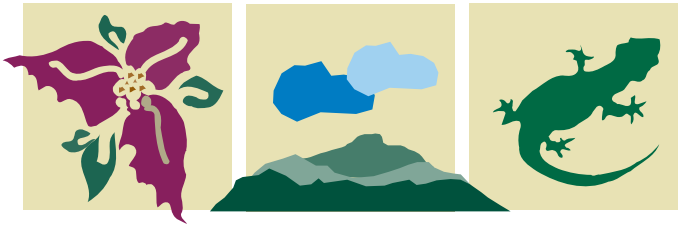
Vermont's Natural Heritage

Conserving Biological Diversity in the Green Mountain State

A report from the Vermont Biodiversity Project



VERMONT BIODIVERSITY PROJECT

This report was funded in part by
Sweet Water Trust, The Orton Family Foundation, Davis Conservation Foundation and the Vermont Housing and Conservation Board

This work should be cited as follows:
Thompson, Elizabeth H. 2002. Vermont's Natural Heritage: Conserving Biodiversity in the Green Mountain State. A Report from the Vermont Biodiversity Project. 48 pp.

To obtain additional copies of this report, please contact one of the following organizations or agencies, or view the report on their web sites (contact information is found in Appendix A, pages 38-40):

Vermont Land Trust
The Nature Conservancy
The Orton Family Foundation and Orton Institute
Vermont Department of Fish and Wildlife
United States Fish and Wildlife Service
Vermont Biodiversity Project (web site only)

VERMONT BIODIVERSITY PROJECT

The partners in the Vermont Biodiversity Project are:

- The Nature Conservancy
- Vermont Land Trust
- United States Environmental Protection Agency
- United States Fish and Wildlife Service
- United States Department of Agriculture, Natural Resource Conservation Service
- United States Department of the Interior, Forest Service (Green Mountain National Forest)
- Vermont Agency of Natural Resources
- Middlebury College
- University of Vermont
- The Orton Family Foundation
- Sweet Water Trust

Executive Summary

In 1995, a group of natural resource agencies and conservation organizations initiated the Vermont Biodiversity Project to assess the status of biological diversity in Vermont, and to make recommendations for protecting it. This book is a report on that work.

The vision of the Vermont Biodiversity Project is to maintain ecological integrity in a manner that insures the long-term viability of all native species and natural community types in Vermont within their natural ranges

The Vermont Biodiversity Project established specific conservation goals for biological diversity in the state at three levels: *enduring features, natural communities,* and *native species.* This report lays out these goals in detail, and summarizes conservation successes and needs for each. It should be noted that the goals and recommendations do not represent policies of any of the public agencies involved in this project.

For *enduring features,* our goal is to conserve a full representation of the mountains, cliffs, clayplains, and moist hollows that give Vermont its physical beauty and diversity. By several measures, we find that although most kinds of physical features can be found on conserved lands, some kinds are not well represented. The lowest elevations are the least conserved, and certain regions have much less conserved land than others. Only seven percent of the Southern Vermont Piedmont Biophysical Region is conserved, whereas 33 percent of the Southern Green Mountains is conserved, some of that as wilderness. Conservationists should work toward protecting more land in those underrepresented regions.

For *natural communities,* our goal is to conserve representative examples of all Vermont's upland, wetland, and aquatic natural communities. For some communities we have done a good job. The recent conservation of the Nulhegan Basin in the Northeastern Highlands will mean long-term conservation for Lowland Spruce-Fir Forest and Black Spruce Swamp, among other communities. For others, such as Valley Clayplain Forest, we will need to work very hard to restore the community in some of the places where it once occurred. Water quality has improved in many aquatic communities due to good stewardship, but we still need to be vigilant about pollution and nuisance aquatic species.

For *native species,* our goal is to conserve all native plants and animals in such a manner as to insure their long-term viability. For rare species, we can point to some real successes like the recovery of the peregrine falcon. Other species, like white-throated sparrow and calypso orchid, are in decline for unknown reasons and will need special research and conservation attention.

To meet these goals, the Vermont Biodiversity Project recommends an **ecological reserve system** for Vermont that includes **core reserves** where natural processes can work over large areas without human alteration; **natural areas** where particular natural communities and species are protected on smaller parcels; **stewardship lands** where logging, farming, and other human activities compatible with certain biodiversity values can be pursued; and **connecting lands** to hold the reserve system together.

The Vermont Biodiversity Project encourages all Vermonters to contribute to the conservation of biodiversity by working to protect biodiversity in their own towns and watersheds.

Rod and Betty Vallee

Foreword

Biodiversity is a word we hear often these days. It rolls easily off the tongue and slips into our common lingo. It conjures images of jungles with tangles of plants and teeming with exotic animals.

Despite its simple syllables and abundant images, it is a complex and controversial concept. It poses countless questions and hints at multiple meanings – not only for those who hear the word on the news, but for those whose lives center on studying or trying to conserve it. It is not just about jungles; it is also about mountaintops and valleys, forests and grasslands, tundra, deserts, oceans, ponds, rivers, and marshes,

It means more than creatures on a landscape; it is about the landscape itself and about how everything works together. Every crack and corner of the earth and all of us who dwell here – our shared futures – are embodied in this inviting, yet troublesome word. Like life itself, biodiversity is at once huge and tiny, at times seeming too much so for us to comprehend.

So laden with shades of meaning, the word triggers many different reactions – some of them antagonistic. We worry about the diminishment of biodiversity. We fear the implications of the word for our ways of life and our livelihoods. We get frustrated trying to bridge the gaps and gulfs between opinions. And we are bewildered by the daunting tasks of understanding and acting on the word's meaning.

In the small universe we call Vermont, we have urgently needed something to help us make sense of biodiversity. We need to attach numbers and pictures to ideas that drift and form, then re-form, like clouds in our minds. We need to know what biodiversity really means – on the ground, in the water, and even in the air. We need all this to help shape our concern into fruitful action, and to allay fears, ease frustration, lessen bewilderment, and shape our awe into new understanding.

Here we have what we need, all in one source. *Vermont's Natural Heritage: Conserving Biological Diversity in the Green Mountain State* is the product of years of cooperative work by organizations and people who are deeply involved with this state's biodiversity. It can help to frame our thinking and direct our actions as responsible citizens of Vermont. But it can do more than this; it can allow us better to know and cherish the home we love.

Charles W. Johnson
September 10, 2001

Rod and Betty Vallee

Table of Contents

Illustration opposite page by Betsy Brigham

Chapter 1.

The Vermont Biodiversity Project

The vision of the Vermont Biodiversity Project is to maintain ecological integrity in a manner that insures the long-term viability of all native species and natural community types in Vermont within their natural ranges. The Missisquoi National Wildlife Refuge contributes to this vision by protecting thousands of acres of wetland and upland in a diverse, thriving ecosystem. Canoeists, hunters, and anglers enjoy the beauty and bounty this area has to offer.

In 1994, the Northern Forest Lands Council published its final report, "Finding Common Ground." In that report, the council recommended, among other things, that the states in the region design systems of ecological reserves to protect the biodiversity of the region.

In 1995, The Nature Conservancy of Vermont, in response to that recommendation, convened a group of representatives from many of the agencies and organizations involved in conservation in Vermont. From this group the Vermont Biodiversity Project was born.

The vision of the Vermont Biodiversity Project is to maintain ecological integrity in a manner that insures the long-term viability of all native species and natural community types in Vermont within their natural ranges.

The first goal of the Vermont Biodiversity Project was to assess biodiversity in the state of Vermont and to identify the places in the state that are most in need of biodiversity conservation. This book is a report on the work we have done so far to achieve that goal.

Conserving biodiversity is not a new idea – a variety of organizations and agencies have been working toward this goal for many years. The Nature Conservancy of Vermont has been hard at work here for 40 years. The Agency of Natural Resources has kept track of biodiversity resources in a detailed way since 1989, when the Vermont Fish and Wildlife Department established the Nongame and Natural Heritage Program. And the Green Mountain National Forest protects biodiversity in its Wilderness and Research Natural Areas.

However, the agencies and organizations have lacked a coordinated, statewide effort to identify and conserve biodiversity on both public and private lands. One role of the Vermont Biodiversity Project is to provide this coordination.

