BioFinder Development Report - 2013

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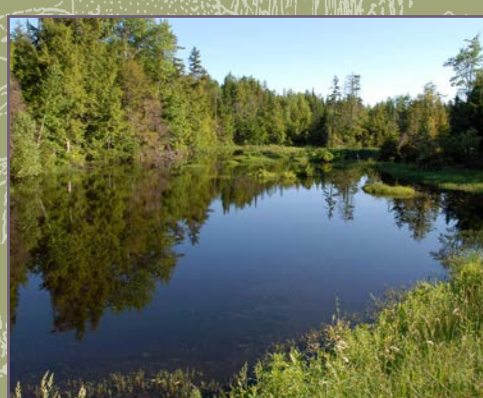

Prepared by Vermont Agency of Natural Resources Natural Resources Mapping Project

BioFinder: Project Development Report

A Product of the ANR Natural Resources Mapping Project,
2013

Produced by the Vermont Agency of Natural Resources
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About BioFinder

The text, graphics and data provided in this report explain how and why BioFinder was produced. To access, use and explore BioFinder, please go to: www.BioFinder.Vermont.gov

Acknowledgements

Telling the story of Vermont's natural heritage in its myriad and nuanced forms required intense collaboration among the people who know Vermont, its geology, climate, natural communities, waters, species and the processes that bind them together, as well as those who can translate this knowledge into Geographic Information Systems, and back again. The Agency of Natural Resources, and in particular the authors of this report, wish to thank those people who have contributed to the creation of BioFinder, including:

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Contents

1. Executive Summary

BioFinder is a map and database identifying Vermont's lands and waters supporting high priority ecosystems, natural communities, habitats, and species. The most comprehensive assessment of its kind in Vermont, BioFinder was developed by the Vermont Agency of Natural Resources and partners to further our collective stewardship and conservation efforts.

At its core, BioFinder is 21 datasets representing terrestrial and aquatic biological, ecological, and natural heritage data at various scales and aspects. These datasets were then stacked together for a co-occurrence analysis which identified the locations of greatest overlap (concentration) for priority ranking at the statewide scale.

You can use the BioFinder Mapping Tool to explore the distribution and richness of Vermont's fish, wildlife and natural heritage, to review the potential of sites for development projects and to help secure Vermont's natural heritage for future generations.

The Agency of Natural Resources seeks to preserve, enhance, restore, and conserve Vermont's natural resources, and protect human health for the benefit of this and future generations. The Agency is comprised of the Departments of Environmental Conservation, Fish & Wildlife, and Forests, Parks & Recreation.

Funding

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2. Introduction

The Natural Resources Mapping Project and BioFinder

In April, 2011, the VT Agency of Natural Resources established the **Natural Resources Mapping Project**, the goal of which was to map the lands and waters supporting high priority natural areas and habitats—those places deserving of conservation and/or restoration in order to secure Vermont's natural heritage for future generations.

These places, these lands and waters, provide the foundation for Vermont's biological diversity. Biodiversity is the variety of life and its processes. It includes our fish and wildlife and all other organisms, their genetic differences, the ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, changing and adapting (Noss and Cooperrider, Saving Nature's Legacy: Protecting And Restoring Biodiversity, 1994).

Biological diversity is rooted in place, and Vermont has lots of places. From the depths of Lake Champlain to the peaks of the Green Mountains and the myriad fields, forests, streams and other natural areas, each provides a set of conditions that fish, wildlife and other species finds desirable and require for their survival. In many cases, such life supports the lives of others—including our own.

While all these places contribute to Vermont's biological diversity, not all places were created equal. To map the relative contribution of each, places were prioritized using the best available science in a consistent and reliable process. Prioritization is an elemental step in conservation. It supports strategic planning and helps ensure the greatest success when resources are limited.

The resulting product, **BioFinder**, is the single most comprehensive effort initiated to synthesize Vermont's biological diversity in map form, and to make the information widely available. BioFinder is an interactive tool to inform land-use decision-making and planning, and an educational resource for exploring the richness of Vermont's biodiversity. At its core are the **Components Contributing to Biodiversity** and the **Tiered Contribution to Biodiversity**.

> **Components Contributing to Biodiversity:** BioFinder is built upon a foundation of Components Contributing to Biodiversity, elements of biological diversity—21 in all—that we could map statewide (table 2.1). These include obvious components of biodiversity such as rare species, wetlands and rare habitat types as well as less obvious, but nonetheless important, components such as habitat connectivity and mast production areas. While ecological processes (e.g., hydrologic cycle, fire regime, evolution) are fundamental elements of diversity, they are not readily and precisely mappable in the way that the locations of rare species, forest blocks or rivers are. We believe, however, that the 21 components selected for BioFinder represent many elements that could not be mapped. For example, the four components that collectively form the "network of connected lands" map habitat connectivity, a function that allows many species to find food, to move seasonally, to find mates and to move in response to climate change. Connectivity also supports gene flow among populations and thereby helps support the process of evolution. Each of the 21 components is available as an individual dataset (and map layer) via BioFinder.

Table 2.1: The 21 Components Contributing to Biological Diversity

#	Component Name
Landscapes	
L1	Habitat Blocks
L2	Grasslands and Shrublands
L3	Rare Physical Landscape
L4	Representative Physical Landscape
L5	Connecting Lands (<2000ac)
L6	Connecting Blocks (2,000-10,000ac)
L7	Anchor Blocks (>10,000ac)
L8	Riparian Connectivity
L9	Wildlife Road Crossings
Aquatics	
A1	Surface Waters & Riparian Areas
A2	Representative Lakes
A3	Important Aquatic Habitats & Species Assemblages

#	Component Name
Species & Natural Communities	
SN1	Rare Species
SN2	Uncommon Species
SN3	Rare Natural Communities
SN4	Uncommon Natural Communities
SN5	Common Natural Communities
SN6	Vernal Pools
SN7	Vernal Pools (Potential)
SN8	Wetlands
SN9	Mast production areas

Tiered Contribution to Biodiversity: The 21 components of biological diversity were then prioritized and integrated to form a **Tiered Contribution to Biodiversity**. The priority ranking of a land or water location was based on the relative importance of each component and their concentration (co-occurrence or overlap). The Tiered Contribution to Biodiversity is available as a single dataset (and map layer) in six tiers (priority levels) via BioFinder.

Why BioFinder?

A 2011 survey confirmed what we already know: Vermonters love the outdoors. We rank first in the lower 48 states with a 62% participation rate in wildlife-associated recreation—including hunting, fishing, and wildlife watching. Residents and tourists spent more than $744 million on these activities in Vermont that year alone. Moreover our healthy environment underpins our larger economy, adds to our quality of life, provides clean water and fresh air and is one of the state's core strengths in attracting and keeping businesses.

BioFinder is a tool that can help Vermonters plan development in a manner that respects the value of Vermont's environment. Developers can use BioFinder to more quickly and easily identify areas that may not be suitable for development due to natural resource values. This should prove useful for large-scale projects such as wind energy and ski resort development. State and regional policy makers, planners and management agencies can use BioFinder when preparing development plans to avoid, minimize and mitigate impacts to biodiversity. ANR staff will more efficiently and consistently review Act 250/248 applications using BioFinder, saving everyone time and money. Municipal/local-scale planners can use BioFinder to integrate landscape-scale conservation and biodiversity needs into local decision making. And, students, educators and the general public can use BioFinder to explore the distribution and richness of Vermont's natural environment.

The 2011 historic flooding and damage wrought by Hurricane Irene clarified for many Vermonters our relationship with nature in this age of climate change. To ensure a sustainable Vermont we need ecosystems, communities, and economies that are resilient. A resilient Vermont starts with a functioning natural environment, one that retains the ability to heal itself from natural disturbance events. Forests must be able to filter and slow water runoff, and provide habitat as wildlife populations and plant communities evolve and change; rivers must remain connected to their floodplains and have room to meander; there must be redundancy in habitats; and blocks of intact forest must be connected across the state.

3. Methods

A steering committee was established with representation from the three departments of the Vermont Agency of Natural Resources (ANR). Additional members were recruited for their scientific expertise (Table 3.1). The steering committee was responsible for developing and guiding the scientific process.

Table 3.1 Roster of BioFinder Steering Committee and Working Group Participation

Name	Affiliation	Committees & Working Groups (WG)
Gretchen Alexander	DEC-River Corridor Mgmt	Aquatics WG
John Austin	FWD-Wildlife	Steering Comm.; Landscape WG
Doug Blodgett	FWD-Wildlife	Species & Natural Communities WG
Lou Bushey	FPR-Forest Resource Mgmt	Landscape WG
Billy Coster	ANR-Planning & Legal Affairs	Steering Comm.; Communications WG
Ken Cox	FWD-Fisheries	Aquatics WG
Jeremy Deeds	DEC-Lakes & Ponds Mgmt/Protection	Aquatics WG
Erik Engstrom	ANR-IT GIS	Steering Comm and all Working Groups
Mark Ferguson	FWD-Wildlife	Species & Natural Communities WG
Steve Fiske	DEC-Monitoring Assessment Planning	Aquatics WG
Jens Hilke	FWD-Wildlife	Steering Comm.; Aquatics, Landscape and Communications WGs
Neil Kamman	DEC-Monitoring, Assessment & Planning	Steering Comm.; Aquatics WG
Jon Kart	FWD-Wildlife	Steering Comm. and all Working Groups
Rich Kirn	FWD-Fisheries	Steering Comm.; Aquatics WG
Rich Langdon	DEC-Monitoring, Assessment & Planning	Aquatics WG
Lil Lumbra	FWD-Public Outreach	Communications WG
Kellie Merrell	DEC-Lakes & Ponds Mgmt/Protection	Aquatics WG
Shannon Morrison	DEC-Wetlands	Species & Natural Communities WG
Bob Popp	FWD-Wildlife	Species & Natural Communities WG
Tom Rogers	FWD-Public Outreach	Communications WG
Kim Royar	FWD-Deputy Commissioner	Steering Comm.
Michael Snyder	FPR-Commissioner	Steering Comm.; Communications WG
Eric Sorenson	FWD-Wildlife	Steering Comm.; Aquatics, Landscape and Species & Natural Communities WGs
Peter Telep	ANR-IT GIS	Steering Comm.; Communications WG
Lisa Thornton	FPR-Forest Resource Mgmt	Species & Natural Communities WG
Susan Warner	FWD-Public Outreach	Communications WG
Susan Warren	DEC-Lakes & Ponds Mgmt/Protection	Aquatics WG
Diane Burbank	U.S. Forest Service	Steering Comm.; Landscape, Species & Natural Communities WGs
Steve Faccio	VT Center for Ecostudies	Species & Natural Communities WG
Charles Ferree	The Nature Conservancy	Steering Comm.; Landscape, Species & Natural Communities WGs
Phil Huffman	The Nature Conservancy	Landscape WG
Michael Lew-Smith	Arrowwood Environmental	Aquatics WG
Paul Marangelo	The Nature Conservancy	Aquatics and Landscape WGs
Andrew Milliken	U.S. Fish & Wildlife Service	Steering Comm.
Rose Paul	The Nature Conservancy	Steering Comm.; Species & Natural Communities WG
Leslie Pelch	VT Center for Geographic Information	Communications WG
Walter Poleman	University of Vermont	Communications WG
Conrad Reining	Wildlands Network	Landscape WG
Scott Schwenk	U.S. Fish & Wildlife Service	Landscape WG
Jim Shallow	Audubon Vermont	Landscape WG
Liz Thompson	Vermont Land Trust	Steering Comm.; Landscape, Species & Natural Communities WGs
Mike Winslow	Lake Champlain Committee	Aquatics WG

DEC=Department of Environmental Conservation, FPR=Forests, Parks & Recreation Department, FWD=Fish & Wildlife Department.

Eleven elements were selected to represent conceptual categories of biological diversity (Table 3.2). These elements served as a framework for BioFinder development and we then developed component datasets (Table 3.2) that allowed us to map each.

Three science Working Groups (landscape, aquatic, and species/natural communities) were established and charged with: (1) identifying component datasets to represent each mapping element; (2) developing selection criteria to identify the most ecologically significant attributes of each dataset; (3) providing recommendations to the Steering Committee for the weighting of each dataset, and; (4) ensuring that biodiversity elements (physical, biological and process) are represented at appropriate scales across their natural ranges.

Agency of Natural Resources Information Technology-GIS staff provided the spatial analyses and online mapping application development. A Communications Working Group provided advice on communications around the BioFinder project. Working Groups were staffed with members from the three ANR departments and additional members were recruited for their scientific expertise (table 3.1).

Table 3.2: BioFinder Working Groups, Mapping Components, and the Dataset(s) Developed to Represent Each Map Component

Working Group	**Element of Biological Diversity** (Conceptual Category)	**Dataset #**	**Component Dataset** (BioFinder Dataset)
Landscape	Habitat Blocks	L1	Habitat Blocks
		L2	Grasslands and Shrublands
	Physical landscape diversity	L3	Rare Physical Landscape
		L4	Representative Physical Landscape
	Connectivity	L5	Connecting Lands (<2000ac)
		L6	Connecting Blocks (2,000-10,000ac)
		L7	Anchor Blocks (>10,000ac)
		L8	Riparian Connectivity
		L9	Wildlife Road Crossings
Aquatics	Aquatic Base layer	A1	Surface Waters & Riparian Areas
	Lakes, Ponds	A2	Representative Lakes
	Lakes Ponds, Rivers & Streams	A3	Important Aquatic Habitats and Species Assemblages
Species & Natural Communities	Rare & Uncommon Species	SN1	Rare Species
		SN2	Uncommon Species
	Natural Communities	SN3	Rare Natural Communities
		SN4	Uncommon Natural Communities
		S5	Common Natural Communities
	Vernal Pools	SN6	Vernal Pools
		SN7	Vernal Pools (Potential)
	Wetlands	SN8	Wetlands
	Mast	SN9	Mast stands

Standards for selecting data and mapping components

The following standards were applied to dataset selection and development and were based on several factors, including the project goal and the need for data consistency and quality:

1. Data must help identify lands and waters supporting high priority ecosystems, natural communities, habitats, and species that contribute to Vermont's biological diversity and natural heritage.
2. Data must reflect as best as possible the statewide extent of the element and be available in a format that can be used in the geographic information system (GIS) analysis used in BioFinder.
3. Data must contain sufficient information to allow prioritization of the features. The project timeframe will not allow for an additional field investigation or inventory to add new data or improve the quality of existing data.
4. Whenever possible, data should be based on field-verified information, as there is likely to be the highest confidence in the quality of this data. However, datasets developed from GIS models should be used when these are the best sources available and help to identify high priority areas that could not otherwise be identified.

Components

Each science Working Group selected component data based on the available data and the extent to which that data adequately represented the desired mapping elements. While some component data corresponds directly to the mapping element (e.g., the concept of habitat blocks is expressly represented by the habitat blocks dataset), in other cases, multiple datasets had to be combined in order to best represent other mapping elements (e.g., rare species are represented by three complimentary datasets).

For each of the twenty-one component datasets (table 3.2), a Working Group developed criteria to define the parameters of the selected data. For components such as wetlands, rare species, and mast production areas, all known records were selected for inclusion. For others, only a portion was used. For example, of the 4,052 blocks in the habitat block dataset (Sorenson & Osborne, in prep.), 870 blocks were selected for inclusion in BioFinder. Selection criteria are detailed for each component in the Component Abstracts (appendix 1).

Weighting

Working Groups developed weighting (importance) recommendations (high, medium, and low) for each component dataset. Weighting of data makes it possible to show the relative ecological importance of each component. Recommended weights were developed by consensus of expert opinion among Working Group members and reflect relative ranking among that Working Group’s components. The Steering Committee reviewed and adjusted weights across Working Groups as described below.

Two component datasets, Rare Species and Rare Natural Communities, were not included in the weighting process described below and instead were assigned a Tier 1 status because of their obvious and inherently significant contribution to Vermont’s biological diversity.

Weighting of the remaining 19 component datasets occurred via a two-step iterative process. In round one, Steering Committee members ranked the component datasets on a scale of 1 – 10 in terms of their importance for representing biological diversity. Steering Committee members considered the weighting recommended by each Working Group, and then adjusted weights to ensure that all components were adequately represented. These scores were then averaged, and those averages were used in the weighted co-occurrence process described below. The resulting map was reviewed by the Steering Committee before the second round of weighting.

The second round of weighting employed a slightly different process providing greater stratification of the components based on their contribution to biological diversity. Each component was weighted on a score of 1-10 by each Steering Committee member but a maximum point allocation was assigned. Scores for each component were averaged among all steering committee members and then reviewed. Results of the two rounds of weighting showed little difference in scores and the Committee elected to use round two scores.

Co-Occurrence

When two or more components are found in the same location they are considered co-occurring. In general, sites with more co-occurring components make greater contributions to biological diversity. To calculate co-occurrence across the state, each of the twenty-one components was converted into a Boolean 10m grid cell component raster. Each component raster was then assigned its weighted value and run through a weighted sum analysis. The resulting output values were reclassified into six tiers using "natural breaks" to assign break points. The outcome is the "Tiered Contribution to Biological Diversity" raster dataset.

Mapping Module (online web application)

The mapping module of the BioFinder website consists of a Latitude Geographics Geocortex Essentials Silverlight mapping front-end, consuming ArcGIS Server 10.1 GIS mapping services published by the Agency of Natural Resources. The Tiered Contribution Dataset and the 21 component datasets were published as separate ArcGIS Server mapping services. Due to the complexity and sheer volume of data in the Tiered Contribution Dataset, this layer was cached for display performance. Base map services from ESRI, Microsoft BING, and the Vermont Center for Geographic Information provide cached aerial imagery, topographic maps, and a basic boundary map. These services are consumed into the Essentials mapping module. Tools, including the Point Identify, Area Identify Tier Report and Component Report tools, were developed to create user workflows, which guide users through the steps needed to retrieve desired results.

4. Components Contributing to Biological Diversity

The 21 Components Contributing to Biodiversity, the foundation of BioFinder, embody elements of biological diversity across the state in a spatially explicit manner. These components encompass both an impressive range of scales and ecological concepts: from huge landscapes such as the massive forests of the Nuhlhegan Basin to sites less than an acre in size where a rare species is located; and from grassland habitat to aquatic habitat connectivity and representativeness of even common features such as the widely distributed Mountain Slopes physical landscape.

Summary descriptions of each component follow below and detailed reports for each can be found in the appendix. Each of the 21 components is also available as individual dataset (and map layer) via the online BioFinder map.

Table 4.1: The 21 Components Contributing to Biological Diversity

#	Component Name
Landscapes	
L1	Habitat Blocks
L2	Grasslands and Shrublands
L3	Rare Physical Landscape
L4	Representative Physical Landscape
L5	Connecting Lands (<2000ac)
L6	Connecting Blocks (2,000-10,000ac)
L7	Anchor Blocks (>10,000ac)
L8	Riparian Connectivity
L9	Wildlife Road Crossings
Aquatics	
A1	Surface Waters & Riparian Areas
A2	Representative Lakes
A3	Important Aquatic Habitats & Species Assemblages

#	Component Name
Species & Natural Communities	
SN1	Rare Species
SN2	Uncommon Species
SN3	Rare Natural Communities
SN4	Uncommon Natural Communities
SN5	Common Natural Communities
SN6	Vernal Pools
SN7	Vernal Pools (Potential)
SN8	Wetlands
SN9	Mast production areas

Landscapes

Habitat Blocks (L1)

Habitat blocks are areas of contiguous forest and other natural habitats that are unfragmented by roads, development, or agriculture. In Vermont, habitat blocks are primarily forested, but also include wetlands, rivers, streams, lakes, ponds, cliffs, rock outcrops, and other natural features. Forests included in habitat blocks may be young, actively managed, or mature forests with little or no recent logging activity. The defining factor for a habitat block is continuous natural cover and little or no permanent fragmentation from roads, agricultural lands, and other forms of development. BioFinder includes a subset of the best examples of habitat blocks, which are 500 to 1,000 acres and larger and include an assortment of ecological features. The effects of roads on interior forests vary with road size and traffic volume and the effects generally extend 100-300 feet into the adjacent forest. To more accurately identify locations with interior forest conditions, buffers were assigned to each road, with wider buffers assigned to larger and busier roads. For purposes of defining the blocks, class four roads were not considered a fragmenting feature, but their potential effects on wildlife are important to consider.

