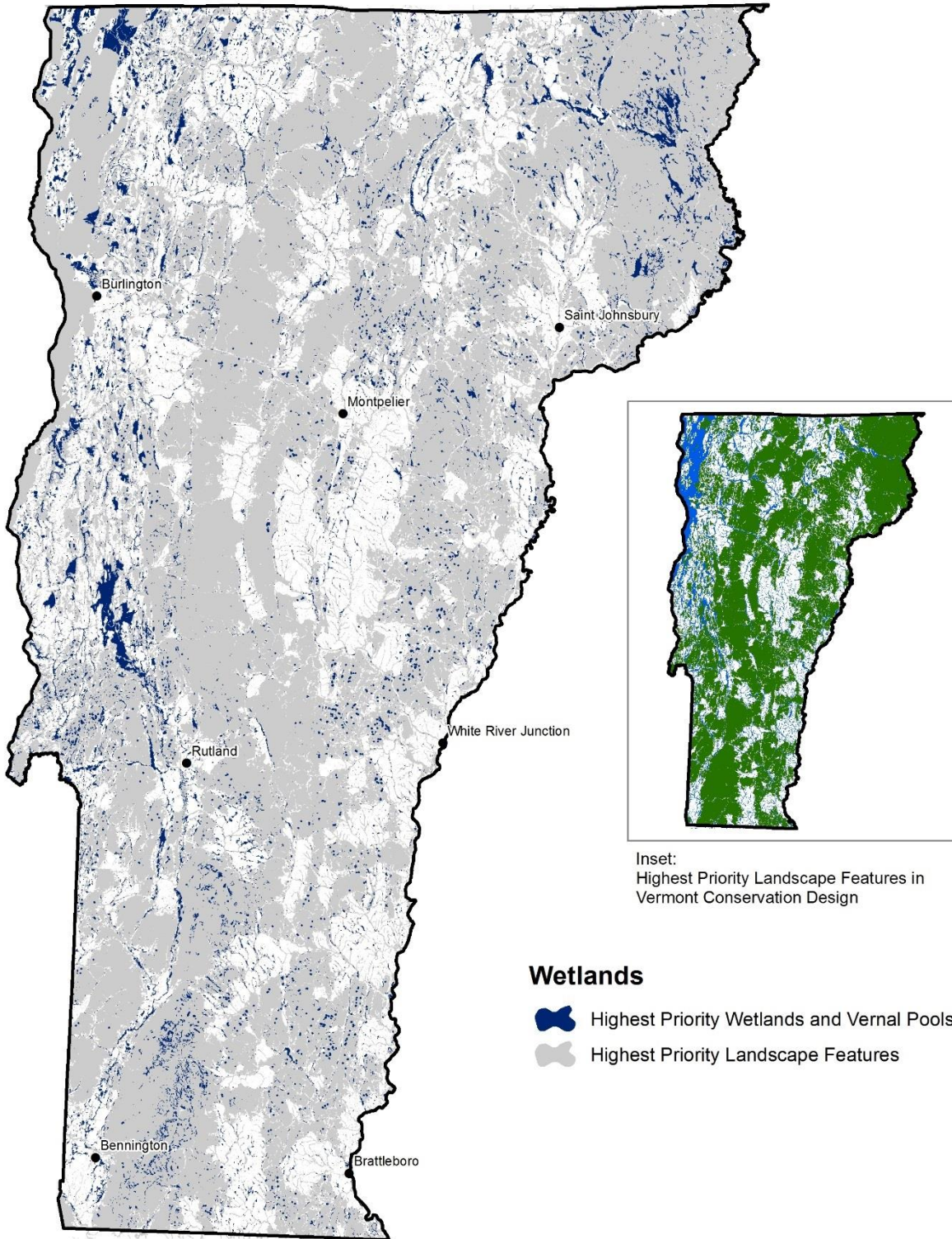
Wetland functions can be conserved by maintaining or restoring natural ecological conditions, including unaltered soils and hydrology, native vegetation appropriate to the site, and suitable conditions for native fish and wildlife species. Conservation should account for appropriate upland buffer zones, the ecological processes that support wetlands (especially



hydrology), and a network of connected lands, waters, and riparian areas to allow ecological exchange between wetlands. More than 35% of the original wetlands in Vermont have been lost to agriculture, development, and other land uses, so wetland restoration is needed to achieve full ecological function across the landscape. For vernal pools, special attention is needed to maintain or enhance conditions in and around the pool for pool-breeding obligate species. In addition to the guidelines above, maintain or restore a mostly 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.