As work on the Vermont Biodiversity Project has progressed, many other related efforts have evolved. Among these are the following:

- The Nature Conservancy has initiated an international effort called Conservation by Design to plan for biodiversity conservation in large ecoregions such as the Northern Forest.
- The Vermont Agency of Natural Resources recently published a Lands Conservation Plan that calls for the development of a natural reserve system for Vermont.
- The Wildlands Project is working to identify priorities for wilderness conservation in the Northeast and elsewhere in the Americas.
- Several towns and watershed associations are currently planning to conserve biodiversity locally and are seeking information on how to coordinate this work from town to town and region to region.
- Vermont has benefited from several significant conservation successes, including the purchase of the former Champion Lands by the U.S. Fish and Wildlife Service, Vermont Agency of Natural Resources, and Essex Timber Company. This purchase resulted from the cooperation of many people and organizations with a variety of goals.

These good planning efforts and on-the-ground conservation successes show that Vermonters want to conserve their natural heritage, and want to do it in a thoughtful, informed, and efficient way.

The information presented in this book is a scientific assessment of biological diversity in Vermont based on what we know today. It is not public policy. It is intended to encourage more conservation in two ways. First, it can help landowners, conservation commissions, planners, policy makers, and conservation organizations make sound, informed decisions in the specific places where they work. And second, it can provide the basis for the development of a statewide system of ecological reserves.

Chapter 2.

What is Biodiversity and Why Does it Need Our Help?

"The first step in intelligent tinkering is to save every cog and wheel."

– Aldo Leopold

Biodiversity, or Biological Diversity, is the variety of life in all its forms, and all the interactions between living things and their environment. It includes ecosystem diversity, landscape diversity, community diversity, species diversity, and genetic diversity.

Vermonters care about biodiversity for many reasons.

All of the pieces of an ecosystem are important to its functioning. From bears, bobcats, and falcons all the way down to soil microbes that decompose leaf litter in the autumn woods, everything counts. The great conservationist Aldo Leopold said it best: "The first step in intelligent tinkering is to save every cog and wheel." Leopold recognized that humans are tinkering with nature, and that as tinkerers we should follow the example of a good mechanic who is a bit of a packrat, keeping odd parts around "just in case." Functioning ecosystems are critical to the health of all species, including our own. We rely on healthy ecosystems to provide us with food, water, wood, minerals, and other products that we need, and to keep our water and air clean.

We find solace in being surrounded by nature. Nature provides a sense of peace because of its diversity. An evening walk in the woods without the sound of the hermit thrush would somehow seem empty. We'd be disappointed if the only shrub we saw on our walk was the imported Asian Morrow's honeysuckle – we'd miss the native witch hazel, moosewood, and shadbush that are so common in healthy Vermont woods. If the soil fungi were missing and we couldn't smell the decomposing leaf litter in the fall, our noses would wonder what was wrong.

Rod and Betty Vallee

The Hermit Thrush, Vermont's state bird, has a beautiful song.

There are medicines and other useful products yet to be found in nature. A full 40 percent of all prescription drugs contain active ingredients originally derived from wild plants and animals. Witch hazel and aspirin were once natural remedies. Countless other natural medicines still used by traditional cultures never make it into our drugstores, but they have great value in promoting health and curing disease. Someday, we may want to know more about them.

We respect all forms of life. Humans are but one of the millions of species found on earth, all of which deserve to survive.

Some of us care for all of these reasons. But some also ask, does biodiversity really need our attention? Vermont appears to be a green place, with abundant forests and healthy ecosystems. If we look closely, though, we find that the picture is not so perfect as it looks.

First of all, we are missing populations of several species that were here prior to European settlement. Among these are the passenger pigeon, timber wolf, wolverine, elk, caribou, and mountain lion (though there have been some sightings in recent years). Some of these animals had vital roles in the ecosystem, regulating populations of herbivores such as white-tailed deer. Of the 1,500 native plant species ever recorded from Vermont, 95 are now known only from historical records. Among these are small round-leaved orchid, whorled milkweed, and swamp birch.

In addition, many species are declining. Amphibians and reptiles are considered to be in decline globally. Among birds, northern flicker, field sparrow, song sparrow, white-throated sparrow, whip-poor-will, and slate-colored junco are all in decline. Among plants, butternut, calypso orchid, and wild lupine are declining.

John Hall

Many Vermonters enjoy wild nature by hunting or fishing in beautiful places.

Of the species that are increasing in number, most are not native. Although it is tempting to think that the addition of non-native species increases biological diversity, in reality many of these species can be very destructive, decreasing diversity locally and altering ecosystem function. Zebra mussel, Eurasian water-milfoil, Morrow's honeysuckle, and purple loosestrife are among the non-native species that have no natural predators on this continent and can therefore quickly overtake a lake, a woodland, or a wetland, displacing native species and altering community structure.

Elizabeth Thompson

The Calypso orchid, also known as fairy slipper, is declining in Vermont. It grows in cold cedar swamps.

One positive thing we can say about Vermont (and the Northeast in general) is that forests have returned to a land that was cleared and drastically altered in the 1800s. Prior to European settlement, Vermont was about 95 percent forested. In 1870, at the height of New England agriculture, Vermont was only about one-third forested – the rest was in cropland or pasture. When the fertile lands of the Midwest opened for settlement, Vermont's hill farms were abandoned, so today the state is green again – it is now about three-quarters forested.

But these woods are not the same woods that the settlers originally found. Trees are much younger, on average, and there is practically no true old growth forest left. There are stone walls throughout the woods, and the soil structure reflects a past of plowing or grazing. On many hilltops, the original soil is now gone, having been washed into streams and rivers.

Finally, streams and rivers suffer from a reduction in water quality. Almost 41 percent of Vermont's rivers and streams, 63 percent of its lakes and ponds, and all of Lake Champlain, are not able to fully support "designated uses" (drinking, swimming, fishing) because of pollution, siltation, excess nutrients, habitat alteration, algae, and exotic plants and animals.

Elizabeth Thompson

Protecting natural places will give our children and grandchildren a healthy environment and wild things to enjoy.

This all sounds like bad news, but the good news is that we are now uniquely poised to do something positive for biodiversity in Vermont. The forest is young, but it is returning and maturing. The rivers and streams are compromised, but water quality has improved in many places due to good stewardship. Several species are missing, but forested habitat is now available for the return of some of the species that were lost during the 19th century.

Protecting the ecological integrity of Vermont's landscape now, through careful planning, will ensure a rich future for all native species, as well as for our children and grandchildren.

Avi Hestermann

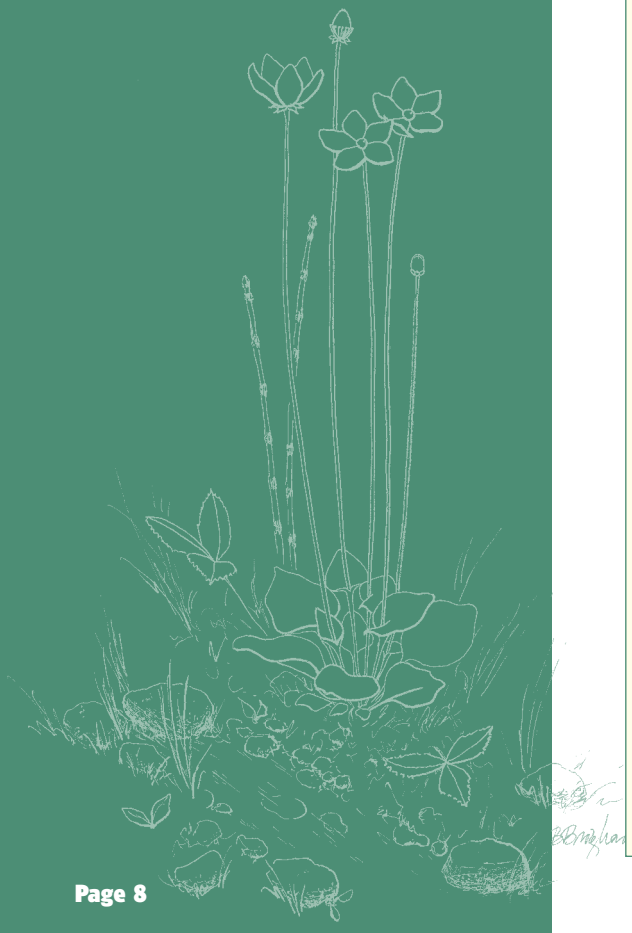
In an article published in the Atlantic Monthly in 1995, author Bill McKibben described the reforestation of the Northeast as "an explosion of green." The new forest, though not quite the same as the original one, gives us a second chance at conserving Vermont's nature.