Habitat blocks support the biological requirements of many native plants and animals including viable populations of wide-ranging animals, such as bobcat, American marten, and black bear. This component provides access to important feeding habitat and the ability to find mates and disperse, and as a result can ensure the genetic integrity of populations.

Grasslands and Shrublands (L2)

Grasslands are open lands dominated by grasses, sedges, and broadleaf herbs, with little or no woody vegetation. They include wetland natural communities, such as Sedge Meadows and Alder Swamps, and lands actively managed by people, such as hay fields. Shrublands are areas dominated by low, dense shrub vegetation, such as dogwood, willow, tall grasses, and sedges. They are often associated with the margins of grassland habitats and are influenced by human activities, such as agriculture or active land management, as well as by natural processes.

Grasslands and shrublands, whether of natural origin or resulting from active land management, are critical to the survival of a suite of bird species in Vermont including the Upland sandpiper, Grasshopper sparrow, Sedge wren, Vesper sparrow, Savannah sparrow, Bobolink, and Eastern meadowlark. Most of these and other grassland and shrubland species will continue to decline in Vermont if grassland habitat is not maintained.

Physical Landscape Diversity

Rare Physical Landscapes (L3)
Representative Physical Landscapes (L4)

Physical landscapes (often referred to as "enduring features") are the hills and valleys, the underlying bedrock, and the surficial deposits left behind by glaciers. These physical landscapes are the settings that support the development of biological diversity. Differences in physical settings (such as the amount of calcium in bedrock, elevation, and soil type) play a large role in determining which plant and animal species will occur in an area. Physical landscapes remain largely unchanged over the vast amounts of time, even as land cover, climate and wildlife changes. In this way the physical landscape components of BioFinder, help ensure the relevance of the Tiered Contribution to Biodiversity dataset even as conditions (and hence location of various species) change in the coming years.

These physical landscape features can be used to predict habitat conditions and species presence. For BioFinder we chose to use Land Type Associations (LTA) to classify the variation in physical landscape. Rare LTAs, those that cover less than 4.5% of Vermont's land area, were selected to represent rarity in the physical landscape. Of Vermont's more common Land Type Associations (i.e. the LTAs not included in rare physical landscapes), certain high quality examples were selected as representative physical landscapes.

The Network of Connected Lands (Regional Connectivity)

Connecting Lands (L5)
Connecting Blocks (L6)
Anchor Blocks (L7)

Generally speaking, connecting habitat links larger patches of habitat within a landscape, allowing the movement, migration, and dispersal of animals and plants. The Network of Connected Land, consisting of three separate datasets (table 4.2), was developed to represent regional-scale connectivity needs of wildlife. It includes large blocks of contiguous, unfragmented habitat (**Anchor Blocks**), the source and principle home area of many wide-ranging species, as well as C**onnecting Blocks**, large forested habitat blocks that have good cover, but are not necessarily large enough in and of themselves to maintain populations of wide-ranging species, and smaller units, **Connecting Lands** that are less than 2,000 acres and include very small habitat blocks and land outside of blocks (for example, roadsides, fields and other developed areas).

Table 4.2: Habitat Connectivity at Regional & Local Scales as Used in BioFinder

Scale	Data #	Component	Description
Network of Connected Lands (Regional Connectivity)	L5	Connecting Lands	Habitat blocks that are less than 2,000 acres and lands outside of blocks (e.g., roadsides, fields and other developed areas).
	L6	Connecting Blocks	Habitat blocks greater than 2,000 acres and less than 10,000 acres.
	L7	Anchor Blocks	Habitat blocks greater than 10,000 acres.
Local Connectivity	L8	Riparian Connectivity	Lands along streams, rivers, lakes and ponds including those agricultural lands in pasture/hay, grasslands and all other natural-cover types. Does not include developed lands and agricultural lands with cultivated crop.
	L9	Wildlife Road Crossings	Locations where wildlife is likely to cross roads based on the presence of adjacent natural cover.

Local Connectivity

Riparian Connectivity (L8)
Wildlife Road Crossings (L9)

Habitat is also connected at a finer scale. For example **Riparian Connectivity** and **Wildlife Road Crossings** (table 4.2) describe waterways and crossroads used by terrestrial wildlife to move to and from cover and feeding areas on a regular basis.

It is important to note that much of Vermont is important for local connectivity (allowing wildlife to move locally)

Riparian areas, the banks of rivers, streams, lakes and rivers and wetlands are critically important travel corridors for a variety of wildlife species as well as contributing to surface water quality, flood attenuation, and shoreline stability. These areas are especially important for terrestrial wildlife species that are closely associated with waters, including mink, otter, beaver, and wood turtle, but are also used by a wide assortment of other species. The riparian connectivity dataset represents the vegetated portions of river and stream valley bottoms and lakeshores as well as floodplain forests and other riparian natural communities that together provide habitat for many rare species and represent a concentration of biological diversity. Many of these areas are actively used for agriculture, which compromises their functionality as travel corridors.

Riparian connectivity, in the context of BioFinder focuses on connectivity for terrestrial animals. Aquatic connectivity, i.e. continuous habitat for fish and other aquatic life un-impeded by culverts and impassible diversions has not been adequately mapped and so no reliable dataset exists. This is an important missing piece that should be included in future iterations of BioFinder.

Wildlife Road Crossings are locations where wildlife is likely to cross roads. The dataset is the result of an assessment of structural features (for example, where there is forest and/or other natural vegetation on both sides of a road) that predict the ease of movement for a variety of wildlife species.

Aquatics

Surface Waters and Riparian Areas (A1)

This component includes all aquatic habitat: rivers, streams, lakes and ponds, adjacent riparian habitat, and all valley bottoms through which rivers and streams migrate over time and where seasonal river or stream flooding is expected. Although rivers, streams, lakes, and ponds cover a small percentage of Vermont, they provide vital habitat for a rich assemblage of aquatic species, including fish, amphibians, reptiles, invertebrates, and plants and an enormous contribution to Vermont's biological diversity.

The ecological integrity of rivers, streams, lakes, and ponds is closely linked with the condition of their riparian areas and contributing watersheds. Naturally vegetated riparian areas provide many critical ecological functions, including stabilizing shoreline against erosion, storage 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. The ecological integrity of rivers and streams is also closely linked to the stability of the river channel and the river corridor within which the river meanders.

Representative Lakes (A2)

This component is a subset of 100 Vermont lakes and ponds selected as the best examples of their type and condition. Types classified based on trophic status, depth, and alkalinity. Lakes and ponds provide critical habitat for many species of fish, amphibians, reptiles, invertebrates, 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.

Table 4.3 Representative Lakes

	Low Alkalinity		Moderate Alkalinity		High Alkalinity	
	Lake	Pond	Lake	Pond	Lake	Pond
Dystrophic	Wheeler (Brunswick)	Dennis McConnell Notch South America West Mountain Wolcott				
Oligotrophic	Little Averill* Great Averill*	Norford*	Miller* Crystal* Willoughby*		Caspian*	Mitchell*
Mesotrophic	Beaver (Holland) Holland May Ricker	Kettle, Lewis, Lily (Londonderry), Little, Elmore, Nulhegan, Osmore, Paul Stream, Schofield, Stratton Athens, Gates, Gillett, Hancock (Stamford), Kenny, Lakota, Lowell, Shippee, Turtlehead, Lily (Vernon), McAllister, Pigeon, Tiny, Ninevah	Buck Center Long (Greensboro) Long (Sheffield) Perch	Bruce Daniels Flagg Fosters Horse Lower Symes Stannard Abenaki, Milton, Mud (Peacham), Old Marsh Upper Symes Mudd	Emerald Ewell Rood Warden Berlin	Coits Half Moon Johnson (Orwell) Mud (Leicester) Chandler Jobs Keiser Little Hosmer North (Brookfield) Bean (Lyndon) South (Brookfield)
Eutrophic	Minards Silver (Georgia)	Little (Franklin) Mile Spruce (Orwell)	Harriman (Newbury) High (Sudbury) Spring (Shrewsbury) Colchester	Burr (Pittsford) Mud (Morgan)-N Toad (Charleston)	Long (Milton) Zack Woods Valley Great Hosmer Hough, Memphremagog* Round (Milton) Inman	Bliss Tildys Winona
Lake Champlain	Lake Champlain includes parts in different trophic levels.					

*Denotes lakes that are included for special reasons, but are also considered best examples in a designation.

Important Aquatic Habitats & Species Assemblages (A3)

This component is a subset and of the Surface Waters and Riparian Areas component that includes locations with concentrations of rare species, especially diverse areas, and/or important species assemblages. Selections were primarily based on the occurrence of fish species, although other biological conditions and information was also considered. As such, these waters make an exceptional contribution to Vermont's biological diversity.

Species & Natural Communities

Species

Rare Species (SN1)
Uncommon Species (SN2)

A rare species of plant or animal is one that has only a few populations in the state and that faces threats to its continued existence in Vermont. Uncommon species are defined as facing a "moderate risk of extinction or extirpation due to restricted range, relatively few populations or occurrences, recent and widespread declines, or other factors." The Vermont Fish & Wildlife Department ranks the relative rarity of species using a national Natural Heritage methodology from S1 (very rare) to S5 (common and widespread). Rarity ranks are based on the number of known individuals, the population size statewide, and the degree to which the populations are threatened. Rare species are generally considered to be those with twenty or fewer populations statewide, whereas uncommon species are generally considered those with more than 20 but 80 or fewer populations statewide.

A species may be rare in Vermont for several reasons, including the following: the species is near the edge of its geographic range; the species only occurs in specialized habitats or rare natural communities; or human activities have resulted in a direct loss of the species or the habitat it requires. Rare and uncommon species, like any species that have evolved over millennia, are important for their intrinsic values. Each species serves an important role in maintaining ecological integrity. Sometimes the details of this role may not be known until a species is lost or becomes extinct. Rare and uncommon species, especially populations occurring at the edge of the species' geographic range, provide important genetic diversity that may be especially significant in allowing species to adapt and evolve to changes in the environment, such as climate change.

Natural Communities

Rare Natural Communities (SN3)
Uncommon Natural Communities (SN4)
Common Natural Communities (SN5)

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 use the assemblages as "coarse filters" for conserving biological diversity. The Vermont Fish & Wildlife Department uses the Natural Heritage methodology[1] to rank the relative rarity of natural community types in Vermont. The range is from S1 (very rare) to S5 (common and widespread). Examples of common natural community types include Northern Hardwood Forest (S5) and Alder Swamp (S5).

Although the species composition of natural communities may shift over time in response to changing climate, it is believed that the locations of high quality natural communities represent physical landscape settings that will continue to support important natural communities into the future. Rare and uncommon natural communities typically include rare species and are not necessarily widely distributed.

S1 and S2 (rare) natural community types include Subalpine krummholz (S1), Red Maple-Black Gum Swamp (S2), and Pitch Pine Woodland Bog (S1), all of which are naturally rare because their landscape positions. Mesic Clayplain Forest (S2), which was once extensive but became rare in the 19th century because of large-scale conversion to agricultural use, is also classified as rare. S3 (uncommon) and S4 (uncommon to widespread) natural community types include Montane Spruce-Fir Forest (S3), Dry Oak-Hickory-Hophornbeam Forest (S3), Boreal Outcrop (S4), and Northern White Cedar Swamp (S3). All of these are naturally uncommon, since their soils are uncommon, but

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[1] NatureServe and the Natural Heritage program in all 50 states, Canada, Latin America and the Caribbean use a consistent set of methods to identify rank and map rare species and natural communities.

Sliver Maple-Ostrich Fern Riverine Floodplain Forest has been made more uncommon by the conversion of many floodplain areas to agriculture. Common natural communities are important ecologically because they form the natural matrix of the Vermont landscape, provide habitat for innumerable species, and support ecological processes, such as natural disturbance, water filtration, and carbon sequestration.

Vernal Pools-Confirmed (SN6) and Vernal Pools-Potential (SN7)

Vernal Pools are small ephemeral water bodies that occur in natural basins within upland forests. These pools typically have no permanent inlet or outlet streams and have very small watersheds. They generally last only a few months and then disappear by the end of summer, although some pools may persist in wet years. The periodic drying prevents the establishment of fish populations, but supports a specialized assemblage of species that typically includes amphibians (such as spotted salamanders and wood frogs), specialized insects (such as caddis flies), mollusks (such as fingernail clams), and other invertebrates (such as fairy shrimp). 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.

Confirmed pools (SN6) are those that have been confirmed by site visits as part of the Vermont Vernal Pool Mapping Project. Potential pools (SN7) have not yet been confirmed by a site visit but have been identified via for remote sensing with high or medium-high mapping confidence.

Wetlands (SN8)

Wetlands are vegetated ecosystems characterized by abundant water and include the vegetated, shallow-water margins of lakes and ponds and the seasonally flooded borders of rivers and streams. They occur in an amazing diversity of topographic settings across the landscape, including basins, seepage slopes, and wet flats. All wetlands have three characteristics in common: (1) they are inundated by or saturated with water during varying periods of the growing season; (2) they contain wetland or hydric soils, which develop in saturated conditions and include peat, muck, and mineral soil type; and(3) wetlands are dominated by plants that are adapted to life in saturated or inundated soils. Few natural systems have been studied as much for their ecological functions as have wetlands. Although they occupy only about five percent of the land area in Vermont, wetlands provide necessary habitat for the survival of a disproportionately high percentage of the rare, threatened, and endangered species in the state.

Mast Production Areas (SN9)

Mast is the fruit of shrubs and trees with nuts and seeds such as beech nuts and acorns considered hard mast whereas fruits such as cherries, raspberries, blackberries and apples considered soft mast. While most forested areas contain at least a few mast producing trees and shrubs, forests producing significant concentrations of mast are much less common.

A beech or oak Mast Production Area representing important wildlife habitat exhibits bear scarring on at least 15-25 tree trunks (most readily identifiable on beech) and/or show some evidence of use by bears (e.g., bear nests in crown of tree). These Mast Production Areas are disproportionately important to myriad wildlife species and crucial to the survival of Vermont's black bear population.

For example, red and gray squirrels rely on beech nuts and acorns for their survival and reproductive success. And since these animals are prey for fisher, coyote, fox, owls, hawks, and other predators, the influence of Mast Production Areas can be seen throughout the food chain.

5. Tiered Contribution to Biodiversity

Each of the 21 components introduced in the previous chapter (and discussed in detail in Appendix A) illuminates a fundamental element of biological diversity. Each is available as a separate map layer via BioFinder. We weighted each component based on its relative importance and then assessed the concentration (i.e., co-occurrence or overlap) of all components on the landscape to create the Tiered Contribution to Biodiversity. This chapter explains the processes for weighting and ranking.

The Tiered Contribution to Biodiversity dataset is the result of a weighted-sum model also known as co-occurrence analysis. It depicts the relative concentration of the 21 components contributing to Vermont's biological diversity (Table 5.1) found at any location and is expressed in terms of six tiers (Table 5.2). Tier 1 contains the highest concentrations of components contributing to biological diversity and Tier 5 the lowest concentrations. Tier 6 denotes locations that lack, as best we can tell, any of the 21 components of biological diversity as selected. Descriptions of each component can be found in Appendix A.

Table 5.1: The 21 Component Contributing to Biological Diversity and the Weights Assigned to Each

Data #	Dataset	Weight
Landscapes		
L1	Habitat Blocks	7
L2	Grasslands & Shrublands	3
L3	Rare Physical Landscape	9
L4	Representative Physical Landscape	4
L5	Connecting Lands (<2000ac)	7
L6	Connecting Blocks (2,000-10,000ac)	4
L7	Anchor Blocks (>10,000ac)	3
L8	Riparian Connectivity	8
L9	Wildlife Road Crossings	4
Aquatics		
A1	Surface Waters & Riparian Areas	6
A2	Representative Lakes	4
A3	Important Aquatic Habitats & Species Assemblages	8
Species & Natural Communities		
SN1	Rare Species	Tier 1
SN2	Uncommon Species	6
SN3	Rare Natural Communities	Tier 1
SN4	Uncommon Natural Communities	6
SN5	Common Natural Communities	3
SN6	Vernal Pools	7
SN7	Vernal Pools (Potential)	5
SN8	Wetlands	8
SN9	Mast production areas	4

Weights between 1 and 10 were assigned to each component (Table 5.1) to reflect the nuanced differences in contribution to biological diversity that each provides. Higher weights reflect a greater contribution to biological diversity.

Co-occurrence refers to the presence of two or more components at the same location. For BioFinder we created a grid of 10m x 10m cells (pixel) covering the entire state and then looked for the presence (co-occurrence) among the 21 component in each pixel—254,096,429 in all (Figure 5.1).

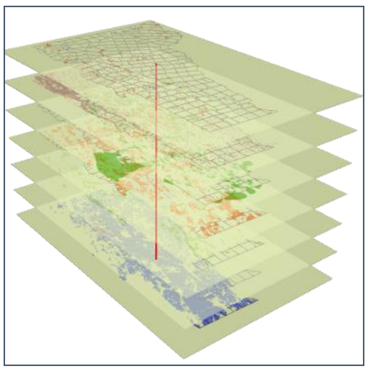


Figure 5.1. Co-occurrence was determined by "stacking" the 21 component datasets to identify the locations (10m x 10m cells or pixels) where features in two or more datasets are present.

Tier Rankings: A co-occurrence score for each pixel was then calculated by summing the weights of each component present with higher scores indicating a greater contribution to biological diversity. When these scores were plotted on a graph, six tiers were identified using natural breaks as dividing lines. Tiers are defined in Table 5. 2. Mapping the pixels based on tier ranking resulted in the Tiered Contribution to Biodiversity.

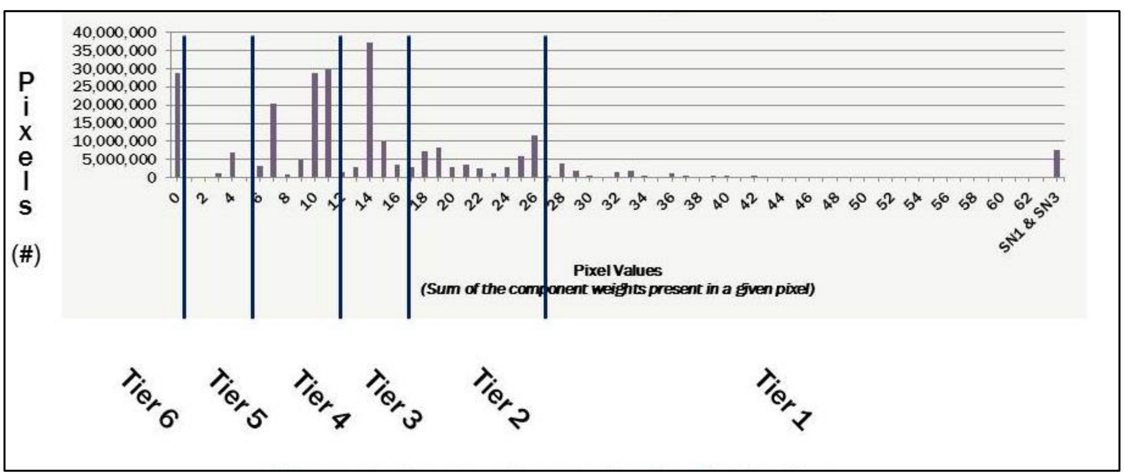


Figure 5.2 Natural breaks in pixel scores were used to group pixels into tiers. Mapping the pixels based on their tier produced BioFinder's Tiered Contribution to Biodiversity dataset.