For more information on wetlands, see the following sections in the Part 2 Vermont Conservation Design Technical Report:

- Wetlands
- Vernal Pools



Map 9. Highest Priority Wetlands and Vernal Pools. Mapping represents the best current knowledge; additional highest priority wetlands and vernal pools exist that are not shown on the map.

Grasslands and Shrublands

Grasslands are dominated by non-invasive (but often non-native) grasses in agricultural settings. Shrublands are old fields and other upland areas characterized by at least 50% cover of native shrub species. (Wet shrublands, such as Alder Swamps, are included under natural communities and wetlands.) Grasslands and upland shrublands are managed habitats created by humans.

Ecological Functions

Grasslands and Shrublands support many wildlife species—particularly birds—that have become more abundant in Vermont since the start of widespread agriculture. In grasslands, these include bobolink, eastern meadowlark, and savannah sparrow. Shrubland species include American woodcock, brown thrasher, eastern towhee, blue-winged warbler, and eastern cottontail.

Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies the need to maintain these habitats and their associated species as highest priority for an ecologically functional landscape. Specifically, a total of 7,500 acres, divided between the northern Champlain Valley/Champlain Hills, southern Champlain Valley, and the Lake

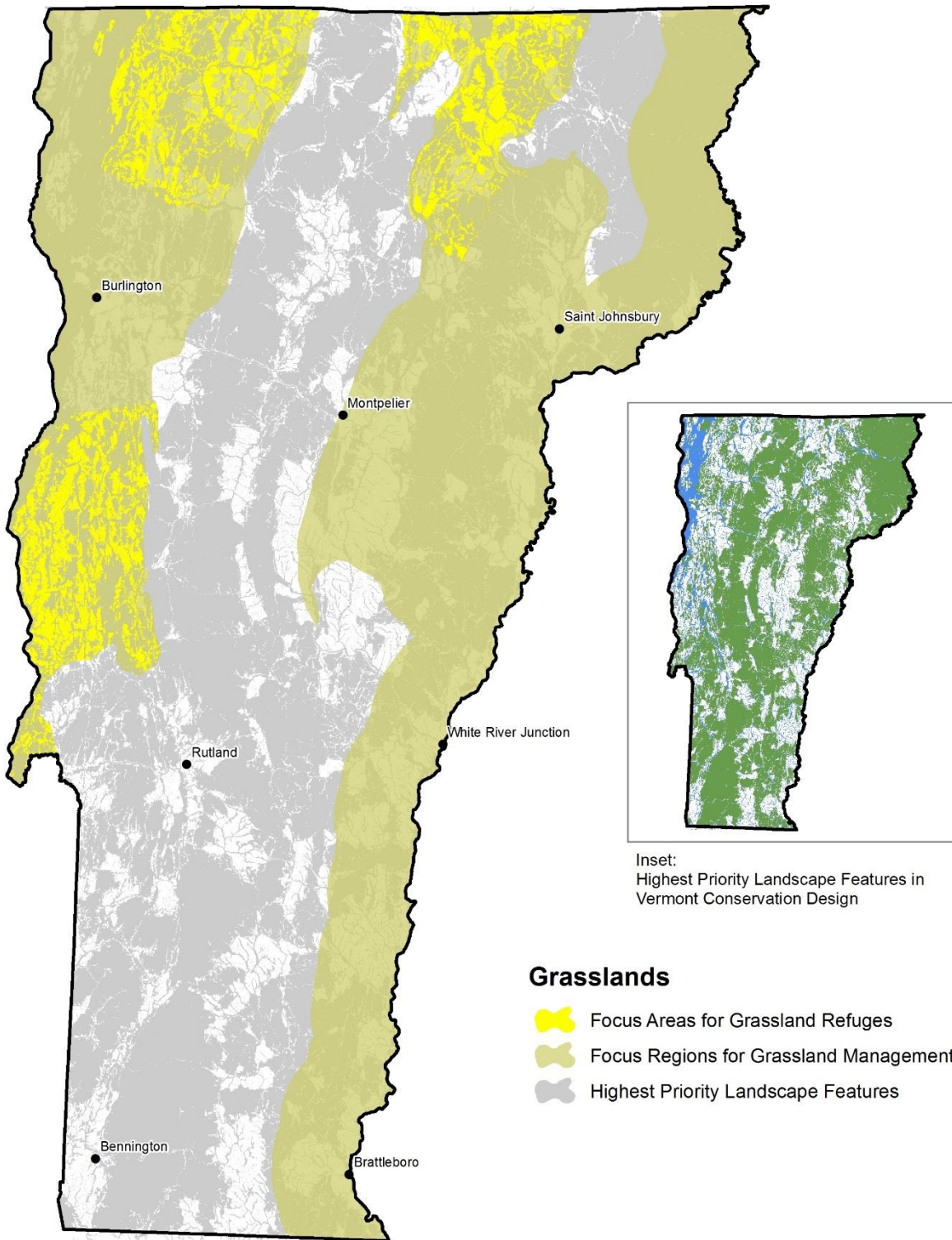


Memphremagog area, should be managed as “refuges” for grassland birds. In addition, bird-friendly practices should be promoted on active agricultural fields in the Champlain Valley, Champlain Hills, Northern Vermont Piedmont, and along the Connecticut River. Shrublands should be managed as a percentage of the undeveloped land in each biophysical region, with a target of 2-3% in the Champlain Valley and 0.5-1% in all other regions.