Chapter 3.

The Science of Conservation

The vision of the Vermont Biodiversity Project is based on two principles:

Representation and Viability



The science of conservation biology helps us to understand how we can best conserve biodiversity. The vision of the Vermont Biodiversity Project is based on the two following principles of conservation biology:

Representation:

In order to fully conserve biodiversity, we must represent everything in our system of conserved lands. This includes all species, from wide-ranging species like bobcat and lynx to soil fungi and bacteria that are crucial to breaking down organic matter in the forest. It also includes all natural communities, from vast expanses of northern hardwood forest to seeps and vernal pools. Finally, it includes all the physical features of Vermont, from the highest mountaintops in the Green Mountains to the lowest, wettest swamps along Lake Champlain.

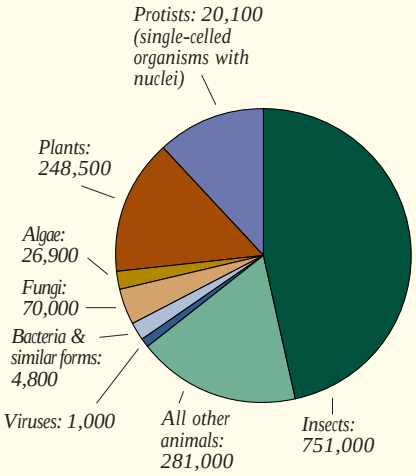
Biodiversity Worldwide

Throughout the world, approximately 1.5 million species have been named by scientists to date.

One of these groups, the fungi, contains about 70,000 organisms that have been discovered and named, but scientists estimate that there are another 1,430,000 species of fungi that have not yet been discovered. In another, less conspicuous group, the bacteria, only 4,800 species have been named. But a study in Norway suggests that there are many more. This study showed that a gram of soil from a forest contained over 4000 species of bacteria, and another gram of soil from the ocean floor also contained about 4000 species, and there was little or no overlap in species between the two samples. Based on these samples, it is likely that there are literally billions of unnamed bacteria, more than the total number of currently named species in all groups.

Bacteria and fungi perform vital ecological functions, including breaking down organic matter, converting nutrients to usable forms, and cycling nutrients in other ways. Without them, we would not have ecosystems. Clearly, we cannot know each species or the functions it performs. The only strategy we know to conserve these poorly understood species is to conserve a diversity of habitats, hoping this translates into a diversity of species.

For some of the more conspicuous species like peregrine falcons and showy lady's slipper, we can make population estimates and develop species-specific conservation strategies.



Viability:

In order to conserve the full suite of species, natural communities, and physical features of Vermont, we need to consider not only where they are now, but also what they will need to survive into the future. To assess whether a species or community will be viable over the long term, we ask four specific questions:

1. *Is it big enough?*
2. *Is it healthy?*
3. *What surrounds it?*
4. *Is it threatened?*

Is it big enough?

Each species has its own specific area requirements, depending on how wide-ranging it is, its habitat or food needs, and how vulnerable it is to inbreeding depression – the loss of genetic vigor in a population that is too small.

Many plants can survive in small areas of a few acres or less for long periods, as long as there is cross-pollination with other populations in the area, and as long as there is some assurance that new habitat will be available if the present habitat changes. Other plants need larger areas. Unfortunately, we know very little about the area needs of most native plants.

Each natural community type has specific area needs, too, depending upon its physical setting, the ecological processes that maintain it, and the individual species that make it up.

Ecological processes such as wind, fire, flooding, nutrient cycling, and groundwater movement maintain natural communities. Scientists study these ecological processes to help them understand how large an area of each community type is needed to maintain all its successional stages and all its inherent variety. Northern Hardwood Forests, for example, naturally occur in large areas in Vermont, and are influenced by large-scale ecological processes such as hurricanes. If we wanted to ensure the existence of a mix of old and young forest on this landscape, we would need to protect an area large enough to accommodate hurricanes, fires, and other natural disturbances with some older areas left intact. Based on the historic frequency of disturbance, and the usual size of hurricanes, fires, and other disturbance events, scientists estimate that an area of several thousand acres is needed to maintain a healthy, viable Northern Hardwood Forest with a mixture of old-growth and young areas.

At the other end of the spectrum, Dry Oak Woodlands often occur as small patches, and respond mostly to local-scale ecological processes like droughty soils and fires. Ten to fifty acres may therefore adequately protect a Dry Oak Woodland.

A conservation plan that meets the ecological needs of both large forests and small swamps at the same time is the most efficient.

How Much Do They Need?

Although we know little about how much area is needed to support viable breeding populations of most animals, we can at least make some comparisons. For the following animals, we can estimate, based on territory needs, how much area is needed at a minimum to support 25 breeding pairs. This may or may not represent a viable population – that depends on the species and other factors, like whether there is contact with other populations for interbreeding.

Area needed to support 25 breeding females of:

Mountain lion	475,000 acres
Black bear	150,000 acres
Bobcat	125,000 acres
Lynx	80,000 acres
Spruce grouse	7,500 acres
Woodland jumping mouse	25 acres
Southern red-backed vole	8 acres

Elizabeth Thompson

◄ *If a large hurricane hit the landscape shown to the left, as it did in 1938, large swaths of forest would be blown down, and early successional species like paper birch and pin cherry would replace the sugar maple and beech. We need to protect large areas of northern hardwood forest in order to ensure a mix of old and young forests.*

Area Needs for Natural Communities

Average area needs of a few select natural communities, based on their natural size and the disturbances that affect them.

Northern Hardwood Forest.....5,000-25,000 acres, depending on surrounding landscape

Lowland Spruce-Fir Forest..... 500-5,000 acres

Red Maple-Black Ash Swamp..... 50-1,000 acres

Dry Oak Woodland..... 10-50 acres

These estimates are based on the work of Mark Anderson of The Nature Conservancy.

Is it healthy?

How long will a given species continue to thrive in a given place? It depends not only on the size of the population, but also on the quality of its habitat.

For species like salamanders, which breed in vernal pools in the spring but migrate to the surrounding forest for the summer, the answer has to do with both parts of its habitat, the pool and the forest. The pool itself must be in good condition, with clean water, natural vegetation, and natural hydrology. The forest must also be in good condition, with a full canopy to provide shade, moist rotting logs for salamanders to rest under, and no roads where salamanders could be killed by passing cars on a rainy night.

CHRIS FICHTEL

The amphibians that breed in vernal pools also need healthy surrounding forest to migrate, feed, and complete their life cycles.

For natural communities, the ability to survive long term has to do with several factors. We understand that over time, natural communities will change in species composition and in other ways, but still we look for some relative stability that reflects natural change and ecological process.

Does the community have all of its component species, as we know them and as they change over time? In a Dwarf Shrub Bog as it exists today, these include carnivorous plants and heath shrubs, a variety of insects, sphagnum moss that has built up as peat over centuries, and soil bacteria and fungi that are crucial to nutrient cycling.

Is the soil intact? A Pine-Oak-Heath Sandplain forest where the soil has never been plowed is likely to have more seeds stored in the soil, ready to germinate in the event of a fire, than one that has been plowed, grazed, or dug in. It is also more likely to have the full complement of soil bacteria and fungi that help the system function.

Is the community free of weedy species that can replace native species and reduce overall diversity? In a Limestone Woodland Morrow's honeysuckle, an Asian plant, can become dominant and replace native species like witch hazel, maple-leaved viburnum, and fringed polygala.

Does the community have all its natural structural complexity? In a Red Oak-Northern Hardwood Forest, this complexity includes standing snags and downed trees where animals, mosses, and fungi live; multiple age classes to provide habitat for a number of species; and a hummocky topography resulting from years of tree fall, providing a diversity of habitats for plants.