Table 5.2: Tiered Contribution to Biological Diversity

Tier 1	**Greatest** concentration of components contributing to biological diversity or presence of rare species or rare natural communities.
Tier 2	**Very high** concentration of components contributing to biological diversity.
Tier 3	**High** concentration of components contributing to biological diversity.
Tier 4	**Moderate** concentration of components contributing to biological diversity.
Tier 5	**Low** concentration of components contributing to biological diversity.
Tier 6	**Insufficient data.** There are currently no data identifying components assessed during BioFinder development. Site evaluation may identify one or more components.

Two components, Rare Species and Rare Natural Communities, were not assigned weights in the same manner as the other 19 components. These two components make such significant contributions to Vermont's biological diversity that the presence of either results in a Tier 1 ranking. So a Tier 1 ranking may be the result of either multiple co-occurring components, or the presence of a rare species or natural community or all three. Tier 2 rankings (and most Tier 3 and 4 rankings) are due to the presence of multiple components. Tier 5 rankings are the result of a low concentration of components Tier 6 rankings identify those places where either no data was available for the components or none was selected based on component criteria.

The Tiered Contribution to Biodiversity dataset offers a comprehensive look at the components to Vermont's biological diversity. While there are undoubtedly additional elements that could add to the biodiversity picture, the 21 components included in the Tiered Contribution dataset represent the single most comprehensive effort to bring all of this data into one place and to make the data widely and readily available. BioFinder offers anyone interested in Vermont's landscape a new understanding of how aquatic and terrestrial, coarse and fine scale, biological and physical characteristics create diversity in the Green Mountain State and how that diversity is spatially distributed. It has applications in land use planning, development review, scientific analysis, and educational arenas.

6. The Landscape View —Results and Discussion

Summary of Results from the Tiered Contribution to Biological Diversity and Components' Contributions to Biodiversity

Every place in Vermont contributes to biological diversity in its own way. By helping us compare the relative contribution of places—even those that couldn't be more different—BioFinder helps reveal interesting patterns and insights in Vermont's natural heritage. For example, much of the top of Mount Mansfield is designated Tier 1 (greatest contribution) because of the presence of a rare montane bird species, habitat blocks, anchor blocks and uncommon natural communities. By contrast, the Tier 1 designation for the mouth of the Missisquoi River stems from the presence of very different rare species, as well as overlapping aquatic components including Riparian Connectivity, Surface Waters, Important Aquatic Habitats, and Representative Physical Landscapes. The following is an assessment of the relationship between the tier rankings and the various components that co-occur to produce those rankings.

As previously described, the Tiered Contribution to Biological Diversity is made up of six tiers, with each tier representing the relative concentration of components contributing to biological diversity. Tier 1 has the greatest concentration of components contributing to biological diversity or the presence of rare species or natural communities. Tiers 2 through 5 have decreasing concentrations of components contributing to biological diversity. Tier 6 identifies locations where no component data was assessed or selected during the development of BioFinder. Table 6.1 shows this distribution of components across the five tiers, expressed as percentages. Note that 100% of Rare Species and Rare Natural Communities are assigned to Tier 1 because these components make an especially important contribution to biological diversity, and they were not subjected to weighting as were the other 19 components.

In addition to these rare components, the four components associated with aquatic features also have a high percentage assigned to Tiers 1 and 2. This includes the three components in the Aquatics group and Riparian Connectivity in the Landscape group. Within the Landscape group, Riparian Connectivity has the greatest percentage assigned to Tiers 1 and 2, combined. Similarly, all three of the aquatic components have high percentages assigned to Tier 1 and 2 combined (79.7%, 94.8%, and 95.1%). These high percentages in Tiers 1 and 2 for these four components are the result of significant overlap of these mapping components. The Surface Water & Riparian Areas component includes all rivers, streams, lakes, and ponds, all valley bottoms, and adjacent riparian areas. The other three components all overlap completely with this component and typically with each other, as well—there is a high level of co-occurrence.

Three components in the Species and Natural Communities group have the highest percentage assigned to Tier 1, not including the two rare components with 100%. These three are Uncommon Species (62.1% in Tier 1), Uncommon Natural Communities (57.4% in Tier 1), and Wetlands (60.9% in Tier 1). These high percentages are the result of co-occurrence, as they cannot be the result of weighting alone. Uncommon species of plants and animals frequently occur in rare natural communities, uncommon natural communities, wetlands, or aquatic features. Similarly, mapped uncommon natural communities frequently include rare species or are a type of wetland. In addition, many uncommon species populations and mapped uncommon natural communities occur within Habitat Blocks and Connecting/Anchor Blocks. Wetlands are known to provide habitat for a high percentage of rare species, many wetlands are also mapped as state-significant natural communities (rare and uncommon), and there is a high degree of overlap between the Wetlands component and the Surface Waters and Riparian Areas component.

Table 6.1: BioFinder Components, Weights, and Distribution Across the Five Tiers*

Data #	Weight	Component	Tier 1 Greatest	Tier 2 Very High	Tier 3 High	Tier 4 Moderate	Tier 5 Low
Landscapes							
L1	7	Habitat Blocks	12.7%	18.1%	30.1%	39.1%	0.0%
L2	3	Grasslands & Shrublands	4.3%	20.8%	22.7%	10.9%	41.3%
L3	9	Rare Physical Landscape	15.7%	53.9%	11.0%	19.4%	0.0%
L4	4	Representative Physical Landscape	17.2%	19.1%	43.4%	13.7%	6.6%
L5	7	Connecting Lands (<2000ac)	10.1%	23.4%	19.1%	47.4%	0.0%
L6	4	Connecting Blocks	9.2%	12.2%	24.0%	51.8%	2.7%
L7	3	Anchor Blocks	12.1%	19.7%	35.3%	32.7%	0.1%
L8	8	Riparian Connectivity	36.4%	52.9%	10.8%	<0.05%	0.0%
L9	4	Wildlife Road Crossings	12.8%	28.1%	20.9%	26.8%	11.4%
Aquatics							
A1	6	Surface Waters & Riparian Areas	31.1%	48.6%	12.9%	7.4%	0.0%
A2	4	Representative Lakes	10.3%	84.5%	5.3%	<0.05%	0.0%
A3	8	Important Aquatic Habitats & Species Assemblages	19.9%	75.2%	4.9%	<0.05%	0.0%
Species & Natural Communities							
SN1	Tier 1	Rare Species	100.0%	0.0%	0.0%	0.0%	0.0%
SN2	6	Uncommon Species	62.1%	21.7%	10.0%	6.1%	0.0%
SN3	Tier 1	Rare Natural Communities	100.0%	0.0%	0.0%	0.0%	0.0%
SN4	6	Uncommon Natural Communities	57.4%	31.0%	11.4%	0.2%	0.0%
SN5	3	Common Natural Communities	9.8%	52.9%	37.1%	0.2%	<0.05%
SN6	7	Vernal Pools (Confirmed)	20.5%	57.0%	8.3%	14.1%	0.0%
SN7	5	Vernal Pools (Potential)	6.0%	30.1%	52.3%	2.4%	9.2%
SN8	8	Wetlands	60.9%	31.0%	5.1%	3.0%	0.0%
SN9	4	Mast production areas	10.3%	49.3%	35.2%	4.0%	1.2%

*The sum of percentages for each component totals 100%.

Grasslands & Shrublands is the component with the highest percentage (41.3%) assigned to Tier 5 (Table 6.2). This is because this component has a low weight (3) and because the grassland habitat occurs primarily in agricultural fields in the Champlain Valley where it overlaps with few other components. Note that only those components with a weight of 6 or less can be assigned to Tier 5, because a pixel score of 6 separates Tier 5 from Tier 4.

Table 6.3 provides another way of understanding the distribution of the 21 components into the five tiers of contribution to biological diversity. Whereas Table 6.2 shows how each component is distributed into the five tiers (with each *component* totaling 100%), Table 6.3 shows the contribution of each of the 21 components to a tier (with each *tier* totaling 100%). Table 6.3 takes into account the number of pixels from each component and the weight assigned to each component. For example, the contribution to Tier 1 from Rare Species is 82.9% and 9.0% for Rare Natural Communities, but the other 19 components also contribute to Tier 1 (note that in Table 6.3, because of decimal rounding, many of the figures labeled 0.0% are actually a small value less than 0.05%). Conversely, only 10 components contribute to tier 5 lands. The contribution of Representative Physical Landscape is 67.0%–the most common component present, with Grasslands and Wildlife Road Crossings also important contributors.

Table 6.2: Components Contribution to Each Tier*

	Data #	Weight	Component	Tier 1 Greatest	Tier 2 Very High	Tier 3 High	Tier 4 Moderate	Tier 5 Low
Landscapes	L1	7	Habitat Blocks	1.6%	17.6%	40.2%	49.6%	0.0%
	L2	3	Grasslands & Shrublands	0.0%	0.2%	0.2%	0.1%	10.1%
	L3	9	Rare Physical Landscape	0.4%	10.8%	3.0%	5.1%	0.0%
	L4	4	Representative Physical Landscape	0.7%	5.7%	18.0%	5.4%	67.0%
	L5	7	Connecting Lands (<2000ac)	0.3%	6.0%	6.8%	15.9%	0.0%
	L6	4	Connecting Blocks	0.2%	1.7%	4.6%	9.4%	12.8%
	L7	3	Anchor Blocks	0.4%	4.6%	11.4%	10.0%	0.7%
	L8	8	Riparian Connectivity	1.7%	19.2%	5.4%	0.0%	0.0%
	L9	4	Wildlife Road Crossings	0.0%	0.5%	0.5%	0.7%	7.3%
Aquatics	A1	6	Surface Waters & Riparian Areas	1.3%	16.2%	5.9%	3.2%	0.0%
	A2	4	Representative Lakes	0.1%	3.8%	0.3%	0.0%	0.0%
	A3	8	Important Aquatic Habitats & Species Assemblages	0.3%	7.9%	0.7%	0.0%	0.0%
Species & Natural Communities	SN1	Tier 1	Rare Species	82.9%	0.0%	0.0%	0.0%	0.0%
	SN2	6	Uncommon Species	0.2%	0.5%	0.3%	0.2%	0.0%
	SN3	Tier 1	Rare Natural Communities	9.0%	0.0%	0.0%	0.0%	0.0%
	SN4	6	Uncommon Natural Communities	0.3%	1.2%	0.6%	0.0%	0.0%
	SN5	3	Common Natural Communities	0.0%	0.7%	0.7%	0.0%	0.0%
	SN6	7	Vernal Pools (Confirmed)	0.0%	0.3%	0.1%	0.1%	0.0%

	SN7	5	Vernal Pools (Potential)	0.0%	0.2%	0.4%	0.0%	1.9%
	SN8	8	Wetlands	0.7%	2.7%	0.6%	0.3%	0.0%
	SN9	4	Mast production areas	0.0%	0.1%	0.1%	0.0%	0.1%
			totals	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

*This table shows each component's contribution to the tiers with the sum of the percentages for each tier totaling 100%. This is calculated for each tier by multiplying the component weight (w) by the number places on the landscape (pixels) in which a component is present. Note that all figures are rounded to the nearest 0.1% and some values shown as 0.0% are in fact less than 0.05%. Only those figures marked with an * are actually values of 0, all other figures labeled 0.0% have values less than 0.05%.

Another important way to interpret the results is to examine how lands and waters in the five tiers are distributed across the Vermont landscape based on conserved lands in the nine biophysical regions. Table 6.3 shows the total acres of each tier and the percent of the total acres assigned to each tier. Tier 1 occupies only 9.2% of Vermont, whereas Tier 4 occupies 34.7%. The uneven distribution of acres across the tiers is the result of using natural breaks (a standard statistical method and a classification option in ArcGIS) to identify natural groupings inherent in the tier data.

Table 6.3: Summary of Tiers by Acreage and Conserved Lands

	Total Acres	% of Total Acres	Acres Conserved*	% of All Conserved Acres	% of Tier Conserved
Tier 1	580,202	9.2%	169,198	19.3%	29.16%
Tier 2	1,228,213	19.6%	258,476	29.4%	21.04%
Tier 3	1,368,523	21.8%	246,008	28.0%	17.98%
Tier 4	2,180,170	34.7%	197,496	22.5%	9.06%
Tier 5	205,533	3.3%	1,880	0.2%	0.91%
Tier 6	716,208	11.4%	4,728.8	0.5%	0.66%
Total	**6,278,850**	**100%**	**877,787**	**100%**	**N/A**

* Acres conserved includes all state and federal conserved lands and private conservation easements and is based on 2009 data. All National Gap Analysis Program (GAP) protection categories are included; GAP 4 conservation status does not protect forestlands from being converted to agricultural uses. Lands enrolled in the Use Value Appraisal program are not included in these figures.

Table 6.4 also shows the acres conserved and the percent of conserved acres in each of the six tiers. These results are encouraging in that they show that 99.2% of conserved lands are in areas identified as Tiers 1 through 4—in other words, conservation efforts are being directed at the lands supporting greater levels of biological diversity. However, with Tier 1 and Tier 2 representing the higher concentration of components contributing to biological diversity, Table 6.4 indicates that less than 30% have been conserved and more focused conservation efforts within these tiers seems appropriate, after evaluating and setting priorities for the underlying components that reflect actual biological diversity. Also, there are other conservation priorities to consider in addition to biological diversity, such as conservation of agricultural and forest lands, conservation of recreation opportunities, and conservation of drinking water sources.

The distribution of the acreage within tiers across Vermont has more ecological meaning when examined at the scale of the nine biophysical regions (Table 6.5 and Figure 6.1). Biophysical regions are areas that share features of climate, geology, soils, topography, natural communities, and human land use. The highest percentage of Tier 1 lands are found in the Northeastern Highlands (19%), the Champlain Valley (13%), and the Vermont Valley (11%). These high values are primarily the result of abundant Surface Waters and Riparian Areas and co-occurring Wetlands and Uncommon Natural Communities in the Northeastern Highlands. A similar co-occurrence of components makes up the high percents for the Vermont Valley and the Champlain Valley, but rare and uncommon species are also an important contributor in the Champlain Valley. Although the Champlain Valley is highly fragmented by development and agricultural land, it also has a concentration of rare species and significant natural communities, the result of a warmer climate more typical of areas to our south and diverse physical settings, including abundant calcium-rich bedrock, clay soils, and sandy soils.

The high percent of the Champlain Valley in Tier 2 (32%) is primarily the result of Lake Champlain, which occurs entirely in this biophysical region and is identified in all three of the Aquatic components as a significant feature. The low percent of Tier 6 in the Southern Green Mountains (3%), Northern Green Mountains (4%), and Northeastern Highlands (1%) is primarily because the majority of these three biophysical regions are mapped as Habitat Blocks and one of the three components of the Network of Connected Lands. These three biophysical regions are the least developed in Vermont and have the largest habitat blocks and the most ecologically connected landscapes.

Table 6.4: The Distribution Across Tiers in Each of the Nine Biophysical Regions, Expressed as Percentages of the Area of Each Biophysical Region.

	Taconic Mountains	Vermont Valley	Southern Green Mountains	Southern Vermont Piedmont	Champlain Valley	Champlain Hills	Northern Green Mountains	Northern Vermont Piedmont	Northeastern Highlands
Tier 1	8%	11%	9%	6%	13%	5%	8%	8%	19%
Tier 2	17%	17%	19%	14%	32%	11%	17%	17%	11%
Tier 3	21%	14%	22%	21%	10%	16%	30%	21%	34%
Tier 4	37%	22%	45%	39%	21%	41%	39%	32%	34%
Tier 5	5%	11%	2%	2%	7%	5%	2%	4%	0.4%
Tier 6	11%	24%	3%	18%	17%	22%	4%	18%	1%
	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 6.5: The Distribution of the Tiers Across the Nine Biophysical Regions Expressed as the Percent of Total Statewide Acres per Tier.

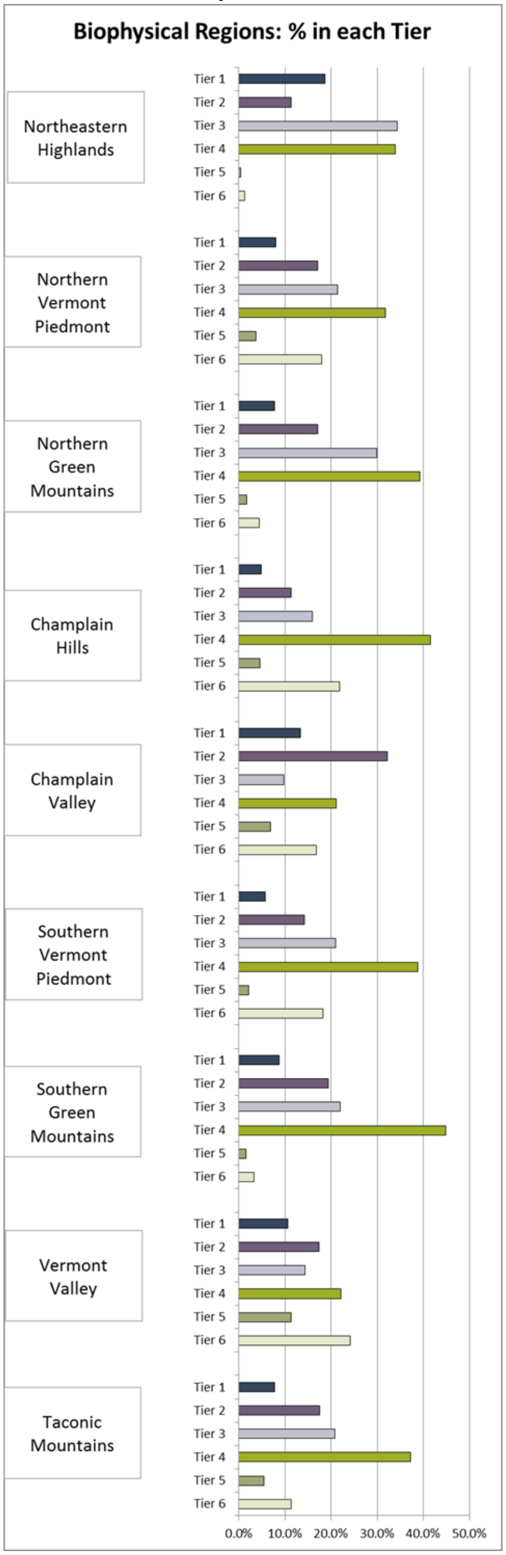
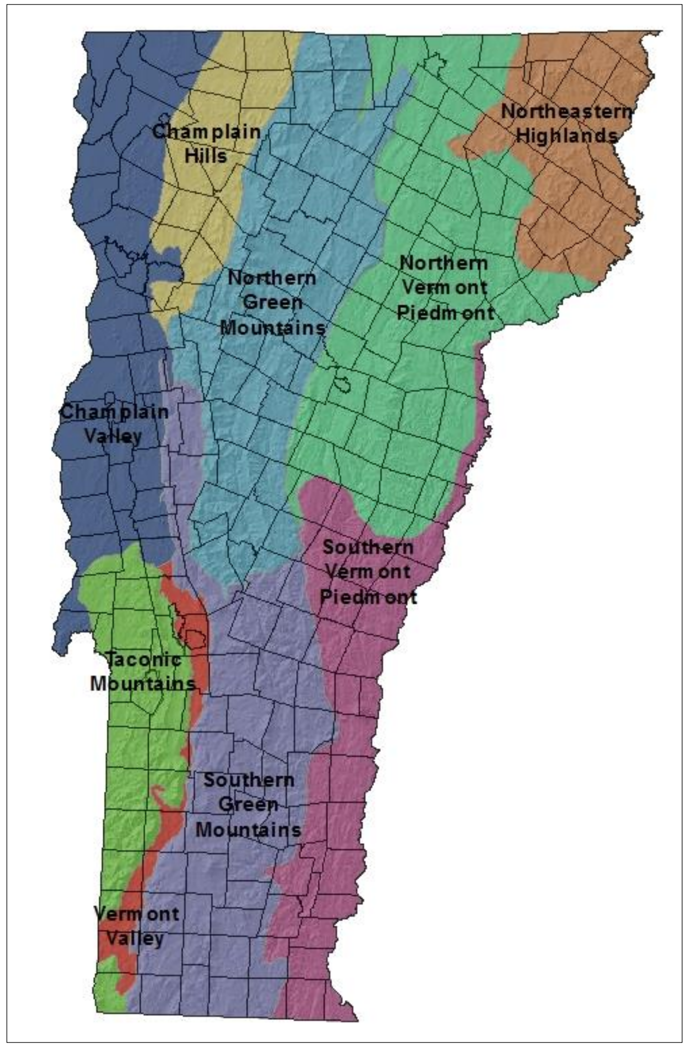


Figure 6.1 Biophysical Regions of Vermont



7. Conclusions: Implications of BioFinder for Statewide Conservation Planning

Vermont has what so many other, once rural places, have lost: a wealth of wildlife and natural beauty, traditional working landscapes that support viable local economies, helpful neighbors, and close-knit villages and towns. This cherished landscape didn't happen by accident; rather it blossomed with the thoughtful and determined efforts of many Vermonters over the decades. Conservation planning tools, such as BioFinder, can support ongoing efforts to maintain Vermont's special character.