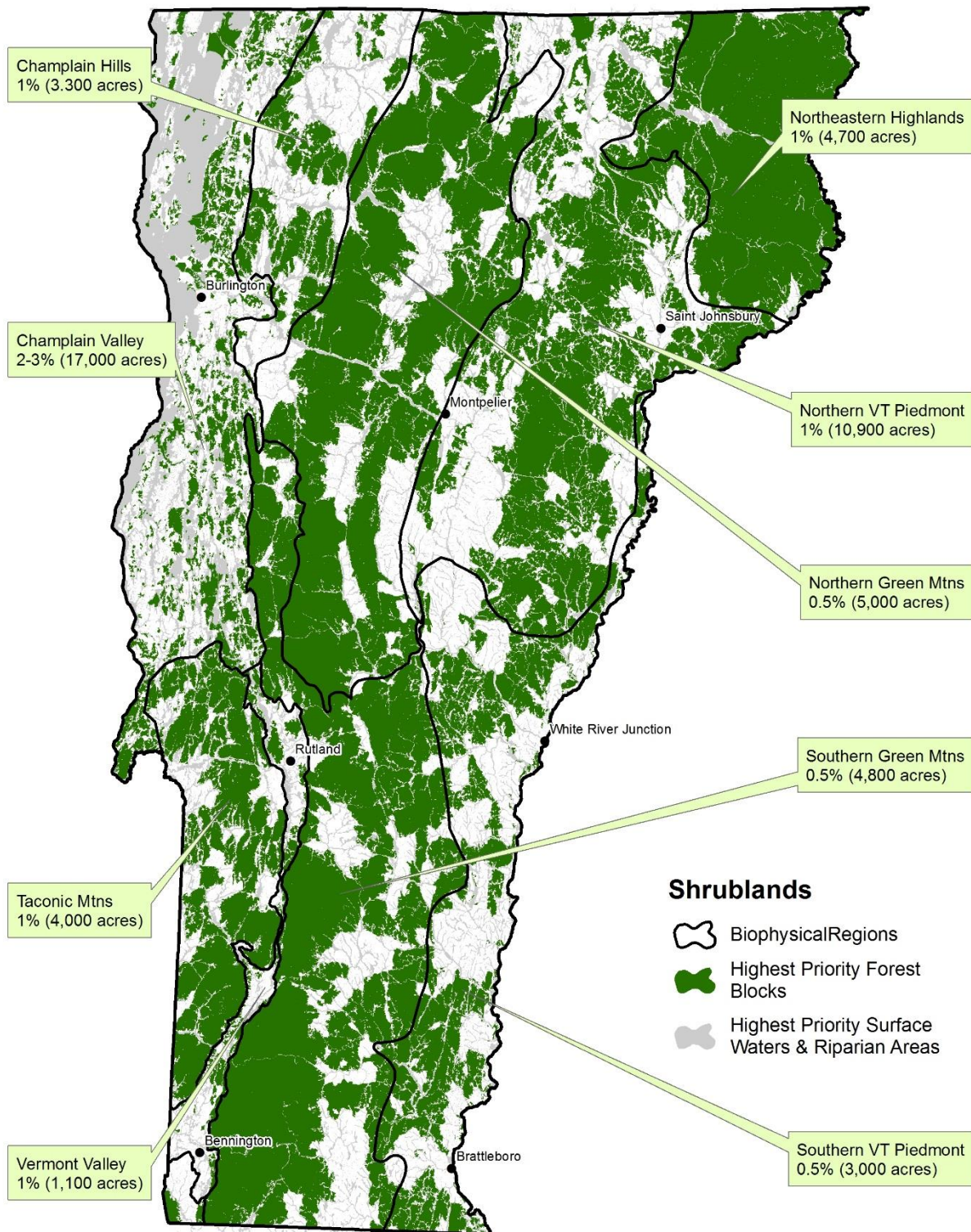
Grassland management must maintain quality grassland, while not destroying nests during the breeding season (May to early August). Mowing or other management should take place after August 1. Grassland patches should be larger than 25 acres. Patches that are blocky or circular have more interior area and support more birds. Mowing should incorporate best management practices for birds and reptiles. To avoid conflicts with other ecological functions, grasslands should be located outside of highest priority landscape features. Shrubland management (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. Shrublands should be composed primarily of non-invasive vegetation.

For more information on grasslands and shrublands, see the following sections in the Part 2 Vermont Conservation Design Technical Report:

- Grasslands – Refuges