ERIC SORENSON

Old snags, stumps, and fallen logs provide critical habitat for mosses, lichens, and fungi that cannot live anywhere else. They also serve as "nurse logs," providing places for tree seeds to germinate. They provide protection and moisture for amphibians and reptiles, and their cavities serve as nesting places for animals like marten, fisher, and dark-eyed junco. Old forests are full of these microhabitats, and therefore full of biodiversity.

What surrounds it?

A large population of a rare plant may look healthy and robust, with many individuals producing large amounts of seed every year, but if a sea of developed land or other inhospitable habitat surrounds that population, it may have trouble surviving over long periods of time.

Wild lupine, for example, a delicate and rare relative of the popular garden lupine, needs open sandy areas to thrive. Its natural habitat is Pine-Oak-Heath Sandplain Forest, which was once common in western Chittenden County.

Presettlement Vegetation of Vermont

Vermont's forests reflect a long history of settlement and farming. In the 1850s, about two-thirds of the state had been cleared by European settlers, and sheep were abundant. Today, forest has returned to much of the land, so that only about 25 percent of the state is open. In the woods now, old apple trees stand where a farm once was. Day lilies reveal the site of a long-abandoned flower garden. Bare hilltops and impoverished soils suggest past grazing and its resulting soil erosion.

In a forest with such an agricultural history, how can we know what it "should" look like? How can we know what might naturally grow there if it were to be left alone for a long period of time? This question challenges ecologists and land managers, and there is no perfect way of answering it. But one thing can help, and that is knowing what grew in our forests before Europeans arrived and cleared the land.

The Vermont Biodiversity Project commissioned a special study of the presettlement forests of the state. Ecologist Charles Cogbill scoured old state archives and discovered a gold mine of information in early surveys of the land. Before the big wave of settlers came, a few hardy souls walked the woods to survey land parcels and in the process recorded trees at regular intervals. Their records tell us a great deal about what the woods looked like in 1790. Cogbill found that beech was the most abundant tree in Vermont back then, whereas sugar maple surely takes that prize now. He also found that the Champlain Valley had abundant hemlock, pine, ash, elm, and basswood, along with maple and beech. Knowing what was there can help us restore some of the native forests.

Beech was once the most abundant tree in Vermont.

Before European settlers inhabited the area, naturally open sandy areas were common where individual trees had blown down or where natural forest fires had burned small areas. Plants like wild lupine moved around from place to place in the forest, thriving for a few years in an opening and then declining at that spot when the forest canopy returned, but also finding new habitat patches elsewhere in the sandplain. The Pine-Oak-Heath Sandplain Forest is now so fragmented by development that lupine is effectively trapped in habitat islands. When the tree canopy closes and the humus layer begins to cover the mineral soil, those islands become unsuitable for lupine, and the plant has nowhere else to go. There is only one population of wild lupine in Vermont today, and we cannot be sure that this population will survive over the long term.

Conservation scientists agree that connecting lands of suitable habitat can go a long way to ensure that there are no true habitat islands. Connections provide a way for an animal or a plant to move about the landscape as its habitat or its needs change.

C. Fichtel

◄ *Wild lupine, a relative of the garden lupine, is extremely rare in Vermont and has declined in every New England State because its habitat has been altered by humans.*

Global Climate Change:

What do we know? How can we deal with it?

Climate change has always been a part of our landscape: the most recent continental glaciers retreated from Vermont only a little over 10,000 years ago. But humans have accelerated the rate of climate change recently, inducing global warming with so-called "greenhouse gases." Recent estimates by the U.S. Forest Service suggest that as a result of global climate change, Vermont will lose its red spruce and balsam fir, along with other northern species, in the next few hundred years. We don't know what will replace these species, but hopefully we can ensure that southern species of plants and animals can easily migrate north and find suitable habitat by providing an interconnected system of ecological reserves that contain a diversity of physical features from low-lying wetlands to high-elevation cliffs and by maintaining a healthy forested landscape between these reserves.

EVERETT MARSHALL

Balsam fir is common in Vermont's mountains, but will likely disappear over the next few centuries due to global warming.

Is It Threatened?

For each species or natural community, we must ask what threatens it. If there are no threats, perhaps we can wait a while before paying attention to it. It is important that we pay most immediate attention to the places that are the most threatened. To assess the level of threat, we look at what is going on there now; we look at human population trends to see if the area will come under pressure for housing or other development; we ask if there are critical resources (minerals, timber, gravel, etc.) which may make the area especially vulnerable to exploitation; we ask if recreational use is heavy or might increase; and we ask if there are other pressures that might make the land vulnerable. Because humans are notoriously bad at predicting the future, we must constantly reassess, and ask these questions at regular intervals.

Reserves and Stewardship Lands: A Mix for Biodiversity

We can apply the concepts of conservation biology on a given piece of land, in a town that is planning for its future, in a biophysical region, in an entire state like Vermont, or across larger ecological regions like the northern forest.

The Vermont Biodiversity Project recommends an **ecological reserve system** for Vermont that includes **core reserves** and **natural areas** where natural processes can work without human interference, **stewardship lands** where human activities compatible with natural processes can be pursued, and **connecting lands** to hold the reserve system together.

Core reserves and **natural areas** are pieces of land that are legally protected and managed primarily for the benefit of the plants, animals, other organisms, natural communities, physical features, and ecological processes that are naturally found there. Neither timber nor mineral resources are taken from the land, and ecological processes (including fire) are allowed to occur as long as they do not endanger human life or personal property.

Vermont's collection of core reserves and natural areas should contain a diversity of physical features, including lowlands, sideslopes, and ridgetops with all kinds of soils, and a diversity of natural communities, from Rich Fens to Northern Hardwood Forests to Alpine Meadows.

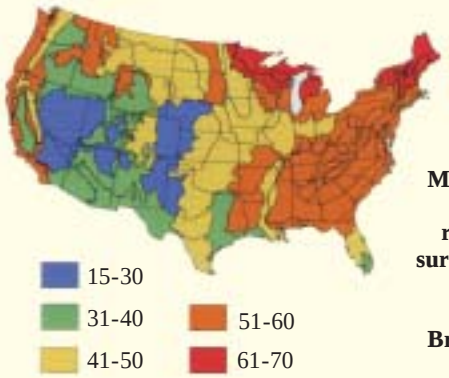
Recreation is allowed in core reserves or natural areas as long as it is compatible with the primary goal of protecting biodiversity. Hiking, hunting, and fishing are usually allowed.

Any agency, organization, or individual can own a core reserve or natural area. Legal protection can take many forms, including ownership by a conservation organization, ownership and appropriate management by a public agency, and easements on private land. Many of Vermont's conserved lands are managed as core reserves or natural areas now, including small private holdings and large public lands.

AVI HESTERMANN

The Equinox Preservation Trust, a branch of the Equinox resort in Manchester, has voluntarily protected 800 acres of forest with a "forever wild" easement.

Vermont in the Big Picture:



Mean number of species recorded per survey route of the North American Breeding Bird Survey

Within the United States, the highest number of breeding bird species occur in the North. Many of these species require large areas of contiguous forest, and some are more abundant in old growth forests. Others thrive in old fields and shrublands. Our core reserves and stewardship lands contribute significantly to their conservation.

Stewardship lands include forests, farms, and parks that are managed with biodiversity in mind. Sometimes they are adjacent to core reserves or natural areas and serve to buffer them from outside influences, and sometimes they stand alone, serving to restore damaged forests to a more healthy condition.