The BioFinder map of Tiered Contribution to Biological Diversity is the first of its kind for Vermont. These tiers represent the concentration of many, but not all, biological, ecological, and physical landscape features contributing to Vermont's rich natural environment. These six tiers provide a guide for better understanding priority areas on the Vermont landscape and can help refine conservation planning, regulatory review, and outreach by the Agency of Natural Resources, partners, and the public. The tiers point out some important places that we know quite a bit about (Tier 1), but also point out places where we know little and where more ecological and biological inventory is needed (e.g., Tier 6 primarily).

Although the Tiered Contribution to Biological Diversity is a very important conservation planning tool, it is the detailed information contained in the 21 underlying component datasets that is key to understanding Vermont's biological diversity. Many of these 21 components are well known and used in Vermont for conservation planning, such as wetlands, rare species, and natural communities. However, BioFinder has generated some new datasets that are likely to be very important for future conservation planning in Vermont and are worth highlighting again here.

Network of Connected Lands: Together, three component datasets make up the Network of Connected Lands: Anchor Blocks; Connecting Blocks; and Connecting Lands. They identify the areas where vegetation and other physical features are most likely to support the movement of wide-ranging animals, migration of species over time, and the functioning of ecological processes such as genetic exchange. Maintaining or restoring a landscape with ecological connectivity is now commonly recognized as one of the most important conservation steps for maintaining biological diversity in the face climatic change. Further refinement of the Network of Connected Lands based on field data and prioritization of portions of the Network that are especially important or at risk is needed and will help us to focus conservation efforts in those areas that are most critical.

Aquatics: The three Aquatic components emphasize the high contribution of lakes, ponds, rivers, streams, and riparian areas to Vermont's biological diversity. Maintaining the entire aquatic network is critical to maintaining the ecological processes that sustain aquatic species populations and assemblages. In addition to the importance of maintaining aquatic connectivity within streams, maintaining the ecological integrity of riparian areas and valley bottoms is critical for protecting river processes, wildlife movement, and the array of biological diversity associated with river corridors and lake shores. The Riparian Connectivity component identifies the naturally vegetated portions of the river and stream valley bottoms that are most likely to provide wildlife connectivity functions.

These river corridor functions, both river processes and wildlife movement, are especially important in maintaining ecological resiliency with respect to climate change.

Physical Landscapes: We typically think first of living things when considering biological diversity. But the diversity in Vermont's physical landscape (geology, soils, climate, elevation, hydrology, and others) is the driving force that establishes which species occur where. Understanding the distribution of diversity in the physical landscape provides a basis for conservation planning for these features that are critical to species distribution. Conservation planning for physical landscape diversity is especially important over longer time periods as climate changes and as species shift their distribution and as natural communities shift their species composition. The two components Rare Physical Landscapes and Representative Physical Landscapes identify some of this critical physical diversity in Vermont and allow us to begin conservation planning for these features by ensuring that examples of all of Vermont's physical landscapes are conserved in settings that support natural communities under the influence of natural ecological processes.

The Road Taken

Some of our greatest conservation challenges today relate to loss and fragmentation of habitat and the largely unknown consequences of a changing climate. Indeed, the spread of invasive species, disease, and loss of species all come together to create profound and serious issues. We believe that Vermont's path to environmental and economic sustainability, predicated on support for working lands, local economies and a strong conservation ethic, is the right one, but seeing neighboring states struggle with the loss of their lands and resources reminds us that we are not immune from these pressures and threats.

The Agency of Natural Resources developed BioFinder to provide greater support to all those people and institutions that seek to advance Vermont's stewardship ethic; including policy makers, scientists, conservationists, land-use planners and land managers, educators and developers. For if we are to foster a Vermont resilient to climate change, flooding and other environmental threats, we need to provide everyone with the tools needed to make good decisions for our communities and our natural heritage.

BioFinder™

Mapping Component Abstracts

Prepared by the

Vermont Agency of Natural Resources'
Natural Resources Mapping Project

2013

Contents

Landscapes

Table 1. BioFinder component datasets, component weights, and the distribution (%) of components across tiers

Data #	Weight	Component	Tier 1 Greatest	Tier 2 Very High	Tier 3 High	Tier 4 Moderate	Tier 5 Low
Landscapes							
L1	7	Habitat Blocks	12.7%	18.1%	30.1%	39.1%	0.0%
L2	3	Grasslands & Shrublands	4.3%	20.8%	22.7%	10.9%	41.3%
L3	9	Rare Physical Landscape	15.7%	53.9%	11.0%	19.4%	0.0%
L4	4	Representative Physical Landscape	17.2%	19.1%	43.4%	13.7%	6.6%
L5	7	Connecting Lands (<2000ac)	10.1%	23.4%	19.1%	47.4%	0.0%
L6	4	Connecting Blocks	9.2%	12.2%	24.0%	51.8%	2.7%
L7	3	Anchor Blocks	12.1%	19.7%	35.3%	32.7%	0.1%
L8	8	Riparian Connectivity	36.4%	52.9%	10.8%	0.0%	0.0%
L9	4	Wildlife Road Crossings	12.8%	28.1%	20.9%	26.8%	11.4%
Aquatics							
A1	6	Surface Waters & Riparian Areas	31.1%	48.6%	12.9%	7.4%	0.0%
A2	4	Representative Lakes	10.3%	84.5%	5.3%	0.0%	0.0%
A3	8	Important Aquatic Habitats & Species Assemblages	19.9%	75.2%	4.9%	0.0%	0.0%
Species & Natural Communities							
SN1	Tier 1	Rare Species	100.0%	0.0%	0.0%	0.0%	0.0%
SN2	6	Uncommon Species	62.1%	21.7%	10.0%	6.1%	0.0%
SN3	Tier 1	Rare Natural Communities	100.0%	0.0%	0.0%	0.0%	0.0%
SN4	6	Uncommon Natural Communities	57.4%	31.0%	11.4%	0.2%	0.0%
SN5	3	Common Natural Communities	9.8%	52.9%	37.1%	0.2%	0.0%
SN6	7	Vernal Pools (Confirmed)	20.5%	57.0%	8.3%	14.1%	0.0%
SN7	5	Vernal Pools (Potential)	6.0%	30.1%	52.3%	2.4%	9.2%
SN8	8	Wetlands	60.9%	31.0%	5.1%	3.0%	0.0%
SN9	4	Mast production areas	10.3%	49.3%	35.2%	4.0%	1.2%

The sum of percentages for each component is 100.

Table 2. Component Contributions to Tiers

	Data #	Weight	Component	Tier 1 Greatest	Tier 2 Very High	Tier 3 High	Tier 4 Moderate	Tier 5 Low
Landscapes	L1	7	Habitat Blocks	1.6%	17.6%	40.2%	49.6%	0.0%
	L2	3	Grasslands & Shrublands	0.0%	0.2%	0.2%	0.1%	10.1%
	L3	9	Rare Physical Landscape	0.4%	10.8%	3.0%	5.1%	0.0%
	L4	4	Representative Physical Landscape	0.7%	5.7%	18.0%	5.4%	67.0%
	L5	7	Connecting Lands	0.3%	6.0%	6.8%	15.9%	0.0%
	L6	4	Connecting Blocks	0.2%	1.7%	4.6%	9.4%	12.8%
	L7	3	Anchor Blocks	0.4%	4.6%	11.4%	10.0%	0.7%
	L8	8	Riparian Connectivity	1.7%	19.2%	5.4%	0.0%	0.0%
	L9	4	Wildlife Road Crossings	0.0%	0.5%	0.5%	0.7%	7.3%
Aquatics	A1	6	Surface Waters & Riparian Areas	1.3%	16.2%	5.9%	3.2%	0.0%
	A2	4	Representative Lakes	0.1%	3.8%	0.3%	0.0%	0.0%
	A3	8	Important Aquatic Habitats & Species Assemblages	0.3%	7.9%	0.7%	0.0%	0.0%
Species & Natural Communities	SN1	Tier 1	Rare Species	82.9%	0.0%	0.0%	0.0%	0.0%
	SN2	6	Uncommon Species	0.2%	0.5%	0.3%	0.2%	0.0%
	SN3	Tier 1	Rare Natural Communities	9.0%	0.0%	0.0%	0.0%	0.0%
	SN4	6	Uncommon Natural Communities	0.3%	1.2%	0.6%	0.0%	0.0%
	SN5	3	Common Natural Communities	0.0%	0.7%	0.7%	0.0%	0.0%
	SN6	7	Vernal Pools (Confirmed)	0.0%	0.3%	0.1%	0.1%	0.0%
	SN7	5	Vernal Pools (Potential)	0.0%	0.2%	0.4%	0.0%	1.9%
	SN8	8	Wetlands	0.7%	2.7%	0.6%	0.3%	0.0%
	SN9	4	Mast production areas	0.0%	0.1%	0.1%	0.0%	0.1%
				100.0%	100.0%	100.0 %	100.0%	100.0 %

This table shows the relative contribution of components to each tier. The is calculated by summing the number of pixels for each component within a tier, multiplying the total by component weight and then dividing by the result by the total pixel count times weight total for the tier.

Note that all figures are rounded to the nearest 0.1% and some values shown as 0.0% are in fact less than 0.05%. Only those figures marked with an * are actually values of 0, all other figures labeled 0.0% have values less than 0.05%.

Habitat Blocks (L1)

Description

Habitat blocks are areas of contiguous forest and other natural habitats that are unfragmented by roads, development, or agriculture. Vermont's habitat blocks are primarily forests, but also include wetlands, rivers and streams, lakes and ponds, cliffs, and rock outcrops. Forests included in habitat blocks may be young, early-successional stands, actively managed forests, or mature forests with little or no recent logging activity. The defining factor is that there is little or no permanent habitat fragmentation from roads, agricultural lands and other forms of development within a habitat block. BioFinder includes a subset of the best examples of habitat blocks 500 to 1,000 acres and larger identified by Vermont Fish & Wildlife Department (Sorenson & Osborne, in prep.). Developed lands, most roads and lands in most agricultural cover classes (including cultivated crops, grasslands and pasture) are not considered natural cover. The effects of roads on interior forests vary with road size and traffic volume and the effects generally extend 100-300 feet into the adjacent forest. To more accurately identify interior forest conditions, buffers were assigned to roads with wider buffers assigned to larger and busier roads. Class four roads and most logging roads are fragmenting features for some species, but not necessarily for wide-ranging species that are the focus of the habitat block analysis.

Ecological Importance

Habitat blocks support the biological requirements of many native plants and animals. They support viable populations of wide-ranging animals, including bobcat, American Marten, and black bear, that require large areas to survive by allowing access to important feeding habitat, the ability to move and find mates for reproduction, and as a result ensure genetic integrity of populations. Larger habitat blocks serve as habitat for source populations of dispersing animals for recolonization of nearby areas that may have lost their original populations of those species. Such habitat, together with other important habitats such as wetlands, also supports natural ecological processes such as predator/prey interactions, hydrologic regimes and natural disturbance. They also serve to buffer species against the negative consequences of fragmentation, maintain air and water quality.

Habitat Block Conservation Goal

To conserve habitat blocks across Vermont that support viable populations of Vermont's native fish and wildlife, including a variety of interior forest birds, wide ranging species such as black bear, bobcat, and American marten, and form a network of lands and waters that include representation of the state's physical landscape diversity.

Component Mapping Goal

To identify the best examples of habitat blocks across Vermont and include appropriate representation of habitat blocks in all biophysical regions.

Source Data and Selection Criteria

Habitat Blocks, Vermont Fish & Wildlife Department (Sorenson & Osborne, in prep.)

Description

Habitat blocks show all areas of natural cover (Using 2006 landcover data from NOAA Coastal Change Analysis Program (CCAP)) surrounded by roads, development and agriculture, ranging in size from 500-acres to 153,000-acres and prioritized for biological importance.

Selection Criteria

Habitat block selection criteria were designed to consider the varying land use patterns within each biophysical region as follows:

Piedmont Biophysical Region (BPR)–all blocks larger than 1000a and all blocks with priority ranks 6-10.

Champlain Valley BPR–all blocks larger than 500a and all blocks with priority ranks 6-10.

Vermont Valley BPR–all blocks larger than 500a and all blocks with priority ranks 6-10.

Taconics, Greens, & NE Highlands BPRs all bocks with priority ranks 6-10

Component Strengths

Habitat blocks are spatially accurate. They are not modeled, but rather are based on land cover data. They reflect a mix of different land cover types, and hence serve as a coarse filter for a wide variety of plant and wildlife species. This dataset includes its own ranking. This ranking system evaluated biological values and physical landscape characteristics for each block allowing for a full range of biological diversity present within the blocks to be highlighted. This dataset excludes roads, development, and agriculture, ensuring that only unfragmented habitat is included.

Component Limitations

The habitat blocks dataset is biased towards higher elevation lands away from larger river valleys and lowlands as it excludes roads and a buffer around each road, and most of Vermont's roads and development are along rivers and in lowlands. This is a very typical development pattern in Vermont, where roads often closely follow streams and rivers where it is easiest to build. It results in some areas of streams not being considered due to their proximity to roads and development. However, the important influence of aquatic habitats is captured through other data sources, as described later, for purposes of this project.

Component Weight and Justification

The Habitat Blocks dataset is weighted a 7 on a scale of 1-10 (with 10 as highest contribution to biological diversity). Habitat blocks are important components of Vermont's biological diversity. These habitats provide critical contiguous natural cover for a variety of wide-ranging animal species and room for natural processes. They also serve as a coarse filter for a variety of finer scaled natural communities and species that occur therein. Although the weighting for this critically important feature was 7 and not 9 or 10, it is important to remember that the weights are meant to put each of the 21 data sets into relative context compared to each other.

References

Sorenson, E. and J. Osborne. In prep. Vermont Habitat Blocks & Wildlife Corridors, an analysis using geographic information systems. Vermont Fish & Wildlife Department. Draft report.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Eric Sorenson, Vermont Fish & Wildlife Department, 802-476-0126, eric.sorenson@state.vt.us

Grasslands & Shrublands (L2)

Description

Grasslands are open lands dominated by grasses, sedges, and broadleaf herbs, with little or no woody vegetation. Grasslands include wetland natural communities, such as Sedge Meadow, and lands actively managed by people, such as hay fields. Shrublands are areas dominated by low, dense shrub vegetation such as dogwood, willow, tall grasses, and sedges. They are often associated with the margins of grassland habitats and are influenced by human activities such as agriculture or active land management, as well as by natural processes.

Birds that rely on grassland and shrubland habitats for their survival in Vermont include: Upland Sandpiper (endangered); Grasshopper Sparrow (threatened); Sedge Wren (endangered); Vesper Sparrow (uncommon breeder in Vermont); Savannah Sparrow; Bobolink; and Eastern Meadowlark (the last 3 are considered common but with declining populations). American woodcock is also associated with these habitats and is considered a species of greatest conservation need in Vermont's wildlife action plan. Other bird, mammal, reptile and invertebrate species use grasslands and shrublands as well, but the above suite is commonly used for conservation planning purposes because these birds are rare or their populations are declining, and they require grassland and shrubland habitat to survive and reproduce.

Today, most of Vermont's grassland habitats occur in the Champlain Valley and, to a lesser extent, in the Connecticut River Valley and the area around Lake Memphremagog. Other grasslands of various types and sizes scattered across the rest of the state. Most are associated with current or past agricultural practices. There are, however, grasslands that are the result of other human activities and are maintained for specific purposes. These include grasslands associated with airports (commercial and private), landfills, utility rights-of-way, fairgrounds, and industrial complexes. Most of Vermont's grasslands are in private ownership, although the state and federal government own small areas of this habitat. Shrubland habitats are more widely distributed throughout Vermont, are associated with both upland and wetland conditions, and occur broadly on both public and private land.

Three separate input datasets are combined to form BioFinder's Grassland and Shrubland component dataset. The grassland patches identified in this work are distinguished as crop fields, including corn, hay, other crops, and fallow, or suburban pastures, including either agricultural pastures or large non-agricultural (suburban) fields. Together they represent the best available data for this contributor to biological diversity. Spatial data for shrubland habitats is limited and is best captured by extensions of the grassland habitat data and some of the Vermont wetlands data. A more complete assessment of shrubland habitat conditions throughout Vermont is needed to more carefully assess its influence on biological diversity.

Ecological Importance

Grasslands and shrublands, whether of natural origin or resulting from active land management, are critical to the survival of a suite of bird species in Vermont. Most of these species will continue to decline in Vermont if grassland habitat is not maintained.

Since a probable historic high during the agricultural boom of the 1800s, populations of grassland birds have declined substantially in Vermont, primarily as a result of habitat loss. Habitat loss has resulted from forest succession after farm abandonment, changes in current agriculture practices, and residential, commercial, and industrial development. Other potential threats include the extensive use of agricultural pesticides and changes in wintering habitats outside of Vermont.

Conversion of natural grasslands elsewhere in the Northeast and especially the Midwest has led to the decline of grassland birds in their historic natural habitats. This has given Vermont, and the Northeast in general, greater importance for the conservation of grassland birds. The North American Bird Conservation Initiative (NABCI) has designated grassland birds as a priority suite of species in Vermont.

Grassland and Shrubland Conservation Goal

Conserve and manage grassland habitats of adequate size and distribution to support viable populations of all grassland bird species in Vermont. Conserve and manage important areas of shrubland habitats associated with grasslands, wetlands, riparian habitats, and other habitats to support birds and other wildlife that depend upon that type of habitat association.

Component Mapping Goal

To identify the best examples of grassland and shrubland habitat across Vermont.

Data Source and Selection Criteria

1. **Grassland patches in Grand Isle, Chittenden, Franklin, & Addison Counties VT.** F. Sutti, 2011.

   Description

   A modeled product of productive patches of habitat for grassland bird species.

   Selection Criteria

   Champlain Valley grassland patches with priority ranks 3-5 aggregated into 200 hectare units. All Grassland datasets were combined into a single unit for weighting purposes.

2. **Grassland patches in the southern Champlain Valley**, **VT**. K. Puryear, 2004

   Description

   A modeled product of productive patches of habitat for grassland bird species.

   Selection Criteria

   Champlain Valley patches with priority ranks 11-13 aggregated into 200ha.

3. **Expert Panel- Grassland patches near Newport, VT.** Landscape Working Group, Grasslands subcommittee 2012

   Description

   Includes three patches of habitat for grassland bird species selected using aerial photos and expert knowledge of grassland habitat.

   Selection Criteria

   Included all sections of the three patches provided by the subcommittee

Component Strengths

Grassland and shrubland habitats are difficult to model, and their ephemeral nature makes field data quickly out-of-date. The Sutti data includes attributes to screen for the presence of some active agriculture allowing for greater certainty that the model is focused on the desired land cover being present.