- Grasslands – Managed Agricultural Lands
- Upland Shrub-Forb



Map 10. Focus areas within which the Highest Priority 7,500 acres of grassland refuge could be established. Specific grasslands cannot be mapped due to a lack of spatial information. To avoid conflicts with other ecological functions, grasslands should be managed outside of the highest priority landscape features.



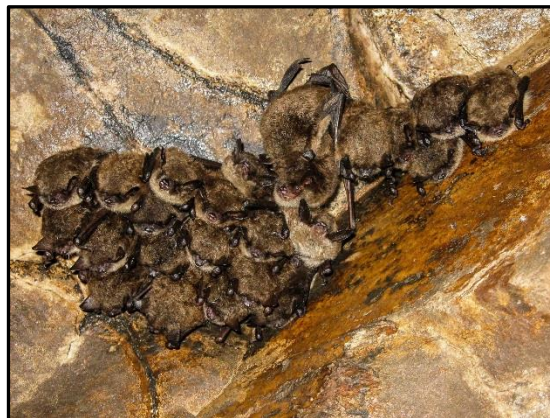
Map 11: Highest Priority Shrubland acreages by biophysical region. Shrubland can be created and maintained both within and outside of the highest priority landscape features, as long as it avoids conflicting with other ecological functions.

Underground Habitats

Caves are a unique habitat with a consistent environment of temperature, relative humidity, and air flow. Abandoned mines can provide many of the same habitat qualities of natural caves.