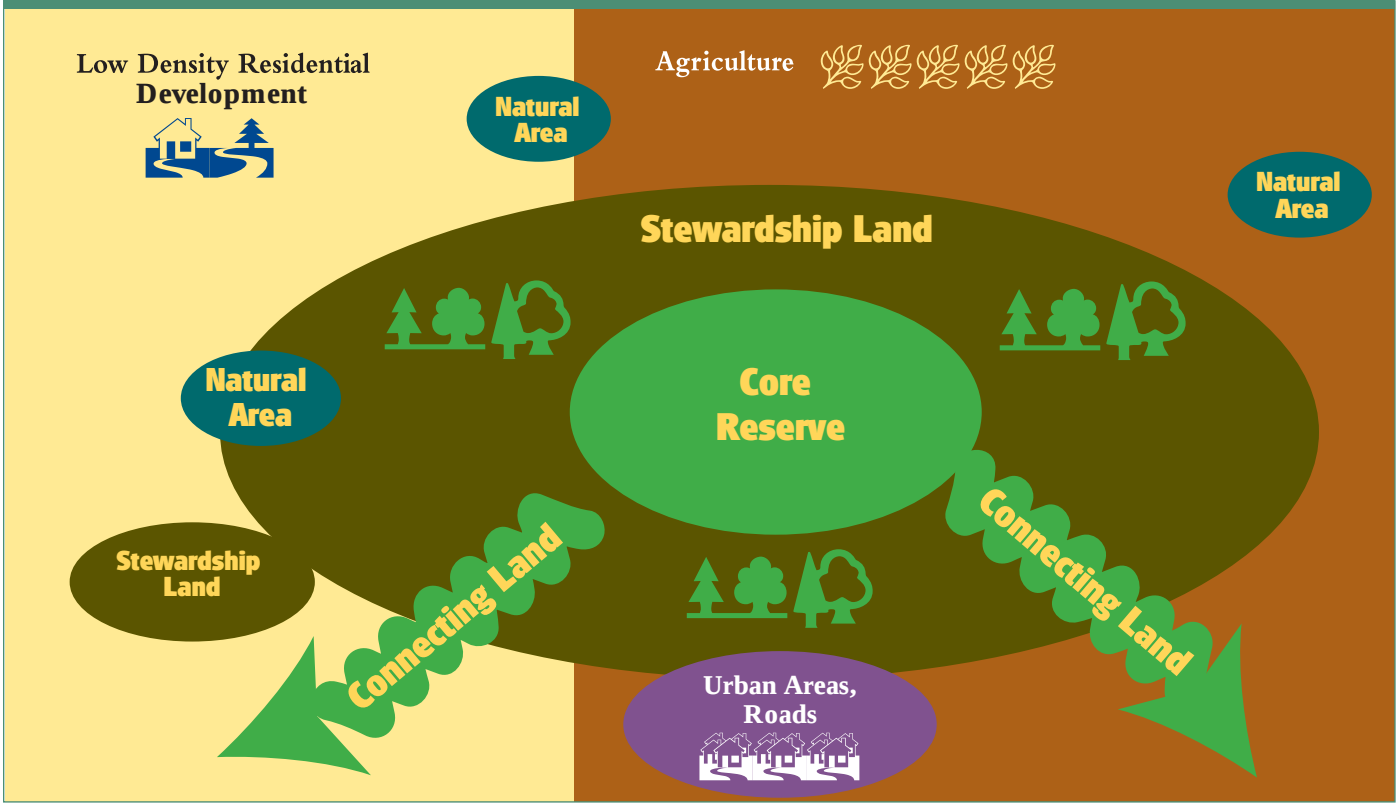
In stewardship forests, timber is extracted but logging practices strive to imitate natural processes as much as possible. Cuts tend to be small (although size can vary depending on the forest type), some logs and standing dead trees are left behind, waterways are protected by vegetation on streambanks to maintain water quality, chemical herbicides and pesticides are not used, and roads are carefully constructed to minimize erosion, habitat alteration, and fragmentation. Special features like Vernal Pools, Dry Oak Woodlands, and rare plant and animal habitats are recognized and protected.

On stewardship farms, crops are planted on the contour to reduce soil erosion, and streams are protected by vegetated buffers so that sediments and chemicals do not pollute surface waters. Special habitats like wetlands, clayplain forests, and cliffs are protected.

Connecting lands link core reserves, stewardship lands, and natural areas in such a way as to allow the free movement of animals and plants. These connecting lands are designed with respect to the biology of the species of concern. Often, but not always, they are natural lands with abundant forest cover.

An **ecological reserve system** is a group of core reserves, natural areas, stewardship lands, and connecting lands that taken together will provide much of what is needed to meet the vision of the Vermont Biodiversity Project: "to maintain ecological integrity in a manner that insures the long-term viability of all native species and natural communities in Vermont within their natural ranges."

Pieces of an Ecological Reserve System



The pieces of an ecological reserve system

Charles Cogbill

◄ Core Reserves and Natural Areas

- Are managed primarily for biodiversity
- Contain a wide variety of physical features and ecosystem types
- May encompass large-scale ecological processes
- Provide clean air and clean water
- Provide habitat for species like Blackburnian warbler and Swainson's thrush that are more abundant in old growth forests
- Are structurally complex
- Have intact soils
- Absorb disturbances

The Vermont Land Trust

The Nature Conservancy

Stewardship Lands ►

- Are managed for biodiversity, for resource production, and for recreation
- Contain a wide variety of physical features and ecosystem types
- Provide habitat for many common species like bobolink and pink lady's slipper
- Provide habitat for certain rare species like upland sandpiper and low bindweed
- May buffer core reserves or natural areas from outside influences like exotic species
- Absorb recreational and economic pressures

Elizabeth Thompson

Elizabeth Thompson

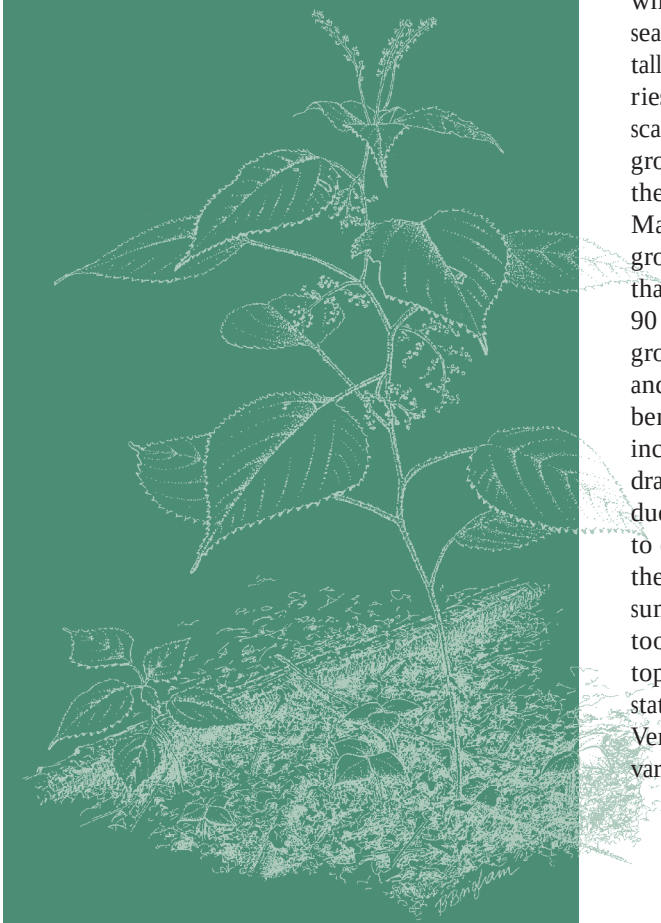
◄ Connecting Lands

- Are managed for biodiversity, for resource production, and for recreation
- Contain a wide variety of physical features and ecosystem types
- Provide connecting links from place to place so that animals and plants can move freely
- Are designed to suit the needs of the animals and plants that need them
- Are diverse physically and biologically

Chapter 4.

Vermont's Natural Heritage

Understanding Vermont's biological diversity requires understanding the physical landscape that underlies it all.



The Physical Landscape

Vermont's landscape is a rich tapestry of mountains, valleys, woods, and wetlands, with a fascinating geological history. It is Vermont's natural landscape that enriches our lives and draws so many visitors to the state. It is this same landscape that provides us with clean air, clean water, and habitat for thousands of species of plants and animals.