This component includes grassland to early shrubland habitats in its focus. This means that the combined dataset achieves a longer lifespan since unmaintained grasslands grow into shrublands. So, even as the species composition changes from grassland birds to shrubland birds the modeled area remains relevant to the target. Given this, we estimate this data to be relevant for 10 years from time of publication (until 2022) but land use changes in the mapped grasslands during this 10-year period may alter their wildlife habitat value significantly

Component Limitations

Grasslands and shrublands in Vermont are inherently ephemeral. Without regular cutting they convert to shrubland and eventually forest. This makes it difficult to model for likely grasslands locations and very few datasets were available for inclusion in BioFinder. The two principal grassland datasets that we used in BioFinder (Sutti and Puryear) are limited to the Champlain Valley. Sutti's model used political boundaries of Franklin, Chittenden and Addison's counties. Puryear's included the remainder of the Champlain Valley biophysical region into Rutland county. There are slight differences in how the two models were put together and thus there is potential for differences between Rutland County and the rest of the Champlain Valley. While there is some concern about the lack of geographic representation from across the state, the Champlain Valley includes an estimated 80% of the overall grassland species diversity in the state. Both of these datasets include lands in row crop which do not support grassland birds. Also, some crops, such as corn and hay, are rotated year-to-year on many farms, so one year the habitat may be potentially good, and another, not.

An expert panel was convened to identify grassland patches outside of the Champlain Valley of the same level of species diversity found in the Sutti and Puryear datasets for inclusion as a separate dataset (See Expert Panel- Grassland patches near Newport, Vermont (2012)). Three additional grassland patches in the Newport area were identified. Other potential patches, especially along the Connecticut River, were thought to include significantly fewer species and thus not included in the third input dataset. Despite these geographic inconsistencies, we believe the three input datasets were the best data available at the time. Future versions would benefit from a more geographically consistent identification of grasslands statewide.

Shrublands are not adequately addressed by any existing datasets given the difficulty in identifying them through remote sensing. None of our input datasets specifically identify shrubland habitat, so they are included in this component to the extent to which grasslands grow into shrublands with new species composition.

Component Weight and Justification

Grassland/Shrubland dataset is weighted a 3 on a scale of 1-10 (with 10 as highest contribution to biological diversity). This low weighting is based on the ephemeral nature of most grassland habitat (both as a result of natural succession and land use changes) and the lack of site specific data and monitoring for most grassland habitats mapped. Even with this low weighting based on data limitations, it is acknowledged that grassland bird species will continue to decline in Vermont if viable grassland habitats are not conserved and managed appropriately.

References

Puryear, K. 2004. Landscape-level grassland bird conservation in the southern Champlain valley, Vermont. The University of Vermont.

Sutti, F. 2009. Identifying Priority Conservation Areas for Grassland Birds in the Champlain Valley of Vermont. The University of Vermont.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Jens Hilke, Vermont Fish & Wildlife Department, 802-879-5644, jens.hilke@state.vt.us

Physical Landscape Diversity: Rare Physical Landscapes (L3) Representative Physical Landscapes (L4)

Description

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. However, these physical landscapes cannot continue to drive ecological processes or support plants, animals, or natural communities if they are developed or otherwise altered by human activities.

If nature is likened to a dramatic play, it's possible to think of the enduring 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. These features can be used to predict habitat conditions and species presence, and recent research supports the long-held notion (see Vermont Biodiversity Project) that diverse landscapes support diverse natural communities and species (Anderson & Ferree, 2010).

In the context of BioFinder, physical landscapes were represented by Land Type Associations (LTA) to classify the variation in physical landscape. Vermont's Land Type Associations were developed with statewide coverage for Green Mountain National Forest by The Nature Conservancy and Vermont Land Trust (Ferree & Thompson 2008). "Land type associations are landscape scale map units defined by multiple biotic and abiotic factors, including a dominant geomorphic process type, similar landforms, surficial and near-surface geologic formations, and associations of soil families and potential natural vegetation at the series level" (Forman and Godron 1986, Bailey and Avers 1993, Cleland et al. 1997).

Rare LTAs, those that cover less than 4.5% of Vermont's land area, were selected to represent rarity in the physical landscape. The chart below (under Selection Criteria) identifies LTAs that were included in this component.

Of Vermont's more common Land Type Associations (i.e. the LTAs not included in rare physical landscapes), certain examples (LTA sub-blocks) were selected for inclusion in this component called representative physical landscapes. These representative areas were selected based on their condition using Land Cover Index and patch size to determine which were in the best condition.

The concept of representativeness is difficult to understand but is an effective tool in conservation planning for ensuring that all parts of Vermont's landscape appear in the assessment. Common species and natural communities in Vermont are every bit as important as the rare species we often focus on, but without datasets like this, it can be difficult to put them on the same map along with smaller scale features such as very rare and rare species.

Ecological Importance

Enduring features are important for understanding biological diversity and informing conservation planning because they can serve as a surrogate, or substitute, for information on natural communities and species when that information is not available. Conserving and providing stewardship for the diversity of enduring features will in turn help protect the diversity of natural communities and species.

Some enduring features are helpful in locating specific natural communities and species. For example, the Valley Clayplain Forest is a natural community that is associated with the Valley Floor Glacial Lake/Marine Plains LTA and is found exclusively on clay soils. Two of its component plant species, bur oak and barren strawberry, are also most common on those soils. Therefore, it is possible to examine information on surficial geology to determine where clay deposits exist and, with that information, predict the potential location of a Valley Clayplain Forest and its component species. Conservation scientists and practitioners have used specific physical landscape features successfully to locate places to search for particular natural communities or rare species.

In the face of climate change, it is clear that plant and animal species will continue to move around on the landscape to adjust their ranges to more climatically suitable conditions. Areas of diversity in the physical landscape are likely to continue as the stage for diversity in the biological landscape even as species composition changes.

Physical Landscape Diversity Conservation Goal

Conserve examples of all of Vermont's physical landscapes in settings that support natural communities under the influence of natural ecological processes. Conservation should include examples of rare and more common (representative) physical landscapes at the scales at which they naturally occur and conserved examples should be part of a network of ecologically connected lands, waters, and riparian areas.

Component Mapping Goal

To identify Vermont's enduring physical features, especially those places with considerable landscape diversity that may continue to foster biological diversity in the future, even as the climate changes and species composition shifts and to identify a subset of the common physical landscapes that is representative of the full diversity of landscapes, and that also has broad geographic representation.

Data Source(s) & Selection Criteria

1. **Land Type Associations**, Ferree & Thompson 2008.

   Description

   Land Type Associations are a modeled product for use as analysis units to organize broad areas by suitability, identify restoration priorities, and serves as a coarse filter for protecting biodiversity. LTAs are landscape scale map units defined by multiple biotic and abiotic factors.

   Selection Criteria

   LTA sub-blocks were created from the LTA dataset to create in order to have smaller scale units for BioFinder analysis. All rare LTA sub-blocks were selected for inclusion (table 3).

Table 3. Selected Rare Land Type Associations

Land Type Association	% of VT
Calcareous Metamorphic High Hills/Low Mountains	0.3
Connecticut River Valley - Lake Hitchcock Sediments	0.8
Enriched Slopes	0.6
Granitic Basin	0.4
Granitic High Hills/Low Mountains	0.5
Granitic Mid-Elevation Hills	1.1
Marine-Lacustrine-Glaciofluvial Coarse Sediments	0.9
Precambrian Plateau	2.2
Upper Mtn Slopes/Mountaintops	2.7
Valley Floor Glacial Lake/Marine Plains	4.4
Vermont Escarpment	0.8
Water-deposited glacial sediments along major riverways	2

For representative physical landscapes a Land Cover Index (LCI) metric was used to select sub-block examples that were most intact compared with others. To the extent possible, sub-blocks were selected based on contiguity to other selected sub-blocks. Table 4 below the percentage of each LTA type selected.

Table 4. Percentage of Representative Land Type Associations Selected

Land Type Association	% of Total LTA in Component
Dissected low to mid-elev calc/metamorphic hills	36.84%
Hills/footslopes; Bedrock hills (Champlain Valley)	33.81%
Low rolling upland	48.08%
Mountain Slopes	44.29%
Rolling low to mid-elev calc/metamorphic hills	31.54%
Temperate oaky hills of southeastern Vermont	34.82%
Valley bottom; Floodplain-riparian (Champlain Valley)	72.13%

2. **Serpentine Bedrock. 2011 Bedrock Geology map.** Ratcliffe et. al. Vermont Geological Survey

Description

New bedrock geology map for the state of Vermont at the 1:100,000 scale. This includes mapping of the rare serpentine bedrock type.

Selection Criteria

All mapping units with serpentine bedrock type.

Component Strengths

This dataset identifies rare conditions in the physical landscape that may support rarity and diversity in the biological world and serve as important surrogates where species-specific field data is lacking. With more than 24,000 species in Vermont, this dataset provides a mechanism to focus inventories and further our understanding of species-habitat relationships.

LTAs selected as best examples of common (representative) LTA types were filtered for naturalness of cover and acreage. The use of the Land Cover Index (LCI) metric allowed us to select examples that were most intact compared with others. This was an advantage of other conservation planning datasets available that ignore current land use. Land Cover Index (Anderson et al., 2006) is a simple metric to quantify the degree of human conversion of natural land cover within and in the immediate neighborhood of each of a set of polygons or cell-based (raster) occurrences.

Component Limitations

Rare Land Type Associations are a modeled product based on some well-mapped features (e.g., bedrock, soils, and landforms) and some biological principles relating to these feature. As such they have some inherent limitations in how they should be used. Land Type Associations are only one way of classifying physical landscape characteristics and it is not known at this time which physical landscape characteristics are most likely to be relevant to conservation of biological diversity as climate changes. This type of data product involves expert opinion in forming associations in various physical landscape characteristics and assigning those to a single unit. While this process offers some meaningful results, it does rely on a variety of assumptions throughout the modeling process that may not prove themselves true on the ground.

There are multiple "solutions to the problem", or ways to choose one set of LTAs over another to represent the diversity of common (representative) physical landscapes of which examples to use (i.e. spatial areas used to represent these common species or natural communities). We used the best available data to compare the condition of these LTA sub-blocks for inclusion in this representative selection but LCI and acreage as metrics do not necessarily determine that one block is "better" than another. When choices had to be made, this was done based on expert opinion rather than a rigorous methodology. Also, Land Type Associations are only one way of classifying physical landscape characteristics and it is not known at this time which physical landscape characteristics are most likely to be relevant to conservation of biological diversity as climate changes.

Component Weight and Justification

The Rare Physical Landscape component was weighted a 9 on a scale of 1-10 (with 10 as highest contribution to biological diversity) because of the strong relationship between physical diversity and biological diversity and the need to represent physical landscape diversity, particularly in a changing climate.

The Representative Physical Landscape component was weighted a 4 on a scale of 1-10 (with 10 as highest contribution to biological diversity). This relatively lower score is based upon the inherently subjective nature of selecting best representative LTA sub-blocks when there are multiple solutions possible.

References

Anderson M.G., and C. Ferree. 2010. Conserving the stage: Climate change and the geophysical underpinnings of species diversity. PLoS ONE 5(7):E11554.doi:10.1371/journal.pone.0011554

Bailey, R.G., and P.E. Avers. 1993. Multi-scale ecosystem analysis. In: G. Lund, ed. Integrated ecological and resource inventories: Proceedings of the symposium. Washington, DC: USDA Forest Service Publication WO-WSA-4.

Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. National hierarchical framework of ecological units. In: *Ecosystem Management: Applications for sustainable forest and wildlife resources*, ed. M.S. Boyce and A. Haney, pp. 181-200. New Haven, CT: Yale University Press.

Forman, R.T.T. and M. Godron. 1986. Landscape Ecology. John Wiley and Sons, Inc., New York, NY, USA

Ferree, C. & L. Thompson. 2008 Land Type Association Descriptions for Vermont, report to the Vermont Forests, Parks & Recreation Department

Ratcliffe, N.M., Stanley, R.S, Gale, M.H., Thompson, P.J., and Walsh, G.J., 2011, Bedrock Geologic Map of Vermont. U.S. Geological Survey Scientific Investigations Map 3184, 3 sheets, scale 1:100,000.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to Physical Landscape Diversity, contact Jens Hilke, Vermont Fish & Wildlife Department, 802-879-5644, jens.hilke@state.vt.us

The Network of Connected Lands:
Connecting Lands (L5)
Connecting Blocks (L6)
Anchor Blocks (L7)

Description

Generally speaking, connecting habitat links larger patches of habitat within a landscape, allowing the movement, migration, and dispersal of animals and plants. Habitat Connectivity is a complex process that functions at different scales for different species. Riparian areas along streams and rivers, strips of forest cover between developed areas, and even hedgerows/ fencerows all represent potential connecting habitat for wildlife and other organisms. Sometimes these habitats are called "corridors" even though they are not always linear, as the term implies.

The composition and functions of connecting land are based on the scale at which it is considered. At the coarsest, eco-regional scale, connecting land in Vermont can be thought of as a "network" supporting genetic heterogeneity and movement of populations of wide-ranging mammal species across huge swaths of the landscape; such as between the Adirondacks Mountains of New York, Vermont's Green Mountains and the White Mountains of New Hampshire. It is a network in the sense that it includes large blocks of contiguous, unfragmented habitat (**Anchor Blocks**), the source and principle home area of many species, as well as C**onnecting Blocks**, large forested habitat blocks that have good cover, but are not necessarily large enough in and of themselves to maintain populations of wide-ranging species, and smaller units, **Connecting Lands** that are less than 2,000 acres and include very small habitat blocks and land outside of blocks (e.g., roadsides, fields and other developed areas).

Habitat is also connected at fine scales, for example by **Riparian Connectivity** and **Wildlife Road Crossings**, where individual terrestrial animals move along waterways and cross roads. This most local scale of movement may not necessarily be of regional significance, but of course, the regional connections cannot function without local movement. There can be no genetic exchange between wildlife populations in New York and Vermont, for example, without individual animals making sections of the trip, crossing roads and eventually breeding with other individuals. Therefore local and regional connectivity are both vital to the long-term sustainability of wildlife populations and the ecological functions that they support. For the purposes of BioFinder, habitat connectivity is captured in the following components:

Table 5. Habitat Connectivity at Regional & Local Scales as Used in BioFinder

Scale	Data #	Component	Description
Network of Connected Lands	L5	Connecting Lands	Habitat blocks that are less than 2,000 acres and lands outside of blocks (e.g., roadsides, fields and other developed areas).
	L6	Connecting Blocks	Habitat blocks greater than 2,000 acres and less than 10,000 acres.
	L7	Anchor Blocks	Habitat blocks greater than 10,000 acres.
Local Connectivity	L8	Riparian Connectivity	Lands along streams, rivers, lakes and ponds including those agricultural lands in pasture/hay, grasslands and all other natural-cover types. Does not include developed lands and agricultural lands with cultivated crop.
	L9	Wildlife Road Crossings	Locations where wildlife is likely to cross roads based on the presence of adjacent natural cover.

Ecological Importance

Movement of animals from one habitat patch to another is the most common function associated with connecting habitat. This function is particularly important for wide-ranging animals, such as bobcats and black bears, or for animals that require a great deal of space to meet their daily life needs, such as barred owls or otter. Although connecting habitat is often associated with wide-ranging mammals, it is equally important for animals with relatively small ranges and even for plants over long time periods as climate changes. Spotted salamanders, for example, use connecting habitat in spring to move from their hibernation sites to breeding pools, sometimes crossing roads or agricultural fields. The value of connecting habitat is a function of both seasonal and spatial patterns of wildlife behavior. For example, connecting habitat may allow black bears to access important food resources during a specific time of year (seasonal), or it may prevent isolation of bear populations by allowing free exchange of breeding adults (spatial). Ultimately, connecting habitat can ensure that the habitat, movement, migration, and behavior requirements of most native plants and animals are conserved across a broad landscape. The broader ecological value of connecting habitat is to join fragmented pieces of habitat, thereby reducing the deleterious effects of habitat fragmentation and population isolation. Linking small or otherwise isolated habitat patches may reduce the risk of local population extinctions by ensuring immigration, recolonization, reproduction, and exchange of genes for some plant and animal species. While conserving corridors has great merit, do not assume that conserving threads of vegetative cover within a developing landscape will maintain an area's ecological values and biological diversity. Nor will corridors alone meet the habitat needs of all of an area's plant and animal species. Only in conjunction with the conservation of large areas of undeveloped land with diverse habitat conditions, will vegetative corridors assist in supporting ecosystem functions and related public benefits.

The Anchor Blocks component includes all habitat blocks in the State that are larger than 10,000 acres. These serve as core habitat in Vermont and are the backbone of the network of connected land. While these are incredibly important to the overall network, there is considerably more flexibility in how they can be managed, allowing for a variety of uses and some development.

Network of Connected Lands Conservation Goal

Conserve local-scale connecting habitats that support seasonal and spatial patterns of wildlife movement and allow for movement between habitat patches across potential barriers. The larger conservation goal for landscape connectivity is to conserve a connected network of lands, waters, and riparian areas that allow for functioning of ecological processes across the landscape and dispersal, movement, and migration of plant and animal species in response to changing environmental conditions.

Conserve mid-scale connecting habitats that support seasonal and spatial patterns of wildlife movement and allow for movement between habitat patches across potential barriers. The larger conservation goal for landscape connectivity is to conserve a connected network of lands, waters, and riparian areas that allow for functioning of ecological processes across the landscape and dispersal, movement, and migration of plant and animal species in response to changing environmental conditions.

Conserve large-scale connecting habitats and core habitat that support seasonal and spatial patterns of wildlife movement and allow for movement between habitat patches across potential barriers. The larger conservation goal for landscape connectivity is to conserve a connected network of lands, waters, and riparian areas that allow for functioning of ecological processes across the landscape and dispersal, movement, and migration of plant and animal species in response to changing environmental conditions.

Network of Connected Lands Mapping Goals

To identify and map the most vulnerable small blocks and other lands that provide critical connections between Anchor and Connecting Blocks. These important pinch points and stepping stones help form a multi-scaled network of connected land and water that includes core habitat, natural communities and connecting features. To identify and map mid-size (Connecting Blocks) and the largest habitat blocks (Anchor Blocks) within a multi-scaled network of connected land and water that includes core habitat, natural communities and connecting features

Source Data and Selection Criteria

Description

1. **Habitat Blocks**, Vermont Fish & Wildlife Department (Sorenson & Osborne, in prep.) Habitat blocks show all areas of natural cover (Using 2006 landcover data from NOAA Coastal Change Analysis Program (CCAP)) surrounded by roads, development and agriculture, ranging in size from 500-acres to 153,000-acres and prioritized for biological importance.

2. **Northern Appalachian/Acadian Ecoregion: Priority Locations for Conservation Action** Trombulak et al., 2008. This work identifies priority linkages at the ecoregional scale.

3. **Resilient sites for terrestrial conservation in the Northeast and Mid-Atlantic region**. Anderson et al., 2012. Using Circuitscape software this work models flow concentration areas to assess regional-scale connectedness and pinch points.

4. **From the Adirondacks to Acadia: A Wildlands Network Design for the Greater Northern Appalachians**. Reining et al., 2006). This work identifies a network design for regional connectivity based on habitat models for far-ranging mammals.

5. **Linkage Areas of the Northern Appalachian and Acadian Ecoregion**. 2012. Staying Connected Initiative. Staying Connected used models and field data to identify high priority linkages which were incorporated in their entirety because of their finer granularity.

Selection Criteria

To create the **Network of Connected Lands**, habitat blocks with a high ranking for cost-distance to core (Sorenson & Osborne, in prep.) were selected. Additional habitat blocks and connecting lands were added based on overlap with the regional scale datasets described above to represent connectedness within Vermont and outside of the state to the Adirondacks, Whites, Berkshires, Mahoosics, and Sutton Mountains, as well as numerous locations across the Connecticut River.