Ecological Functions

There are six species of bats known to hibernate in Vermont caves and mines. Recent surveys indicate that caves may hold as few as 10 individual bats to over 70,000. Bats use these sites for hibernation, but also spend a disproportionate amount of the year in the area surrounding the cave (e.g., fall swarming). Interest and understanding in the invertebrate communities associated with caves is just beginning, and even less is known about native fungi and other life forms. The condition and biology of the subterranean aquatic habitats is poorly understood. 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. Although abandoned mines are not of natural origin, they augment the natural habitats available and are an additional coarse filter for bat species.



Highest Priority Features and Guidelines for Maintaining Ecological Function

Vermont Conservation Design identifies a set of 22 caves and 19 abandoned mines that are highest priority for maintaining ecological function. Ideally, this set of caves would represent the full range of bedrock type and cave formations found in the state, but currently there is insufficient information to fully assess this. Additional study may ultimately refine these targets.

Changes in structure and hydrology could greatly affect the habitat provided by subterranean areas. Subterranean areas should remain intact, with limited human alteration or influence from above-ground pollutants. Maintain natural processes in caves, including temperature regime, airflow, humidity, and hydrology; natural vegetation conditions above the cave footprint and a 50-meter buffer to moderate air and temperature conditions; and natural groundwater sources. For abandoned mines, maintain the conditions that support hibernating bats or other known obligate species. Recreational exploration of caves and mines can pose a threat to physical conditions and species. Within a 0.25-mile zone around the cave or mine entrance, maintain natural forest vegetation with a diversity of age classes, and abundant live or dead known or potential roost trees with cavities, cracks, crevices, and/or peeling bark.

For more information on underground habitats, see the following sections in the Part 2 Vermont Conservation Design Technical Report:

- Caves
- Abandoned Mines

Caves and abandoned mines are not listed or mapped in this report in order to protect sensitive species and sites.

Species Conservation

Combined, the landscape, natural community, and habitat features identified in Vermont Conservation Design form the ecologically functional landscape. We are confident that these features, if appropriately conserved and managed to maintain their functions, will support the habitat needs of most of Vermont's native species. However, it is equally important to identify those species that will not be effectively conserved by this design. These species may need specific conservation and management actions to maintain viable populations in Vermont.

We tested the overall conservation design against a diverse list of more than 200 species. This list included common species, as well as rare and declining species of plants and animals that are Species of Greatest Conservation Need (SGCN) in the Vermont Wildlife Action Plan. We determined which of these species are expected to be conserved in Vermont by the identified features, and which are expected to require fine-filter conservation attention. Through this analysis, we found that all of the common species assessed can be effectively conserved by Vermont Conservation Design, and approximately 50% of the SGCN. This analysis of the design's capacity to conserve many common species and SGCN demonstrates the efficacy of the selected features and supports our confidence that the targets presented here will effectively conserve many other species—including cryptic and poorly understood species. This analysis of Vermont Conservation Design and the species it effectively conserves is a significant result of the project and will help guide our efficient conservation work—it is included in the Part 2 Vermont Conservation Design Technical Report.

We plan to expand this analysis in collaboration with experts on specific taxonomic groups to include more common species, more SGCN, and all rare plants and animals. To be most effective, this analysis will need to be an iterative process, with periodic reassessment of species as environmental conditions and risk factors change. The results of these analyses will provide a strong framework for focusing

Vermont's species-level conservation and management work.



There will always be certain species that need attention. For example, spiny softshell turtles are extremely rare in Vermont and threatened by nest predation. Other species, such as some wildlife game species, have legal and social, as well as biological, considerations.

Species have come and gone from Vermont over the past millennia. We expect this shifting to intensify with current climate change. Northern species will likely shift out of Vermont, and southern species will likely become more abundant. These changes are part of nature's resiliency, and the ecologically functional landscape facilitates them. As these changes take place, however, we may face difficult choices. Should we attempt to keep in Vermont a species at the southern edge of its range, such as spruce grouse, knowing that its suitable climate is retreating northward? Should we embrace the movement of southern species, like tulip tree, into the state? Vermont Conservation Design cannot fully answer these questions, but it provides a framework to maximize our options into the future.