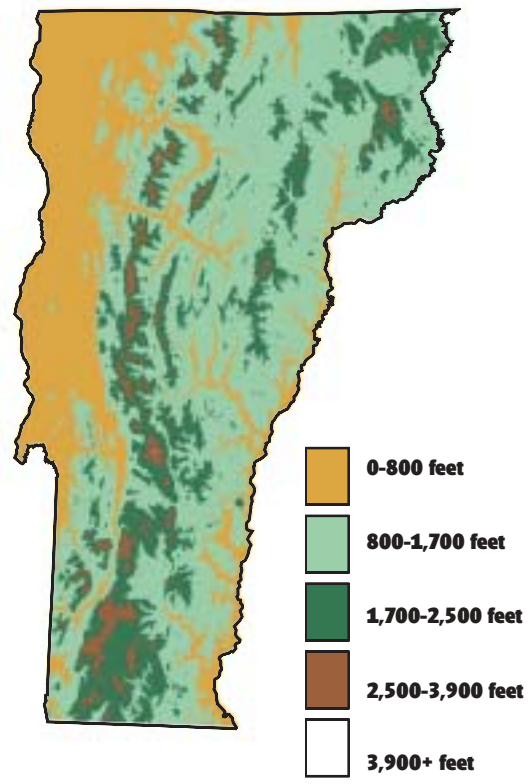
Understanding Vermont's biological diversity requires understanding the physical landscape that underlies it all. The configuration of mountains, valleys, wetlands, lakes, and rivers is crucial in determining the distribution of natural communities and species. This is why we include the physical landscape in our concept of biodiversity.

We have identified four key physical factors that influence the distribution of species and natural communities. These are climate, bedrock geology, surficial geology, and topography. In addition to these physical factors, the human history of the landscape has a dramatic effect on the present-day distribution of communities and species.

Climate

Vermont's lowest point is on the shore of Lake Champlain, only 95 feet above sea level. Vermont's highest point is the Chin on Mount Mansfield, which rises to 4,393 feet. The distance between Lake Champlain and the Chin is only 20 miles, but in that short distance the climate, topography, and vegetation change dramatically. On the shores of Lake Champlain, where the growing season is 150 days, tall shagbark hickories dot the landscape and peaches grow in orchards. On the top of Mount Mansfield, where the growing season is less than 90 days, balsam fir grows in stunted and contorted mats, bending to the incessant winds. This dramatic change is due almost entirely to elevation, though the exposure of the summit plays a part, too. It is the striking topography of the state that dictates Vermont's great variability in climate.

Vermont Elevation Zones



DARIEN MCELWAIN

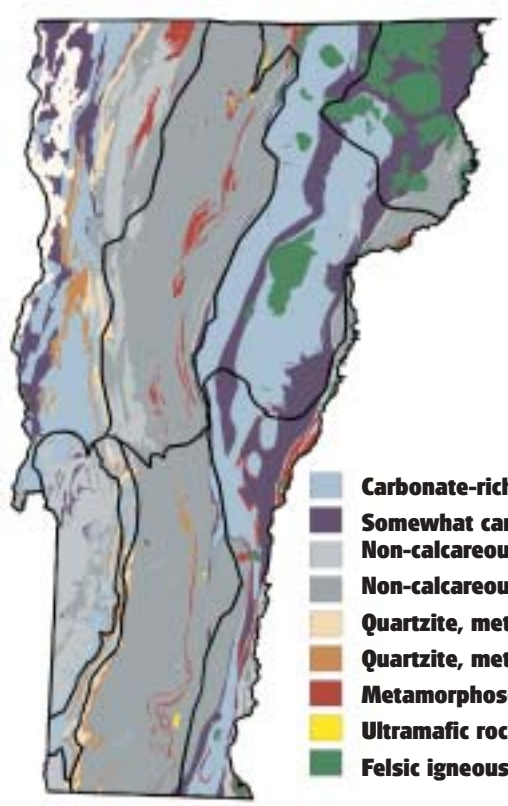
This cross section of a landscape in the Vermont Valley shows that bedrock (straight or wavy lines) underlies everything, but in some places the surficial deposits (pebbly gravel and dark-hatched peat) cover the bedrock and have a greater influence on the vegetation.

Climate is of crucial importance in determining the distribution of natural communities, plants, and animals. We use elevation as a substitute for climate differences, because elevation is easy to measure and map, and because it is the major factor influencing climate in Vermont.

Bedrock geology

Bedrock geology refers to the origin and nature of the rock that underlies all soil and vegetation. Vermont's bedrock has a rich history. The rocks that make up the Southern Green Mountains were formed more than 570 million years ago. The rocks of the Champlain Valley and the Northern Green Mountains date from a time 540 to 443 million years ago when Vermont was the edge of a warm, tropical sea. The remains of marine mammals that inhabited that sea can be found in today's Champlain Valley limestone rock. The youngest rocks in Vermont are the granites, like the stone that makes up the Barre granite quarries. These rocks were formed

Bedrock Geology of Vermont



Generalized bedrock geology of Vermont. This map was developed especially for the Vermont Biodiversity Project from an existing map of the bedrock geology of Vermont (Doll 1961). The nine classes of rock are defined based on their ecological importance rather than on their origin or age. The rocks that dominate much of the Green Mountains (grey on the map) are acidic, while the rocks that dominate the Champlain Valley and the eastern part of the state (blue on the map) are basic because they are buffered by carbonates.

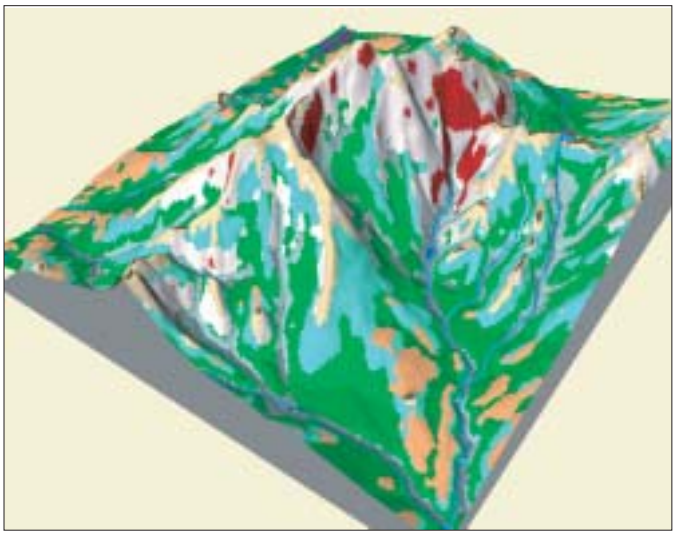
Modified from Doll 1961 by Marjorie Gale and Laurence Becker, Vermont State Geologist's office. Used by permission.

200 to 400 million years ago as a result of deep underground magma welling up and hardening. Granite is one of the dominant kinds of rock in the Northeastern Highlands.

Whether the bedrock is limestone or granite, or some other kind of rock, it is particularly important in the distribution of natural communities and plants because each kind of rock has its own unique chemical makeup. Rich fens, a rare wetland type, occur almost exclusively in areas where limestone or other similar calcium-rich rock is prevalent because the plants that grow in these fens require calcium. The rare Green Mountain Maidenhair fern occurs only on a specialized bedrock type known as serpentine – the rock from which asbestos is mined – because this rock has especially high levels of magnesium, to which the fern has adapted. Animals respond to changes in bedrock geology as well. The rare Taconic Cave amphipod, for example, occurs only in limestone caves.

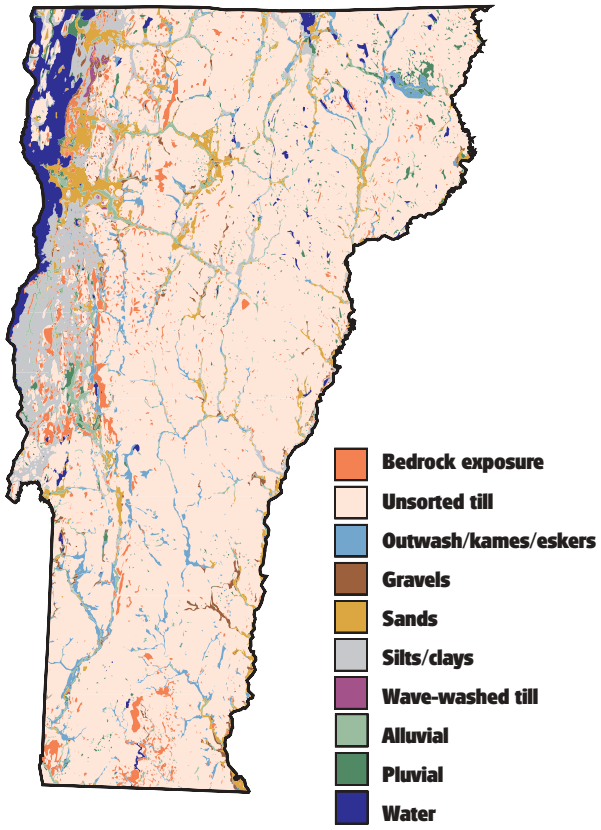
Surficial Geology

Vermont's surficial, or surface geology, is defined by the sands, gravels, clays, peats, and other deposits that landed on top of the bedrock as a result of both glacial activity and postglacial events (like flooding) that continue today. Together, bedrock and surficial geology have a profound influence on the soils in which Vermont's plants grow. In some places, the surficial deposits can mask the effects of bedrock. For example, the deep clay soils of the Champlain Valley support a forest type – Valley Clayplain Forest – that was common prior to European settlement but is now quite rare because those soils have been converted to agricultural use. The sand deposits in Chittenden County and elsewhere support the very imperiled Pine-Oak-Heath Sandplain Forest community.