The resulting Network of Connected Lands dataset (fig A-1) was then split into three component datasets (table 5) to allow for differential weighting based on potential threat and other factors:

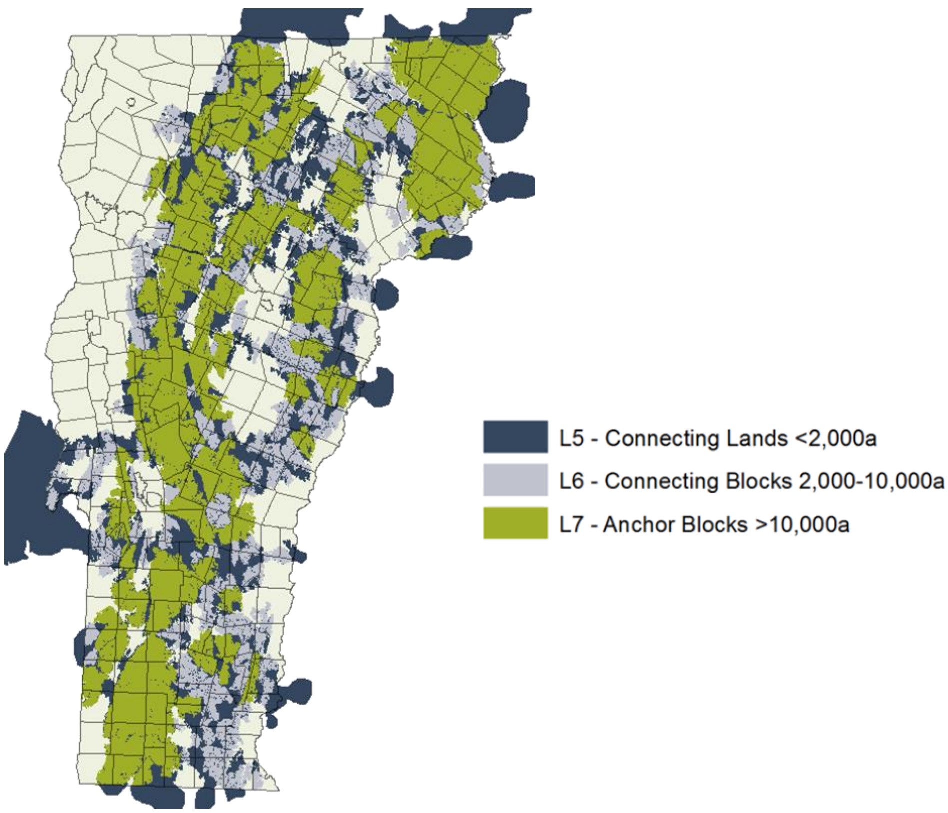


Figure A-1. The Network of Connected Lands (datasets L5, L6, L7)

Network of Connected Lands Component Strengths

The Network of Connected Lands dataset addresses regional scale habitat connectivity and associated wildlife and ecological movement. It uses the regional flow data developed by The Nature Conservancy, as well as habitat linkage areas identified by the Vermont Habitat Block project. This gives us a sense of lands within the State that play a role in connectivity well beyond the state's borders. This makes it possible to identify a network within Vermont important for climate change adaptation and other regionally pressing issues that occur at regional scales

The Connecting Lands component has the strength of focusing on the most threatened areas within the network. Places within the Connecting Lands component are either small habitat blocks or the narrow places between blocks where they are closest together. This means this component focuses on the most modified and threatened part of the overall network and allows priority to be placed on these areas because of this function of helping wildlife move.

The Connecting Blocks component focuses on "stepping stone" blocks within the network. These are places that are currently covered in natural vegetation (i.e. they are considered habitat blocks), and so there is relatively high confidence that they represent functional portions of the network of connected lands.

The Anchor Blocks component has the strength of focusing on the largest habitat blocks within the network. These are places that are considered "core habitat" and anchor the network of connecting land in Vermont.

Network of Connected Lands Component Limitations

The Network of Connecting Lands dataset focuses on lands important for regional-scale habitat connectivity. Only places that allow for movement between contiguous habitat (such as the Adirondacks or Green Mountains) are considered important. This leaves out large areas of the state that are critically important for wildlife at a statewide or local scale. Movement between patches of habitat remains important even if the wildlife populations in question aren't operating at a regional scale of movement.

The Connecting Lands component is the finest scale (smallest area) portion of the Network of Connecting Lands, but still misses locally important connectivity areas, especially for amphibians and reptiles. We rely on the use of the Wildlife Road Crossings dataset and Riparian Connectivity dataset to address more local scale movement areas. The connecting lands component is not based on field data and site visits are always needed to identify specific locations of functioning connectivity within the mapped polygons.

Component Weights and Justifications

Connecting Lands was weighted a 7 on a scale of 1-10 (with 10 as highest contribution to biological diversity). This relatively high weighting is based on the critical nature of these connecting lands as part of the network of connecting lands and the high threat that future development will further fragment these areas, tempered by the general lack of site-specific knowledge about the mapped connecting lands.

Connecting Blocks was weighted a 4 on a scale of 1-10 (with 10 as highest contribution to biological diversity). This low weight is based on relatively high confidence in the interior forest values provided by connecting blocks, tempered by the relatively large area occupied by these blocks and the relatively low risk that the functions of individual connecting blocks will be altered by development as there are few types of development at this landscape scale.

Anchor Blocks was weighted a 3 on a scale of 1-10 (with 10 as highest contribution to biological diversity). This low weight is based on the high confidence in the interior forest values provided by anchor blocks, tempered by the large area occupied by these blocks and the relatively low risk that the functions of individual connecting blocks will be altered by development, as there are few types of development at this landscape scale.

References

Anderson, M.G., M. Clark, and A.O. Sheldon. 2012. Resilient sites for terrestrial conservation in the Northeast and Mid-Atlantic region. The Nature Conservancy.

Reining, C., K. Beazley, P. Doran and C. Bettigole. 2006. From the Adirondacks to Acadia: A Wildlands Network Design for the Greater Northern Appalachians. Wildlands Project Special Paper No. 7. Richmond, VT: Wildlands Project.

Linkage Areas of the Northern Appalachian and Acadian Ecoregion. 2012. Staying Connected Initiative

Sorenson, E. and J. Osborne. In prep. Vermont Habitat Blocks & Wildlife Corridors, an analysis using geographic information systems. Vermont Fish & Wildlife Department. Draft report.

Trombulak, S.C., M.G. Anderson, R.F. Baldwin, K. Beazley, J.C. Ray, C. Reining, G. Woolmer, C. Bettigole, G. Forbes, and L. Gratton. 2008. The Northern Appalachian/Acadian Ecoregion: Priority Locations for Conservation Action. Two Countries, One Forest Special Report No. 1.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to the Network of Connected Lands components, contact Jens Hilke, Vermont Fish & Wildlife Department, 802-879-5644, jens.hilke@state.vt.us

Riparian Connectivity (L8)

Description

Habitat Connectivity is a complex process that functions at different scales for different species. Generally speaking, connecting habitat is represented by land that links larger patches of habitat within a landscape, allowing the movement, migration, and dispersal of animals and plants. Riparian connectivity refers specifically to lands along streams and rivers and lakes and ponds used by wildlife and plants to move. Sometimes these areas are called "corridors" even though they are not always linear, as the term implies.

The word "riparian" literally means of, or pertaining to, the bank of a river or lake. Riparian areas are ecosystems comprised of streams, rivers, lakes, wetlands, and floodplains that form a complex and interrelated hydrological system. These ecosystems extend up and down streams and along lakeshores, and include all land that is directly affected by surface water (Verry et al., 2000). Riparian ecosystems are generally high in biological diversity. They are "characterized by frequent disturbances related to inundation, transport of sediments, and the abrasive and erosive forces of water and ice movement that, in turn, create habitat complexity and variability…resulting in ecologically diverse communities" (Verry et al., 2000).

Riparian connectivity, in the context of BioFinder, includes all non-developed cover classes within the Surface Waters and Riparian Area (A1) dataset. Developed land classes were filtered-out from the surface waters dataset to create the riparian connectivity component. This identifies stream reaches that haven't been developed and are critical travel corridors for a variety of wildlife species. Many of these areas are actively used for agriculture, which compromises their functionality as travel corridors.

Ecological Importance

Riparian connectivity is especially important for wildlife species that are closely associated with rivers and lakes, including mink, otter, beaver, and wood turtle but are used by a wide assortment of wildlife. The riparian connectivity component represents the vegetated portions of river and stream valley bottoms and lakeshores which provide numerous ecological functions relating to surface water quality, flood attenuation, and shoreline stability. It also includes floodplain forests and other riparian natural communities that together provide habitat for many rare species represent a concentration of biological diversity.

Riparian Connectivity Conservation Goal

Conserve a connected network of lands, waters, and riparian areas that allow for functioning of ecological processes across the landscape and dispersal, movement, and migration of plant and animal species in response to changing environmental conditions. Restoration and conservation of riparian connectivity is especially important in areas of Vermont that are highly developed.

Component Mapping Goal

To identify riparian areas statewide with natural vegetation cover and those in agricultural use (e.g., hay, pasture, grassland) except for cultivated crops.

Input Datasets and Selection Criteria

Description

1. **Surface Waters & Riparian Areas Component (A1),** VT Agency of Natural Resources, Natural Resources Mapping Project, BioFinder. 2012.
2. **Regional Land Cover**, NOAA Coastal Change Analysis Program (CCAP), 2006.

Selection Criteria

BioFinder's Surface Waters and Riparian Areas component dataset (A1) was used as the basis for Riparian Connectivity. All developed land classes (using NOAA CCAP dataset) were filtered-out (removed) leaving only natural or modified land cover classes. These include grassland, herbaceous and shrub cover classes as well as all forested and wetland cover classes. Agricultural lands are included.

Component Strengths

The Riparian Connectivity dataset is the first of its kind for all of Vermont as it identifies all river and lake riparian areas that have natural or semi-natural vegetation cover – a critical part of landscape connectivity. The other four datasets related to habitat connectivity all focus on terrestrial animals and are generally biased towards far-ranging mammals. This dataset includes all riparian habitats along rivers and streams that aren't currently developed to support movement along rivers, streams, and valley bottoms in general. It is still focused on terrestrial animal movement, but gets at the critically-important land-water interface. There is relatively high confidence that riparian connectivity dataset accurately maps the portions of valley bottoms with natural cover

Component Limitations

The Riparian Connectivity dataset does not factor in aquatic organism passage or other within-stream connectivity functions, but instead looks at stream-side connectivity. This is a limitation given that both of these types of connectivity are ecologically important.

Even with this focus on streamside connectivity, there are still limitations. Stream and river sections are not ranked by length or ecological importance so sections that are longer and can facilitate greater movement, are not prioritized. With the limited time available for this project we could not develop mapping algorithms sufficiently sensitive enough to account for section length and ecological importance without over-weighting headwater streams relative to main-stem channels. Therefore all riparian connectivity sections are treated as equally important. We recommend that future efforts to refine this dataset incorporate a ranking factor.

This dataset uses the Vermont Hydrological Dataset (VHD) that identifies stream centerline data to which a standardized buffer was added to establish stream width at various locations. While centerline data is very accurate in showing the location of a waterbody, the process needed to show the area (width) of that stream section creates inaccuracies. We believe the final product is still the best available data that includes all of Vermont's waterways and as with all features included in BioFinder, we recommend site-specific surveys prior to making any land-use decision

Component Weight and Justification

Riparian Connectivity was weighted an 8 on a scale of 1-10 (with 10 as highest contribution to biological diversity).

References

Verry, E. S., J. W. Hornbeck, and C. A. Dolloff (eds). 2000. Riparian management in forests of the continental Eastern United States. Lewis Publishers, Boca Raton, FL. 402p.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Jens Hilke, Vermont Fish & Wildlife Department, 802-879-5644, jens.hilke@state.vt.us

Wildlife Road Crossings (L9)

Description

Habitat Connectivity is a complex process that functions at different scales for different species. Generally speaking, connecting habitat is represented by land that links larger patches of habitat within a landscape, allowing the movement, migration, and dispersal of animals and plants. Wildlife Road Crossings are locations where wildlife are likely to cross roads. The dataset is the result of an assessment of structural components (i.e., where there is forest and/or other natural vegetation on both sides of a road) to predict the ease of movement for a variety of wildlife species. While this assessment is not specific to particular species, it offers a generalized sense of where the greatest variety of species is likely to move based on the assumption that wildlife.

Ecological Importance

Wildlife road crossings are a critical and vulnerable component of the network of connecting lands. These areas of habitat fragmentation are locations where wildlife species are most likely to cross roads, based on remote assessment of structural connectivity features. Movement of animals from one habitat patch to another is the most common function associated with connecting habitat. This function is particularly important for wide-ranging animals, such as bobcats and black bears, or for animals that require a great deal of space to meet their daily life needs, such as barred owls or otter. Although connecting habitat is often associated with wide-ranging mammals, it is equally important for animals with relatively small ranges. Spotted salamanders, for example, use connecting habitat in spring to move from their hibernation sites to breeding pools. The value of connecting habitat is a function of both seasonal and spatial patterns of wildlife behavior. For example, connecting habitat may allow black bears to access important food resources during a specific time of year (seasonal), or it may prevent isolation of bear populations by allowing free exchange of breeding adults (spatial). Ultimately, connecting habitat can ensure that the habitat, movement, migration, and behavior requirements of most native plants and animals are conserved across a broad landscape. The broader ecological value of connecting habitat is to join fragmented pieces of habitat, thereby reducing the deleterious effects of habitat fragmentation and population isolation. Linking small or otherwise isolated habitat patches may reduce the risk of local population extinctions by ensuring immigration, recolonization, reproduction, and exchange of genes for some plant and animal species. While conserving corridors has great merit, do not assume that conserving threads of vegetative cover within a developing landscape will maintain an area's ecological values and biological diversity. Nor will corridors alone meet the habitat needs of all of an area's plant and animal species. Only in conjunction with the conservation of large areas of undeveloped land with diverse habitat conditions, will vegetative corridors assist in supporting ecosystem functions and related public benefits.

Wildlife Road Crossing Conservation Goal

Conserve wildlife road crossings wherever possible, especially in fragmented landscapes. Wildlife Road Crossings are of critical importance in this network as they are the most threatened by future development.

Component Mapping Goal Statement

To map locations of potential wildlife road crossings statewide based on structural connectivity features.

Input Datasets (s) & Selection Criteria

Linkage Ratings, Habitat Block project. Sorenson & Osborne, in prep.

Description

Linkage Ratings is a dataset created by Vermont Fish & Wildlife Department using the Habitat Block dataset (Sorenson & Osborne, in prep.). A Linkage Ratings is an assessment of the structural connectivity across roads—the expected permeability of the road to crossing. Ratings were assigned to all known Vermont roads (except logging roads) on a scale of 1-5 with one being best and five worst. Ratings utilize a "cost-grid," a tool to help predict locally significant wildlife crossing areas, by identifying road segments where favorable habitat occurs on both sides of the road. Forested uplands and forested wetlands are considered the most favorable habitats (i.e., provide the least cost—resistance—for wildlife movement).Road segments with these land cover types on both sides receive the highest linkage rating. Road segments with favorable habitat on only one side, and areas in or near developed areas receive relatively lower linkage ratings.

Selection Criteria

First, we chose habitat blocks that are 200-acres or larger. Using GIS software, blocks were expanded, regrouped and then shrunk 80m from original polygon size to identify nearby connections. Then the local linkage score from Sorenson & Osborne was used. All roads class 4 or higher were selected from the linkage ratings dataset. Within that selection, linkage scores of 3, 4 or 5 were used. We intersected the expanded blocks and the 3,4,5 road sections to find important road sections that have 200ac or larger blocks on both sides of the road. Then we buffered interstate road sections by 80m. All other road sections were buffered by 100' to show an actual area (rather than a line with no area).

Source Data Strengths

This dataset provides our best look at local-scale movement areas. While areas such as the Champlain Valley of Vermont are not considered important for regional scale movement between the Adirondacks and the Green Mountains, a network of patches of intact forest and small connecting lands between them still exist. Though fragmented habitat, they nonetheless provide connectivity to help wildlife populations persist into the future. This dataset is the best we have for addressing fine scale connectivity.

Component Limitations

Field surveys to document wildlife movement have not been performed in most of these areas. Wildlife road crossings were selected based on the presence of adjacent natural cover (e.g., forest, wetlands and waters). This dataset does not rank crossing areas based on ecological importance. For example, a wildlife road crossing on I-89 may be significantly more important to the overall connectivity network than a rural road in that the interstate is one of the state's most significant barriers to wildlife movement. Under the time limitations of this project we could not discriminate between a crossing of this most significant barrier and the crossing of a small rural road. We recommend that future efforts to refine this dataset incorporate a ranking factor. As with all features included in BioFinder, we recommend site-specific surveys prior to making any land-use decision.

Component Weight and Justification

Wildlife Road Crossings was weighted a 4 on a scale of 1-10 (with 10 as highest contribution to biological diversity).

References

Sorenson, E. and J. Osborne. In prep. Vermont Habitat Blocks & Wildlife Corridors, an analysis using geographic information systems. Vermont Fish & Wildlife Department. Draft report.

For more information

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Surface Waters and Riparian Areas (A1)

Description

This component includes all rivers, streams, lakes, and ponds – all aquatic habitats in Vermont. In addition, this component includes the valley bottoms in which rivers and streams flow. Specifically, the valley bottoms are the areas of alluvial soils (soils deposited by flowing water) through which rivers and streams migrate over time and where seasonal river or stream flooding is expected. Finally, this component includes a band of riparian habitat adjacent to all rivers, streams, lakes, and ponds or to the valley bottom.

Ecological importance

While Vermont's rivers, streams, lakes, and ponds cover a small percentage of Vermont's area, they 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. This represents an enormous contribution to Vermont's biological diversity. All of Vermont's rivers, streams, lakes, and ponds are important for the aquatic biota that they support.

As aquatic species are mobile, it is important to maintain connected aquatic habitats in order to protect the diversity of species. Water quality and temperature of upstream reaches directly influences the ability of downstream receiving waters to support aquatic assemblages. Fish and other aquatic populations may travel extensively throughout the lake and stream network for seasonal and life cycle needs. Therefore, it is critical to protect the entire aquatic network in order to maintain the ecological processes necessary to sustain these aquatic populations and assemblages. It is because of this that the decision was made to include all rivers, streams, lakes, and ponds in this BioFinder component.

The ecological integrity of rivers, streams, lakes, and ponds is closely linked with the condition of their riparian areas and contributing watersheds. Naturally vegetated riparian areas provide many critical ecological functions, including stabilizing shoreline against erosion, storage 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 critical habitat for many species of wildlife that are closely associated with open waters, including mink, otter, beaver, northern oriole, kingfisher, spotted sandpiper, and wood turtle. In addition, the shorelines and riparian areas of rivers and lakes support floodplain forests, several rare and uncommon natural communities, and many species of rare plants and animals.

The ecological integrity of rivers and streams is also closely linked to the stability of the river channel and the river corridor within which the river meanders. Rivers and streams channels naturally migrate within their meander belt widths – the part of a valley bottom across which a stream shifts its channel from time to time in response to erosion and deposition. Meander belts are governed by landforms in the valley bottoms, surficial geology and soils, and other characteristics of the river channels and watersheds. River corridors may be narrow in valleys restricted by bedrock or they may be wide in flat valley bottoms with deep alluvial soils.

Surface Waters and Riparian Areas Conservation Goal

To conserve the ecological integrity of all rivers, streams, lakes, and ponds and the aquatic biota they support and to contribute to a landscape that is more resilient in the face of increasingly frequent and severe flood events, by conserving and restoring watershed processes that support properly functioning aquatic habitats and riparian areas, and by maintaining or restoring river channel equilibriums.

Component Mapping Goal

To map all rivers, streams, lakes, and ponds and their associated riparian areas and river and stream valley bottoms.

Source Data and Selection Criteria

1. **Vermont Hydrographic Dataset (VHD) 1:5,000**

   Description

   The Vermont Hydrographic Dataset 1:5,000 is a spatially accurate statewide mapping of rivers, streams, lakes, and ponds.

   Selection Criteria

   All rivers, streams, lakes, and ponds mapped as lines or polygons. For those smaller rivers and streams mapped as line features in the VHD 1:5,000, the expected stream width from Table 6 is used to map these rivers and streams as polygons. Use the VHD 1:5,000 polygons for larger rivers and all lakes and ponds.