Putting it All Together: The Ecologically Functional Landscape

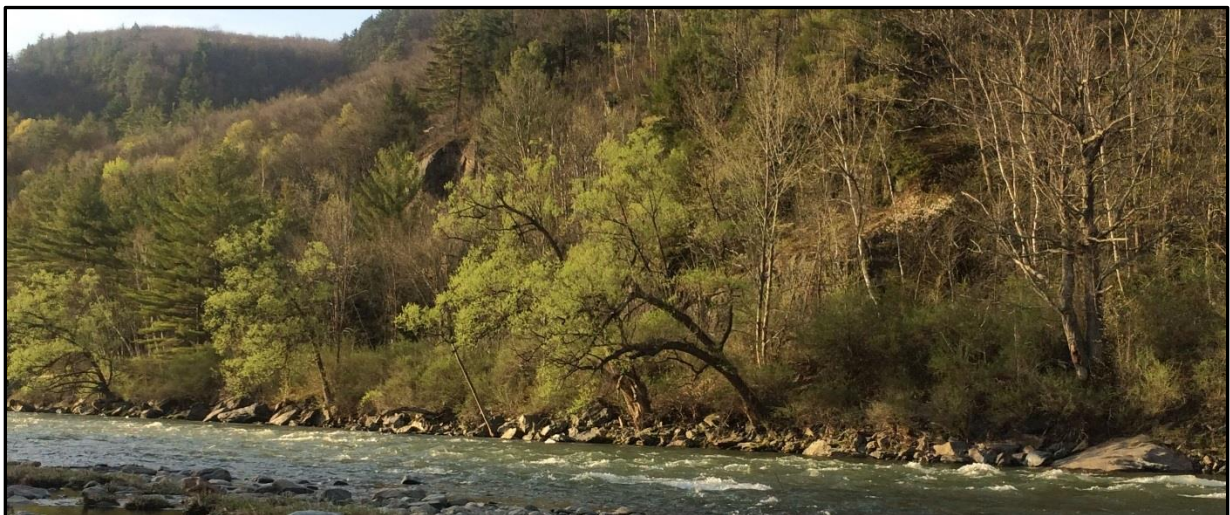
Maintaining or enhancing an ecologically functional landscape in Vermont depends on conservation of all the features described in this report: Interior Forest Blocks; Connectivity Blocks; Surface Waters and Riparian Areas; Physical Landscapes; Natural Communities; Young and Old Forests; Aquatic Habitats; Wetlands; Grassland and Shrublands; and Undergrounds Habitats. It is the specific functions of each of these features, and the complementarity of these features functioning together at multiple scales, that are critical for long term conservation of much of Vermont’s biological diversity and natural heritage.