This diagram of the Mount Mansfield region, looking north from Stowe into Smugglers Notch, shows that there are many different landforms, from cliffs to sideslopes to valley bottoms. Understanding these landforms and how they are distributed can help us understand where plants and animals might live, and which natural communities might be where.

Surficial Geology of Vermont



Generalized surficial geology of Vermont. This map was developed for the Vermont Biodiversity Project from the existing map of surficial geology of the state (Doll 1970). One of the striking features of this map is that the greatest diversity of surficial deposits occurs in the lowlands and valleys, where postglacial lakes and rivers deposited a variety of sediments.

Topography

Topography is the fourth and final aspect of the physical landscape that influences the distribution of plants, animals, and natural communities. The soil on a ridgetop is shallow and dry, whereas the soil at the base of a slope tends to be deep, moist, and rich in organic matter and nutrients that have filtered down from upslope. In order to better understand topographic variations in Vermont, the Vermont Biodiversity Project developed a classification of landforms based on previous work done by The Nature Conservancy. Our classification identifies 16 kinds of landforms that we think influence the distribution of species and natural communities in Vermont.

Upland and Wetland Natural Communities

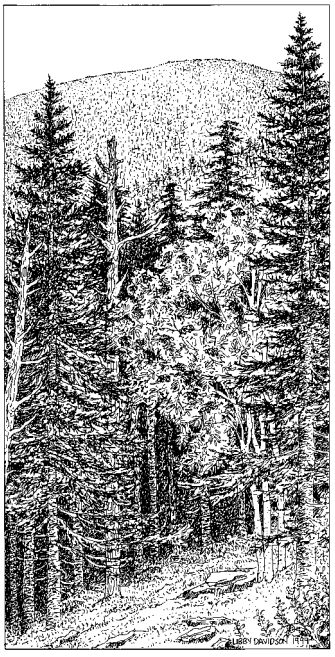
A natural community is an interacting assemblage of organisms, their physical environment, and the natural processes that affect them.

We recognize 80 upland and wetland natural community types in Vermont. Some examples are shown here, and all 80 are listed in Appendix D. The book *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont* (Thompson and Sorenson 2000) provides the framework for our ongoing analysis of upland and wetland communities.

Scale of Natural Communities

The concept of scale is crucially important in the application of the natural community concept to conservation.

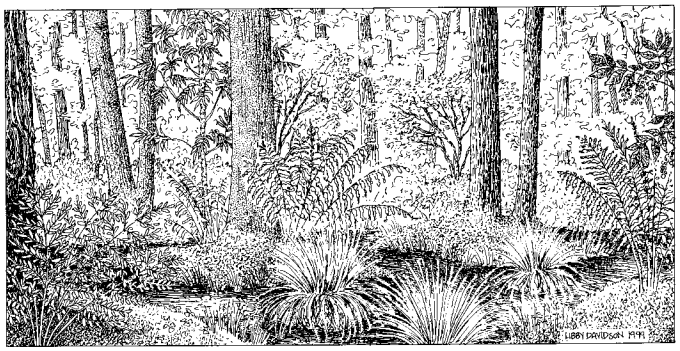
A few widespread communities dominate the landscape and form the background in which other smaller scale communities occur. We call these **matrix** communities. Matrix communities collectively occupy approximately three-quarters of the land area of Vermont. They generally occur in contiguous units of 1,000 to 100,000 acres. Matrix communities occur across a wide range of bedrock types, surface geology types, and topographic positions. Regional-scale processes such as climate typically determine their range and distribution. There are six matrix-forming natural communities in Vermont: Montane Spruce-Fir Forest, Lowland Spruce Fir Forest, Montane Yellow Birch-Red Spruce Forest, Red Spruce-Northern Hardwood Forest, and Northern Hardwood Forest. Valley Clayplain Forest was a matrix forest of the Champlain Valley prior to European settlement, but is now reduced to small, scattered forest fragments. Matrix communities can be conserved through a variety of techniques, from inclusion in core reserves to careful forestry practices that consider biodiversity and ecological integrity. The scale of conserved land should mirror the scale at which matrix communities occur on the landscape.



LIBBY DAVIDSON

► *Montane Spruce-Fir Forest is a matrix community in Vermont; it covers thousands of acres above 2,500 feet.*

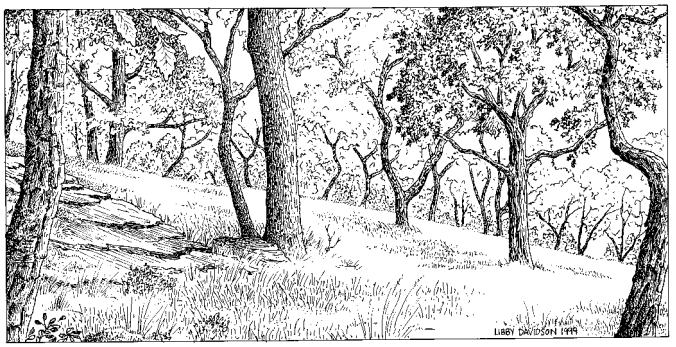
Large Patch communities are nested within matrix communities and collectively occupy approximately one fifth of the land area of Vermont. They occur as discrete units of about 50 to 1,000 acres. The boundaries of large patch communities are usually associated with a single dominant ecological process or environmental condition such as fire or hydrology. There are 17 natural community types that fall within this category, including White Pine-Red Oak-Black Oak Forest, Red Maple-Black Ash Swamp, and Silver Maple-Ostrich Fern Riverine Floodplain Forest. These areas are a critical component to wildlife richness. Protection of large patch communities requires knowledge of where they occur, and should be accomplished both through inclusion in nature reserves and through careful management.



LIBBY DAVIDSON

Red Maple-Black Ash Swamp, a large patch community, is a common wetland type in Vermont. It is found in all biophysical regions.

Small Patch communities are also nested within matrix communities. Together they occupy about one-twentieth of the land area of Vermont. These small, discrete communities are typically less than 50 acres, and some types are consistently under an acre in size. Small patch communities occur where several ecological processes and environmental conditions come together in a very precise way. These communities contain a large percentage of the region's biological diversity. There are 57 small patch community types, including Dry Oak Woodland, River Cobble Shore, Cold Air Talus Woodland, and Rich Fen. If a small patch community is not surrounded by natural communities with intact ecological processes, protection of these patch communities may require special management techniques that consider the ecological processes particular to that community.



LIBBY DAVIDSON

Dry Oak Woodland is a small patch community found on dry hilltops. These woodlands are usually less than 20 acres in size; they occur only on the warmest, most exposed south-facing slopes.

Elizabeth Thompson

Lake Sand Beaches and Sand Dunes are naturally rare in Vermont and are also threatened by development.

Rarity of Natural Communities

Natural communities are not equally distributed across the landscape – some are abundant, some are common, and some are rare. Rare communities are typically a high priority for conservation action, as are high quality examples of the more common communities. Understanding the reasons for a particular community's rarity can be helpful in developing protection strategies. Community rarity may be a natural condition or it may be the result of human activities. Rarity may also be a function of the area in which one chooses to look for the community.

Eric Sorenson

The bark of black gum is unmistakable. This tree is at the northern limit of its range in Vermont, so Red Maple-Black Gum Swamps are rare.

There are several reasons for rarity. In some cases, a dominant species of the rare community is at the edge of its climatic range. An example is Red Maple-Black Gum Swamp. Black gum is a prominent component of this swamp type, and in Vermont this tree reaches the northern limit of its extensive southeastern United States distribution. Red Maple-Black Gum Swamps are considered rare here, even though this community is more common to our south.