2. **Valley Bottom Land Type Associations (Ferree & Thompson 2008)**

   Description

   Valley Bottom LTAs, developed by Ferree & Thompson (2008), are used to map the valley bottoms, floodplains, and river corridors statewide. The Valley Bottom LTA data provides a statewide modeled map of river and stream valley bottom that effectively captures flat valley bottoms and associated alluvial soils, wetlands, and floodplains without extending mapped areas beyond the valley floors. Although partially a GIS model, major portions of the Valley Bottom LTA are based on soil mapping by Natural Resources Conservation Service and wetland mapping by National Wetlands Inventory.

   Selection Criteria

   All Valley Bottom LTAs are included. Riparian area widths are added to all streams and rivers as described in Table 1. This river and stream riparian area is measured from the outer edge of each side of the mapped river or stream polygon or the outer edge of the Valley Bottom LTA, whichever is wider. A 100 foot riparian area is mapped for all lakes and ponds.

Table 6. Stream Widths & Riparian

Stream Order	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Stream Width (feet)	4	10	20	33	66	150	230	
Riparian area (feet) measured from the outer edge of Valley Bottom LTA (if one exists) or the outer edge of stream width (whichever is wider).	50	50	50	100	100	100	100	100

Component Strengths

The Vermont Hydrographic Dataset 1:5,000 is a spatially accurate statewide mapping of rivers, streams, lakes, and ponds. The Valley Bottom LTA data provides a statewide modeled map of river and stream valley bottom that effectively captures flat valley bottoms and associated alluvial soils, wetlands, and floodplains without extending mapped areas beyond the valley floors. Although partially a GIS model, major portions of the Valley Bottom LTA are based on soil mapping by Natural Resources Conservation Service and wetland mapping by National Wetlands Inventory, for which there is relatively high confidence in the mapping accuracy. Valley bottom LTAs and riparian areas includes many of the ecological processes associated with these areas.

Component Limitations

The Vermont Hydrographic Dataset 1:5,000 does not include many small headwater streams which are critically important habitat for some species and the primary source of cool water to lower stream segments. The Valley Bottom LTA is constructed partially as a GIS model, so these portions are not based on field data.

Component Weight and Justification

Surface waters and riparian areas were assigned a weight of 6 out of 10. This medium weighting is based on the very high value of this component in its contribution to biological diversity along with the recognition that the values of these areas will also be represented by other components, including Riparian Connectivity, Important Aquatic Habitats and Species Assemblages, and Representative Lakes.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Eric Sorenson, Vermont Fish & Wildlife Department, 802-476-0126, eric.sorenson@state.vt.us

Representative Lakes (A2)

Description

This component is a subset of lakes and ponds that occur in Vermont, representing the majority of lake types and examples of each type that are in the best condition for that type. While all lakes and ponds are included in the Surface Water and Riparian Areas component, only 100 lakes and ponds are selected for the representative lakes component. The lakes and ponds were classified based on their trophic status, depth, and alkalinity, which are generally the main factors that shape biological communities in lakes (Wetzel 2001).

Ecological importance

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.

Representative Lakes Conservation Goal

To conserve examples of all of Vermont's lake and pond types, including the preservation, maintenance or restoration of the ecological integrity of aquatic habitats and their riparian areas and watersheds.

Component Mapping Goal

To classify Vermont's lakes and ponds based on best available data and to identify and map the highest quality examples of all lake and pond types. The selection of lakes and ponds should ensure that all lake and pond types are represented, and that for each type, the examples that are in the best ecological condition are included.

Source Data and Selection Criteria

Lakes and Ponds Management and Protection Section, Vermont Dept of Environmental Conservation

Description

The Vermont Department of Environmental Conservation's Lakes & Ponds Management and Protection Section maintains an extensive database on the biological, physical, and chemical status of 871 lakes and ponds.

Selection Criteria

The 100 lakes and ponds selected (table 7) are classified based on alkalinity and trophic status into 20 types, with Lake Champlain treated separately. Lakes and ponds were selected based on condition criteria, including naturalness of the outlet, water quality, milfoil abundance, degree of acid impairment, and lack of seasonal drawdown. Three additional lakes with special physical features were also added to the selection. Lily Pond, in Vernon, is included because of its similarity to ponds in the coastal plain. Lakes Champlain and Memphremagog are included because of their size and the extensive fisheries they support despite not meeting three other standards.

Table 7. Representative Lakes

	Low Alkalinity		Moderate Alkalinity		High Alkalinity	
	Lake	Pond	Lake	Pond	Lake	Pond
Dystrophic	Wheeler (Brunswick)	Dennis McConnell Notch South America West Mountain Wolcott				
Oligotrophic	Little Averill* Great Averill*	Norford*	Miller* Crystal* Willoughby*		Caspian*	Mitchell*
Mesotrophic	Beaver (Holland) Holland May Ricker	Kettle, Lewis, Lily (Londonderry), Little, Elmore, Nulhegan, Osmore, Paul Stream, Schofield, Stratton Athens, Gates, Gillett, Hancock (Stamford), Kenny, Lakota, Lowell, Shippee, Turtlehead, Lily (Vernon), McAllister, Pigeon, Tiny, Ninevah	Buck Center Long (Greensboro) Long (Sheffield) Perch	Bruce Daniels Flagg Fosters Horse Lower Symes Stannard Abenaki, Milton, Mud (Peacham), Old Marsh Upper Symes Mudd	Emerald Ewell Rood Warden Berlin	Coits Half Moon Johnson (Orwell) Mud (Leicester) Chandler Jobs Keiser Little Hosmer North (Brookfield) Bean (Lyndon) South (Brookfield)
Eutrophic	Minards Silver (Georgia)	Little (Franklin) Mile Spruce (Orwell)	Harriman (Newbury) High (Sudbury) Spring (Shrewsbury) Colchester	Burr (Pittsford) Mud (Morgan)-N Toad (Charleston)	Long (Milton) Zack Woods Vallley Great Hosmer Hough, Memphremagog* Round (Milton) Inman	Bliss Tildys Winona
Lake Champlain	Lake Champlain includes parts in different trophic levels.					

*denote exceptions to rules, but best examples in designation.

Component Strengths

The lakes classification is based on high quality data from the statewide lakes and ponds inventory and is a good representation of Vermont's lake and ponds types. The filter for various condition factors uses a separate comprehensive dataset which ensures that the best examples of each type are included.

Component Limitations

The lakes classification does not incorporate biological data as it was not available for all lakes.

Component Weight and Justification

Representative lakes were assigned a weight of 4 out of 10. This low weighting is based on the importance of conserving representative lake and pond types, tempered with the lack of biological data incorporated into the classification and the fact that all lakes and ponds are already included under the Surface Water and Riparian Areas and Riparian Connectivity components.

References

Wetzel, R.G. 2001. *Limnology: Lake and River Ecosystems*. Academic Press; 3 edition.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Kellie Merrell, Vermont Department of Environmental Conservation Lakes & Ponds Management & Protection Section, 802.595.3538, kellie.merrell@state.vt.us

Important Aquatic Habitats & Species Assemblages (A3)

Description

This component includes those Vermont lakes, ponds, rivers, and streams that support important aquatic habitats and species assemblages. Important aquatic habitats and lakes and river segments with important species assemblages were selected based on biological data and professional judgment. The selection is primarily based on the occurrence of fish species, although other biological conditions and information was also considered.

Ecological importance

The selected aquatic habitats and river/stream segments represent locations with concentrations of rare species, especially diverse areas, and/or important species assemblages. As such, these waters make an exceptional contribution to Vermont's biological diversity. The ecological importance of each selection is explained in more detail under the selection criteria, below.

Important Aquatic Habitats and Species Assemblages Conservation Goal

To conserve all important aquatic habitats and species assemblages and the ecological condition of the waters, riparian areas, and watersheds that support them.

Component Mapping Goal

To identify and map lakes, ponds, rivers, and streams that support important aquatic habitats and species assemblages based on the best available data and professional judgment.

Source Data and Selection Criteria

Department Databases, VT Fish and Wildlife Dept and VT Dept of Environmental Conservation

Description

The two departments each maintain extensive databases on the location of fish species in Vermont's rivers, streams, lakes, and ponds.

Selection Criteria

The two databases were consulted and combined with the professional judgment/experience of fisheries biologists and aquatic ecologists to select the following lakes, ponds, rivers, and streams.

Lakes and Ponds

a. **Lake Champlain:** due to the influence of biogeography, Lake Chaplain supports native fish and mussel species from two glacial refugia.

b. **Oligotrophic Lakes:** supporting lake trout and/or round whitefish. Great Averill, Little Averill, Beaver, Caspian, Crystal, Echo, Elligo, Seymour, Willoughby

c. **Rutland County Lakes:** supporting or expected to support species assemblages including blackchin shiner, bridle shiner, blacknose shiner, and redfin pickerel.
Austin, Beebe, Black, Breese, Burr, Choate, Doughty, Echo, Halfmoon, High, Hinkum, Hough, Johnson, Mud (Benson), Mudd (Hubbardton), Perch, Roach, Spruce, Sunrise, Sunset, Walker

d. **High elevation ponds**: habitats characterized by simple, cold water obligate aquatic communities. Bourn and Branch (Sunderland), Stratton (Stratton), Lake Pleiad (Middlebury), North Pond (Chittenden), Griffith Lake (Mount Tabor), Big Mud (Mount Tabor), and Little Rock (Wallingford).

Rivers and Streams

a. **Lake Champlain tributaries upstream to the fall line (150 feet elevation):** 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.
   i. Large Rivers

1. Missisquoi River	4. Mallets Creek	7. Otter Creek
2. Lamoille River	5. LaPlatte River	8. Poultney River
3. Winooski River	6. Lewis Creek	9. East Creek

   ii. All other small rivers and streams that drain directly into Lake Champlain.

b. **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.
   i. 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).
   ii. Castleton River from Whipple Hollow Road in West Rutland Marsh (West Rutland) to confluence with Poultney River (Fair Haven).

c. **High elevation coldwater streams**: Streams characterized by simple, cold water obligate aquatic communities dominated by native species, especially brook trout and sculpin. While found at lower elevations, above an elevation of 1400ft almost 100% of the stream miles support native coldwater obligate species. These streams will be the refugia for cold water obligate taxa under predicted climate change warming in the next century. All streams above 1,400 feet elevation are included.

d. **Connecticut River**
   i. Upper Connecticut River supports burbot, round whitefish, and coldwater fish communities. For that section of the river shared by New Hampshire and Vermont, 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).
   ii. Lower Connecticut River: River Mile 120.0 (below Bellows Falls power station) and the bypassed river section reported to be the historic upper limit of American shad in river. From this point downriver to the state line the river is habitat for blueback herring and alewife floater.

Component Strengths

The selected lakes, ponds, rivers, and streams are known locations for important aquatic habitats and species assemblages and therefore are important for conservation of biological diversity.

Component Limitations

The dataset is compiled primarily based on fish data and does not include other biota comprehensively. There is not site specific data available for all high elevation streams, but there is high confidence that these streams support cold water obligate species and that they contribute cold water to downstream waters. Fish and mussel data from small Lake Champlain tributaries is incomplete.

Component Weight and Justification

Important aquatic habitats and species assemblages were assigned a weight of 8 out of 10. This high weighting is based on the critical contribution of these waters to the conservation of biological diversity and the high confidence in the mapping accuracy.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Rich Kirn, Vermont Fish & Wildlife Department, 802-485-7566, rich.kirn@state.vt.us and Kellie Merrell, Vermont Department of Environmental Conservation, Lakes & Ponds Protection Program, 802.595.3538, kellie.merrell@state.vt.us

Rare Species (SN1)

Description

A rare species of plant or animal is one that has only a few populations in the state and that faces threats to its continued existence in Vermont. The Vermont Fish and Wildlife Department uses a ranking scheme to describe the relative rarity of species in Vermont, using a national Natural Heritage methodology. The range is from S1 (very rare) to S5 (common and widespread). Species are assigned a rarity rank based on the number of known individuals, the population size statewide, and the degree to which the populations are threatened. Rare species are generally considered to be those with twenty or fewer populations statewide, whereas uncommon species are generally considered those with more than 20 but 80 or fewer populations statewide.

Ecological importance

A species may be rare in Vermont for several reasons, including the following: the species is near the edge of the geographic range; the species only occurs in specialized habitats or rare natural communities; or human activities have resulted in a direct loss of the species or the habitat it requires. Rare species, like any species, are important for their intrinsic values – as organisms that have evolved over millennia. Each species is assumed to serve an important role in maintaining ecological integrity. Sometimes the details of this role may not be known until a species is lost or becomes extinct. Rare species, especially populations occurring at the edge of the species' geographic range, provide important genetic diversity which may be especially significant in allowing species to adapt and evolve to changes in the environment, such as climate change.

Rare Species Conservation Goal

To conserve populations of all rare species of plants and animals in Vermont, the habitat they need to survive, the ecological processes that support them, and to conserve landscape connectivity to allow individuals to disperse and populations to shift distribution over time in response to changing environmental conditions.

Component Mapping Goal

To identify and map occurrences of all populations of rare species in Vermont using the best available data.

Source Data and Selection Criteria

1. **Natural Heritage Database**, Vermont Fish and Wildlife Department

   Description

   The Natural Heritage Database contains detailed, geographically-referenced information on Vermont's uncommon, rare, threatened, and endangered species and significant natural communities. The database is periodically updated as new information on species and natural communities becomes available. The data used for BioFinder are current as of March 2012.

   Selection Criteria

   a. All Element Occurrences (An "EO" is a specific record representing a place where the species occurs) in the Natural Heritage Database for species with an S-rank (state rank – describes relative rarity) of S1 (very rare) or S2 (rare). All Element Occurrences for species listed as state Threatened or Endangered. Element Occurrences with very poor mapping accuracy, such as those that are mapped to an entire town boundary, are excluded.

b. All Element Occurrences for S1 and S2 species with EO-rank of H (Historic – there is a lack of recent information verifying the continued existence of the species at a specific location). Element Occurrences with very poor mapping accuracy, such as those that are mapped to an entire town boundary, are excluded.

c. All EOs for species with S-rank of SH (State Historic – the species is missing from the state and known from only historical occurrences, but there is still some hope of rediscovery), except those species that are clearly extirpated from Vermont, those Element Occurrences that need to be eliminated because of very poor mapping accuracy, or other reasons. The following species are specifically excluded

   - *Betula × sandbergii*: a sterile hybrid plant species with no unique heritable lineage and known only from a single 1911 collection at Fairfield Pond. (1 EO)
   - *Betula × raymundii*: same as above but known from 1983 Colchester Bog specimens (searched for but not found a few times since) and 1914 Stowe specimens (no specific location). (2 EOs)
   - Loggerhead Shrike: a bird species no longer present in Vermont (2 EOs)
   - Puritan tiger beetle: pre-1932record. Vermont no longer has habitat for this species (1 EO)

2. Bicknell's Thrush observation data, Vermont Center for Ecostudies

Description

Vermont Center for Ecostudies maintains point location data on Bicknell's Thrush, a bird species with an S-rank of S2B (very rare during the breeding season). This observational data for Bicknell's Thrush is much more complete than the data for this species in the Natural Heritage Database. The data used for BioFinder are current as of March 2012.

Selection Criteria

All confirmed point locations for Bicknell's Thrush mapped to the full extent of the associated Montane Spruce-Fir Forest polygon as mapped by Natural Heritage Inventory. Montane Spruce-Fir Forest is an accurate representation of the forest habitat used by this rare bird species. Exclude any duplicate Bicknell's Thrush Element Occurrences from the Natural Heritage Database.

3. Jefferson Salamader data from the Vermont Vernal Pool Mapping Project, Arrowwood Environmental, Inc. and Vermont Center for Ecostudies

Description

The Vermont Vernal Pool Project is a statewide effort to map the locations of vernal pools. Vernal pools are small seasonal wetlands that typically occur in upland forests and provide critical habitat for breeding amphibians. Vernal pools are mapped using aerial photographs and are subsequently visited with landowner permission to confirm their existence and collect biological and physical data, including the presence of Jefferson Salamander, an S2 species. The data used for BioFinder are current as of March 2012.

Selection Criteria

All vernal pools that have been confirmed by site visits and that are being used by Jefferson Salamander. Each vernal pool is mapped as a 600 foot radius circle to include the pool and the expected life zone of amphibians that breed in the pool and use the surrounding forest for other life stages.

Component Strengths

Rare species records from all three data sources are highly accurate and are based on field inventory. Element occurrence data for rare species are mapped using consistent methodology developed by the Vermont Fish and Wildlife Department and NatureServe. Rare species records are typically considered one of the most important "fine filters" for conserving biological diversity. Bicknell's Thrush observation points are mapped to expected forest habitat which is a more accurate representation of species' needs than the mapped observation points.

Component Limitations

Statewide inventories for rare species are on-going and therefore our knowledge of rare species locations is incomplete, although our understanding is relatively high for some groups, such as vascular plants. Many rare species populations that are mapped in the Natural Heritage Database are mapped as circles, with the circle centered on the expected location of the population and the size of the circle representing uncertainty in the mapping accuracy. For older records with poor mapping accuracy this means that more area is mapped for the species population than it actually inhabits. Populations of rare species and other species change over time in response to shifting environmental conditions and periodic monitoring is required. Site visits are required to identify whether rare species occur on a site. Bicknell's Thrush data is from multiple sources which contributes some uncertainty to the data.

Component Weight and Justification

Rare species were not assigned a weight as were most other components. Instead, rare species were assigned directly to Tier 1 of the prioritization due to the critical natural of rare species for conserving biological diversity.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Eric Sorenson, Vermont Fish & Wildlife Department, 802-476-0126, eric.sorenson@state.vt.us

Uncommon Species (SN2)

Description

Uncommon species are defined by the Natural Heritage Inventory of Vermont Fish and Wildlife Department as facing a "moderate risk of extinction or extirpation due to restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, or other factors." In contrast, rare species face a higher risk of extirpation and generally have 20 or fewer populations statewide. The Vermont Fish and Wildlife Department uses a ranking scheme to describe the relative rarity of species in Vermont, using a national Natural Heritage methodology.

Ecological importance

Uncommon species of plants and animals are restricted in their distribution because of limited suitable habitat, either from natural causes or due to habitat loss and fragmentation associated with development. Some uncommon species in Vermont may be at or near the edge of their geographic range. Uncommon species are an important part of Vermont's natural communities and contribute to biological diversity at the genetic and species levels. It is important to keep track of uncommon species as they may become rare or more common as environmental conditions change.

Uncommon Species Conservation Goal

To conserve viable populations of all uncommon plant and animal species in Vermont, the habitat they need to survive, the ecological processes that support them, and landscape connectivity to allow individuals to disperse and populations to shift distribution over time in response to changing environmental conditions. Uncommon species are less at risk than rare species, but conserving all species is critical to conserving biological diversity. Understanding trends in uncommon species and taking appropriate conservation action is important in preventing uncommon species from becoming rare.

Component Mapping Goal

To identify and map all of Vermont's documented uncommon species populations using the best available data.

Source Data and Selection Criteria

Natural Heritage Database, Vermont Fish and Wildlife Department

Description

The Natural Heritage Database contains detailed, geographically-referenced information on Vermont's uncommon, rare, threatened, and species and on Vermont's significant natural communities. The database is periodically updated as new information on species and natural communities becomes available. The data used for BioFinder are current as of March 2012.

Selection Criteria

All uncommon species records in the Natural Heritage Database. These include all records for species with S-rank (state ranks – describes relative rarity) of S3 (uncommon) or S3S4 (uncommon – split rank), with the exception of D-ranked S3 and S3-S4 records (ranks A-D describe the quality of records and a D-rank implies "not viable"). Records with very poor mapping accuracy, such as those that are mapped to an entire town boundary, are excluded.

Component Strengths

Uncommon species records from Natural Heritage Inventory are based on detailed site surveys and data collected by consistent methods. More recent records have high spatial accuracy.