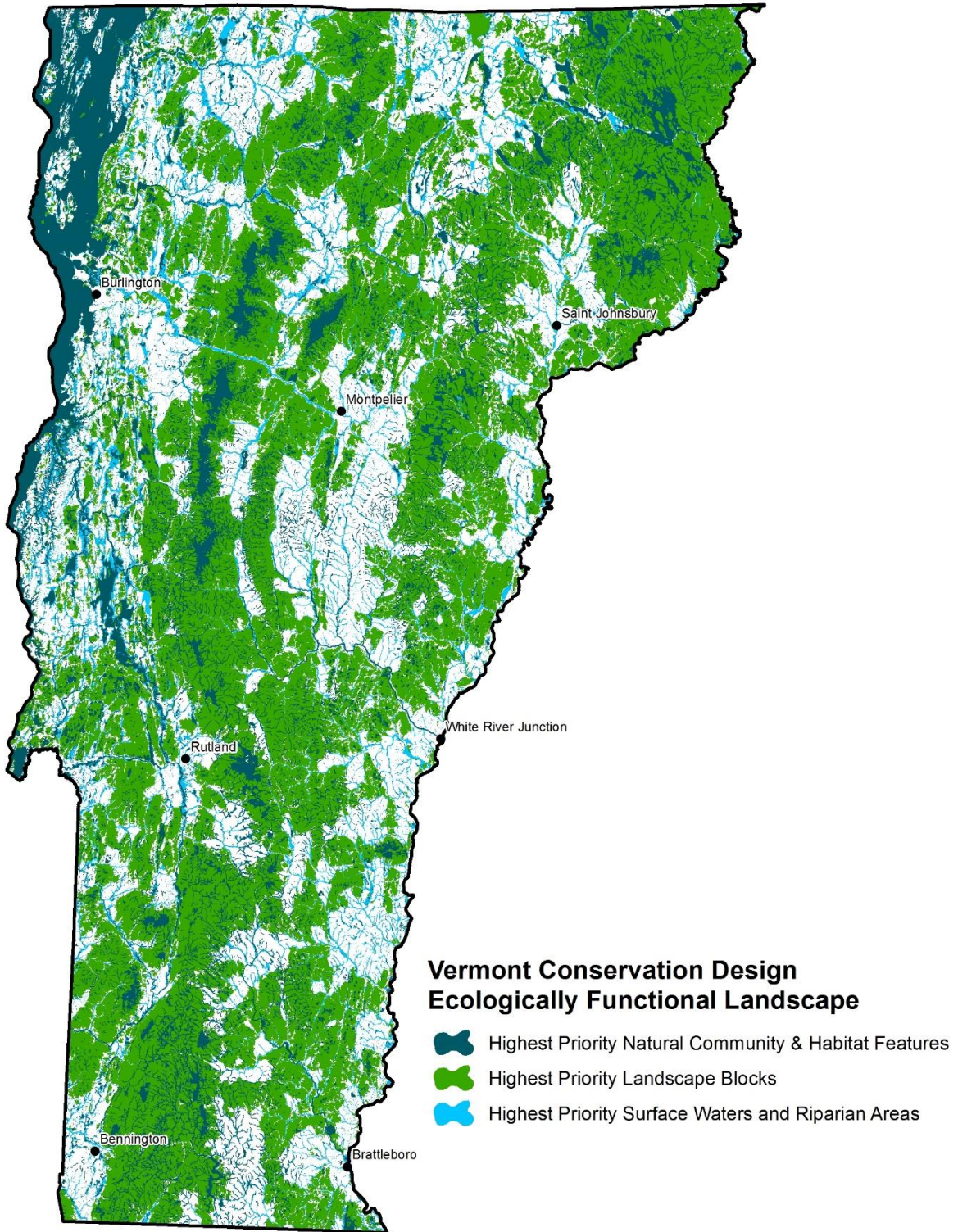
The following map shows the ecologically functional landscape conservation design, with all the highest priority landscape features and all the mapped natural community and habitat features included.

Vermont Conservation Design can maintain our valued natural landscape and the benefits it provides. The landscape it envisions sustains environmental services, like clean air and water, crop pollination, carbon sequestration, and flood protection. It provides resilience to climate change, allowing species and natural communities to rearrange themselves so that all these benefits continue into the future. It supports numerous social and economic values, including our outdoor traditions and outdoor recreation opportunities, the forest products economy, and the landscape that draws people to Vermont. It supports nature—for its intrinsic values, and our enjoyment and use.

It is our hope that this information will inform land management, local planning and development, and land conservation decisions throughout Vermont. We hope that private landowners, municipalities, state agencies, and conservation organizations will use this information as we all work together for a vibrant and healthy Vermont.

Vermont Conservation Design is a science-based vision for the future of Vermont’s natural areas, forests, waters, and wildlife. It can guide us to the long-term conservation of the state’s iconic landscape. Expansive forests, clean water, and abundant fish and wildlife can be our legacy.





Map 12: The Ecologically Functional Landscape of Vermont Conservation Design. Note that all three of the highest priority feature types shown on this map can overlap.

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