Component Limitations

Inventories of uncommon species of plants and animals are incomplete, especially for many invertebrate animals and bryophytes (non-vascular plants). Many uncommon species populations that are mapped in the Natural Heritage Database are mapped as circles, with the circle centered on the expected location of the population and the size of the circle representing uncertainty in the mapping accuracy. For older records with poor mapping accuracy this means that more area is mapped for the species population than it actually inhabits.

Component Weight and Justification

Uncommon species were assigned a weight of 6 out of 10. This medium priority weighting is based on the high importance of all species in their contribution to biological diversity, but the relatively moderate risk of extirpation of these species, compared to rare species. The medium priority also reflects the relatively incomplete set of occurrence records for uncommon species in the Natural Heritage Database.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Eric Sorenson, Vermont Fish & Wildlife Department, 802-476-0126, eric.sorenson@state.vt.us

Natural Communities:
Rare Natural Communities (SN3)
Uncommon Natural Communities (SN4)
Common Natural Communities (SN5)

Description

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. The Vermont Fish and Wildlife Department uses a ranking scheme that is part of the national Natural Heritage methodology to describe the relative rarity of natural community types in Vermont. The range is from S1 (very rare) to S5 (common and widespread). Examples of common natural community types include Northern Hardwood Forest (S5) and Alder Swamp (S5).

S1 and S2 (rare) natural community types are considered rare for BioFinder. Natural communities are rare because the physical and environmental conditions that support the communities are rare. This may be the result of natural conditions such as restricted distribution of a bedrock type or edge of climatic range, or the result of habitat loss or fragmentation from development or other human activities. Examples of rare natural community types include Subalpine Krummholz (S1), Red Maple-Black Gum Swamp (S2), and Pitch Pine Woodland Bog (S1), all of which are naturally rare because their landscape positions are rare, and also Mesic Clayplain Forest (S2), which was once extensive but became rare in the 19^{th} century because of large-scale conversion to agricultural use.

S3 (uncommon) and S4 (uncommon to widespread) natural community types are considered uncommon for BioFinder. Examples of uncommon natural community types include Montane Spruce-Fir Forest (S3), Dry Oak-Hickory-Hophornbeam Forest (S3), Boreal Outcrop (S4), Northern White Cedar Swamp (S3), and Silver Maple-Ostrich Fern Riverine Floodplain Forest (S3). All of these are naturally uncommon, since their soils are uncommon, but Sliver Maple-Ostrich Fern Riverine Floodplain Forest has been made more uncommon by the conversion of many floodplain areas to agriculture.

Ecological importance

Natural communities represent the distribution of plant and animal species in response to current environmental conditions and natural processes. Although the species composition of natural communities may shift over time in response to changing climate, it is believed that the locations of high quality natural communities represent physical landscape settings that will continue to support important natural communities into the future. Rare natural communities typically include rare species and occur in environmental settings that are rare. Natural communities are commonly referred to as one of the "coarse filters" for conserving biological diversity. This is because there are relatively few natural community types (89 types are currently recognized by Vermont Fish and

Wildlife Department) compared to the thousands of plant and animal species, and one approach to conserve most species is to conserve high quality examples of all natural community types across their natural range of distribution. By this approach, natural communities act as a "coarse filter" for conserving species.

Uncommon natural communities typically include rare species and occur in environmental settings that are uncommon. The mapped locations of the uncommon natural communities used in BioFinder represent the best know examples in the state.

Common natural communities are important ecologically because they form the natural matrix of the Vermont landscape, provide habitat for innumerable species and support ecological processes such as natural disturbance, water filtration, and carbon sequestration. Natural communities are commonly referred to as one of the "coarse filters" for conserving biological diversity. This is because there are relatively few natural community types (89 types are currently recognized by Vermont Fish and Wildlife Department) compared to the thousands of plant and animal species, and one approach to conserve most species is to conserve high quality examples of all natural community types across their natural range of distribution. By this approach, natural communities act as a "coarse filter" for conserving species

Natural Community Conservation Goal

To conserve, enhance, and restore high quality examples of all natural community types across their geographic range of distribution and representing all physical settings (soil, bedrock, elevation, etc.) where they occur. Effective conservation should maintain or restore the ecological processes that support the communities and their component species and a network of connected lands, waters, and riparian areas to allow ecological exchange between communities, including the ability of component species to shift over time in response to changing environmental conditions.

Component Mapping Goal

To identify and map all of Vermont's documented natural communities using the best available data.

Source Data and Selection Criteria

Natural Heritage Database, Vermont Fish and Wildlife Department

Description

The Natural Heritage Database contains detailed, geographically-referenced information on Vermont's uncommon, rare, threatened, and species and on Vermont's significant natural communities. The database is periodically updated as new information on species and natural communities becomes available. The data used for BioFinder are current as of March 2012.

Selection Criteria

Rare: All natural communities Element Occurrences in the Natural Heritage Database with S-rank of S1 and S2. An Element Occurrence (EO) is a specific record representing a place where the community occurs.

Uncommon: All natural communities Element Occurrences in the Natural Heritage Database with S-rank of S3 and S4.

Common: All natural community Element Occurrences in the Natural Heritage Database with S-rank of S5.

Component Strengths

Natural community Element Occurrences from Natural Heritage Inventory are based on detailed site surveys and data collected by consistent methods. Inventories for rare and uncommon natural community types are more complete than for common types. Natural communities represent critical coarse-filter elements for conserving biological diversity and overall natural heritage.

Component Limitations

Statewide natural community inventories are on-going and therefore our knowledge of natural community locations is incomplete. Inventories for rare communities are more complete than for uncommon and common communities. Of uncommon communities, inventories for S3 communities are more complete than for S4 community types. A field assessment is always needed to identify whether rare natural communities occur on a site.

The majority of mapped examples of common natural communities are on state-owned land. Statewide inventory of Northern Hardwood Forest, the most widespread natural community type in Vermont, is especially incomplete.

Component Weight and Justification

Unlike most other components in this analysis, rare natural communities were not assigned a weight. Instead, rare natural communities were assigned directly to Tier 1 of the prioritization due to the critical natural of rare natural communities for conserving biological diversity.

Uncommon natural communities were assigned a weight of 6 out of 10. This medium priority weight is based on the high importance of all high quality natural communities in their contribution to biological diversity but the relative abundance of these community types compared to rare communities. The medium priority also reflects that inventory of S4 community types is incomplete.

Common natural communities were assigned a weight of 3 out of 10. This low priority weight is based on the high importance of all high quality natural communities in their contribution to biological diversity, but the low level of inventory that has been completed for common community types and the overall low threat to these common community types.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to natural community components, contact Eric Sorenson, Vermont Fish & Wildlife Department, 802-476-0126, eric.sorenson@state.vt.us

Vernal Pools—Confirmed (SN6)

Description

Vernal Pools are small (generally less than one acre), ephemeral pools that occur in natural basins within upland forests. Vernal pools typically have no permanent inlet or outlet streams and have very small watersheds. These temporary pools generally last only a few months and then disappear by the end of summer, although some pools may persist in wet years. During dry periods, vernal pool depressions may be recognized by the sparse vegetation, stained leaves marked by seasonal high water, and the soils that have many more wetland characteristics than the surrounding upland soils. The periodic drying prevents the establishment of fish populations, but supports a specialized assemblage of species that typically includes amphibians (such as spotted salamanders and woodfrogs), specialized insects (such as caddis flies), mollusks (fingernail clams), and other invertebrates (fairy shrimp). Vernal pools typically lack trees but are shaded by trees growing in the surrounding upland forest. The vegetation that grows in vernal pools is highly variable in composition and abundance, although most pools have only sparse vegetation. 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.

Vernal pools are currently being mapped throughout Vermont as part of the Vermont Vernal Pool Mapping Project (Vermont Center for Ecostudies and Arrowwood Environmental, Inc.). All vernal pools included in this mapping component are those that have been confirmed by site visits. However, 71 vernal pools that were confirmed by site visits and include the rare Jefferson salamander are not included in this component and are instead included under the rare species component.

Ecological importance

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 of 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 600 feet of the pool during the non-breeding season (Semlitsch 1998). A closed forest canopy, abundant coarse woody debris, and a lack of artificial barriers to salamander movement are important habitat features to maintain in the 600 feet of forest adjacent to the vernal pool. 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.

Vernal Pool Conservation Goal

To conserve, enhance, and restore high quality examples of vernal pools across their geographic range of distribution and representing all physical settings (soil, bedrock, elevation, etc.) in which they occur. Effective conservation should include the 600 foot upland forest zone around pools that provide amphibian habitat, the pools' watersheds, and networks of connected lands, waters, and riparian areas to allow ecological exchange between vernal pools over time.

Component Mapping Goal

To identify and map all field verified vernal pools and the associated 600 foot upland forest zone adjacent to pools using the best available data.

Source Data and Selection Criteria

Vermont Vernal Pool Mapping Project Data Set, Vermont Center for Ecostudies and Arrowwood Environmental, Inc

Description

Vermont Vernal Pool Mapping Project data set.

Selection Criteria

All vernal pools that have been field verified and are included in the Vermont Vernal Pool Mapping Project data set. Any duplicates between the Vermont Vernal Pool Mapping Project dataset and the Natural Heritage Inventory (NHI) dataset will be identified and deleted from the NHI dataset. A 600-foot radius buffer is assigned to all pools to include the upland habitat zone.

Component Strengths

This dataset includes 985 vernal pools that have been mapped and confirmed by site visits over the past five years. This new data is spatially accurate and includes detailed information on the condition of each pool, the type and condition of the surrounding forest, and the presence of amphibian species.

Component Limitations

A statewide inventory is in progress and many more vernal pools exist that have not been confirmed by site visits.

Component Weight and Justification

Confirmed vernal pools were assigned a weight of 7 out of 10. This medium-high weighting is based on the critical breeding habitat that vernal pools provide for many species of amphibians. It is also based on the spatial accuracy and high quality of this confirmed vernal pool dataset.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Steve Faccio, Vermont Center for Ecostudies, 802-649-1431, sfaccio@vtecostudies.org

Vernal Pools—Potential (SN7)

Description

Vernal Pools are small (generally less than one acre), ephemeral pools that occur in natural basins within upland forests. Vernal pools typically have no permanent inlet or outlet streams and have very small watersheds. These temporary pools generally last only a few months and then disappear by the end of summer, although some pools may persist in wet years. During dry periods, vernal pool depressions may be recognized by the sparse vegetation, stained leaves marked by seasonal high water, and the soils that have many more wetland characteristics than the surrounding upland soils. The periodic drying prevents the establishment of fish populations, but supports a specialized assemblage of species that typically includes amphibians (such as spotted salamanders and woodfrogs), specialized insects (such as caddis flies), mollusks (fingernail clams), and other invertebrates (fairy shrimp). Vernal pools typically lack trees but are shaded by trees growing in the surrounding upland forest. The vegetation that grows in vernal pools is highly variable in composition and abundance, although most pools have only sparse vegetation. 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.

Vernal pools are currently being mapped throughout Vermont as part of the Vermont Vernal Pool Mapping Project (Vermont Center for Ecostudies and Arrowwood Environmental, Inc.). All potential vernal pools in this mapping component are those that have not yet been confirmed by site visits but for which there is high or medium-high mapping confidence that they exist.

Ecological importance

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 of 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 600 feet of the pool during the non-breeding season (Semlitsch 1998). A closed forest canopy, abundant coarse woody debris, and a lack of artificial barriers to salamander movement are important habitat features to maintain in the 600 feet of forest adjacent to the vernal pool. Vernal pools are also important for other species, including fairy shrimp, fingernail clams, spring peepers, American toad, and several plant and wildlife species.

Vernal Pool Conservation Goal

To conserve, enhance, and restore high quality examples of vernal pools across their geographic range of distribution and representing all physical settings (soil, bedrock, elevation, etc.) in which they occur. Effective conservation should include the 600 foot upland forest zone around pools that provide amphibian habitat, the pools' watersheds, and networks of connected lands, waters, and riparian areas to allow ecological exchange between vernal pools over time.

Component Mapping Goal

To identify and map all potential vernal pools and the associated 600 foot upland forest zone adjacent to pools that have not been field verified but for which there is high to medium-high mapping confidence (Vermont Vernal Pool Project).

Source Data and Selection Criteria

Vermont Vernal Pool Mapping Project Data Set, Vermont Center for Ecostudies and Arrowwood Environmental, Inc

Description

Vermont Vernal Pool Mapping Project data set.

Selection Criteria

All potential vernal pools identified by the Vermont Vernal Pool Project with a high (H) or medium-high (MH) mapping confidence ranking. A 600-foot radius buffer is assigned to all vernal pools to include the upland habitat zone.

Component Strengths

This dataset includes 1,557 vernal pools that have been mapped with high to medium-high confidence by the Vermont Vernal Pool Project. Although these pools have not been confirmed by site visits, the confidence in their mapping makes it very likely that they are vernal pools.

Component Limitations

This set of vernal pools has not been visited and although it is very likely that they are vernal pools, this has not been confirmed and there is no other ecological data available for the pools. The statewide inventory of vernal pools is underway and more pools will be confirmed.

Component Weight and Justification

Potential vernal pools were assigned a weight of 5 out of 10. This medium weighting is based on the critical breeding habitat that vernal pools provide for many species of amphibians, but also on the fact that these vernal pools have not be confirmed by site visits.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Steve Faccio, Vermont Center for Ecostudies, 802-649-1431, sfaccio@vtecostudies.org

Wetlands (SN8)

Description

Wetlands are vegetated ecosystems characterized by abundant water. Wetlands include the vegetated, shallow-water margins of lakes and ponds and he seasonally flooded borders of rivers and streams. They occur in an amazing diversity of topographic settings across the landscape, including basins, seepage slopes, and wet flats. All wetlands have three characteristics in common. First, all are inundated by or saturated with water during varying periods of the growing. 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. As a group, these plants are referred to as hydrophytic vegetation. There are several types of wetlands that are commonly recognized. Swamps are wetlands dominated by woody plants, either trees or shrubs. Marshes are wetlands dominated by herbaceous plants. Fens are peat-accumulating open wetlands that receive mineral-rich groundwater. Bogs are also peat-accumulating wetlands but are isolated from groundwater or surface water runoff by deep peat and therefore receive most of their water and nutrients from precipitation. Vernal pools are small, isolated, seasonally inundated wetlands typically surrounded by upland forests. 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.

Ecological importance

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. 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 is 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 dependant rare species include Calypso orchid, Virginia chain fern, marsh valerian, sedge wren, spotted turtle, and four-toed salamander.

Wetlands Conservation Goal

To conserve the full diversity of wetland types across their geographic ranges. 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.

Component Mapping Goal

To identify and map all wetlands that are expected to provide significant ecological functions.

Source Data and Selection Criteria

Vermont Significant Wetland Inventory (VSWI), VT Department of Environmental Conservation

Description

All wetlands mapped by the Vermont Significant Wetland Inventory (VSWI). The VSWI maps are based on the National Wetlands Inventory maps produced by the U.S. Fish and Wildlife Service, but have been updated periodically by the Vermont Department of Conservation and the Vermont Natural Resources Board.

Selection Criteria

All wetlands in the dataset.

Component Strengths

The VSWI maps are a well-known dataset based on National Wetlands Inventory maps and updated periodically for Vermont based on additional inventory and work by Vermont Department of Conservation and the Vermont Natural Resources Board. The maps are generally very accurate in identifying wetland presence, although the boundaries are not necessarily precise. Studies and on-going regulatory review by the Department of Environmental Conservation have shown that most wetlands mapped on VSWI provide ecological functions at a significant level.

Component Limitations

Not all wetlands with significant ecological functions are included on the VSWI maps. The VSWI maps do not include attribute information describing the wetland type present at a site. Site visits are always needed to identify whether a wetland is present on a site and to determine the actual boundary of the wetland.

Component Weight and Justification

Wetlands are assigned a weight of 8 out of 10. This high weight is based on the high level of ecological functions provided by wetlands, the large number of plant and animal species that are dependent on wetland habitat for survival, and the high accuracy of the VSWI maps for identifying wetland presence.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component summaries can be found at www.BioFinder.vt.us. For more information specific to this component, contact Alan Quackenbush, Vermont Department of Environmental Conservation, Wetlands Division, 802.490.6179, alan.quackenbush@state.vt.us

Mast Production Areas (SN9)

Description

Mast is the fruit and seeds of shrubs and trees that are eaten by wildlife. Hard mast refers to nuts (especially those of beech and oak trees), whereas soft mast refers to berries and fruits of a number of species (such as black cherry, raspberry, blackberry, and apple). While most forested areas contain at least a few mast producing trees and shrubs, forests producing significant concentrations of mast are much less common. In general, hard mast production areas of beech and oak that are used by wildlife represent a small fraction of the landscape.

A beech or oak Mast Production Area representing important wildlife habitat exhibits bear scarring on at least 15-25 tree trunks (most readily identifiable on beech) and/or show some evidence of use by bears (e.g., bear nests in crown of tree). These Mast Production Areas are disproportionately important to myriad wildlife species and crucial to the survival of Vermont's black bear population. For example, red and gray squirrels rely on beech nuts and acorns for their survival and reproductive success. And since these animals are prey for fisher, coyote, fox, owls, hawks, and other predators, the influence of Mast Production Areas can be seen throughout the food chain.

Ecological Importance

Significant mast production areas are generally recognized as a very important wildlife food source, both because of the concentrated nature of the available food in these areas and because of the high energy content of the food, especially for beech nuts and acorns. Mast production areas are used by at least 170 species of wildlife in Vermont, including deer, black bear, turkey, blue jays, and cedar waxwings. Hard mast production areas of beech and oak are absolutely essential for the survival and reproduction of black bear in Vermont. Studies have documented that the availability of hard mast in the fall affects the minimum reproductive age of bears, productivity rates, and cub survival, and that female bears may "skip" reproduction after poor mast years. (Elowe and Rogers 1989)

Mast Production Areas Conservation Goal

To conserve high quality, functioning mast production areas across Vermont, representing the variety of forest types and regions of the state. Effective conservation should strive to maintain mast production areas in unfragmented forest habitat where development and other human activities are least likely to adversely affect wildlife use and would provide a network of connected lands, waters, and riparian areas to allow movement of wildlife species between mast production areas and other necessary habitats and to allow for ecological exchange between unfragmented habitat blocks.

Component Mapping Goal

To map documented hard mast production areas using the best data currently available.

Source Data and Selection Criteria

Mast Production Areas database, Vermont Fish and Wildlife Department

Description

Hard mast production areas mapped by Vermont Fish and Wildlife Department includes 277 mast production areas as of May 2012. Mast production areas are mapped as points, but the size of the habitat is included in the attribute data for 193 of the 277 mapped stands. The average size of these 193 areas is 65 acres and for consistency all 277 mast production areas are mapped in BioFinder as circles with area of 65 acres.

Selection Criteria

All mast production areas in the database

Component Strengths

Hard mast production areas are known to be very important food sources for many species of wildlife. The mast stand data provides some information on associated forest type and species providing hard mast (primarily beech).

Component Limitations

There has not been a statewide inventory of functioning mast production areas, so the data represents a subset of actual mast production areas. The attribute data includes estimates of acreage for about 70 percent of the mapped mast production areas but these areas are mapped as points not delineations of the functioning mast production areas. The current condition and wildlife use of mapped mast production areas is not known as they are not periodically monitored.

Component Weight and Justification

Mast production areas were assigned a weight of 4 out of 10. This low weighting was based on the importance of mast for many species of wildlife but reflects the incomplete nature of the data. It also puts this habitat type into relative importance to other components of the analysis. Therefore, it is a critical habitat condition for many species of wildlife, but was ranked lower than some other components in the analysis to depict the relative contribution to biological diversity in this type of analysis.

For more information

A complete report on BioFinder development, methods and findings, including all 21 component abstracts can be found at www.BioFinder.vt.us. For more information specific to this component, contact John Austin, Vermont Fish & Wildlife Department, 802-476-0197, johnM.austin@state.vt.us