Some communities are rare because the specific physical environments in which they occur are rare. Serpentine Outcrops are found only on serpentine rock, which is limited primarily to the eastern side of the Green Mountains, where it is only exposed in several relatively small areas. Lake Sand Beaches and Sand Dunes are rare in Vermont because limited supplies of sand reach the windward shores of our larger lakes where wind and waves can move it to create the beaches and dunes fundamental to these two communities.

Catherine Paris

Serpentine Outcrop is a rare community because serpentine rock itself is rare. The state-threatened Green Mountain Maidenhair fern grows here.

Human activity is another cause of community rarity. There are several community types for which human disturbance has resulted in the destruction or alteration of most of the physical environment in which the community occurred. Examples include Valley Clayplain Forest, Pine-Oak-Heath Sandplain Forest, and all three types of Riverine Floodplain Forests. All these communities occur on soils or in landscape settings that are highly productive for agriculture or desirable for development. Community restoration will be necessary to re-establish and protect them.

BRETT ENGSTROM

Pine-Oak Heath Sandplain Forests are rare because the land on which they occur has been developed, and because the natural fires that maintain them have been suppressed. Here, managers use prescribed fire to restore one of the last remnants of this community.

ERIC SORENSON

River Valleys provide some of the best agricultural soils in Vermont, so Floodplain Forests are now limited mostly to narrow strips along rivers.

Another reason for community rarity is the alteration of critical ecological processes that support or maintain a particular community. In these cases, innate rarity and human-caused alterations of natural processes conspire to make them especially rare and threatened. Lake Sand Dunes are rare in Vermont not only because there are few locations with abundant sand on the windward exposure of our larger lakes, but also because development in the vicinity of existing dunes has altered wind patterns and the accumulation of sand into dunes. Our most dramatic example of rarity caused by human alteration of ecological processes is the Pine-Oak-Heath Sandplain Forest. This community is rare both because of habitat fragmentation and development and because natural fires have been suppressed. Of the original 15,000 acres of this community in Vermont, only 650 acres remain.

All of Vermont's natural community types have been assigned ranks that reflect their relative rarity. These ranks range from "extremely rare" (fewer than five high quality occurrences) to "common and widespread" (good examples are easily found). Pitch Pine-Oak-Heath Rocky Summit is an example of an extremely rare community type. Alder Swamp is a common and widespread community type. The ranks are given in Appendix D.

Aquatic Natural Communities

Vermont's freshwater aquatic ecosystems – its rivers, streams, lakes, and ponds – are home to a great deal of biological diversity and some of Vermont's most imperiled species. The Vermont Department of Environmental Conservation keeps information on 91 fish species, dozens of plant species, and hundreds of invertebrate species that inhabit freshwater systems. In addition to these, there are uncounted numbers of freshwater algae and microorganisms that are crucial to the functioning of these systems. Many of Vermont's rare animals and plants are found in aquatic systems.

CHRIS FICHTEL

The Brook Floater is a rare mussel known only from the West River in Vermont.

Freshwater systems not only provide habitat for a diversity of species, they also provide the water we drink, power for our electrical systems, and abundant recreational opportunities. Yet they are threatened by decreased water quality and by the invasion of non-native species like zebra mussels and Eurasian watermilfoil.

In order to assess the biodiversity found in aquatic systems, the Vermont Biodiversity Project commissioned a new classification of aquatic communities. A group of scientists identified 33 aquatic community assemblages (Appendix C) of vascular plants, macroinvertebrates, and fish which are found in either standing waters (lakes and ponds) or running waters (rivers and streams).

ELIZABETH THOMPSON

Stratton Pond is a Dystrophic Lake, meaning it is acidic and has brown water resulting from tannic acids. This aquatic community tends to have very few species of plants and fish.

Cold, headwater mountain stream. Invertebrates like caddisflies and mayflies are common in such streams. ►

ELIZABETH THOMPSON

PHOTO INSET: JOHN HALL

Vernal Pools provide habitat for many species of amphibians, like this spotted salamander.

Native Species

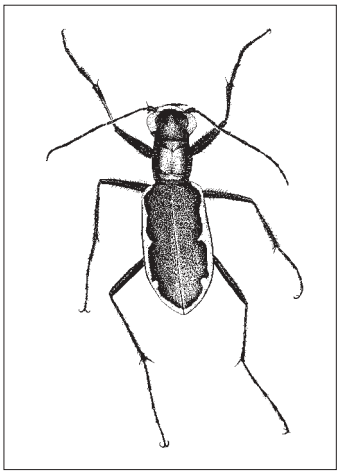
Animals, Plants, and other Organisms

We've made the case that conserving biological diversity requires protecting whole ecosystems with core reserves, stewardship lands, and connecting lands that contain a diversity of physical features and natural communities. This is the most efficient way of ensuring that all species will be protected and will remain viable for a long time.

But even if we protect large, diverse areas and provide habitat connections, some species, the most rare and vulnerable, will fall through the cracks. So we still need to keep track of individual species and to monitor their health.

How many species are there?

Scientists estimate that there are between 24,000 and 43,000 species of higher plants, algae, fungi, lichens, invertebrates, and vertebrate animals in Vermont. For the smaller organisms, like protists, bacteria, and viruses, our knowledge is very incomplete, so these are not included in our total.



Jonathan Leonard

The rare cobblestone tiger beetle is found on River Cobble Shores.

A few interesting statistics can help us understand why we need to pay attention to particular species.

Of the 2,000 or so vascular plants in Vermont (this includes all trees, flowering plants, ferns, and clubmosses), nearly one-quarter are imported from elsewhere in the world – many from Europe and Asia. Some of these imports are attractive and even beneficial, gracing our roadsides with color and providing food for birds and butterflies. But other imports can become very invasive, moving into natural areas and replacing native species.

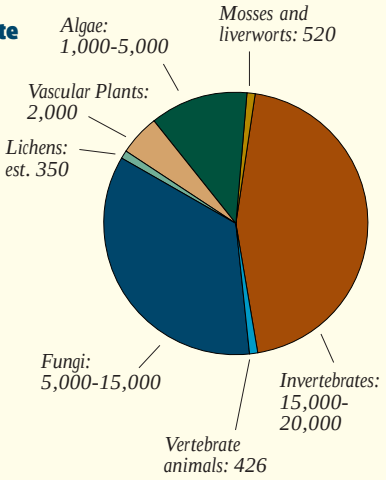
Of Vermont's 1,500 species of native vascular plants, 95 are known only from historical records, meaning they have not been seen in Vermont in more than 25 years, in many cases because their habitats have been altered by humans. Another 350 are considered rare, threatened, or endangered.

Several vertebrate animals are now gone from Vermont and 99 vertebrate species are considered rare, threatened, or endangered. In addition, 81 invertebrates (insects, mussels, crayfish, and the like) are considered to be rare, threatened, or endangered.

The threats to these species are varied, from habitat destruction and forest fragmentation to climate change. And the needs of species vary widely.

Biodiversity in Vermont

Scientists estimate that there are between 24,000 and 43,000 species of higher plants, algae, fungi, lichens, invertebrates, and vertebrate animals in Vermont. Nearly half of these are invertebrates such as insects, crayfish, and mussels.



Wolves need large areas of contiguous forested habitat in which to feed and breed, and are especially shy and vulnerable to human disturbance. Large expanses of core reserves and stewardship lands will be vital to their return to Vermont.

The cobblestone tiger beetle, on the other hand, needs very specialized habitat – River Cobble Shores – which naturally occurs in small patches. For this animal, we need to protect the specific places where it is known to live, or where it might live if it had a chance to get there. We also need to protect or restore the natural processes of flooding and sediment movement along the rivers where it lives.

Steve Faccio

Bicknell's thrush breeds in Vermont's high-elevation forests and spends its winters in the Caribbean. Biologists from the Dominican Republic are working with Vermonters to understand and protect this species.

For songbirds that breed in Vermont but migrate annually to the tropics, we must consider both summer and winter habitats. Many of these species need large areas of contiguous forest habitat here in Vermont to breed successfully. Reducing forest fragmentation can help these birds. But each species has a different migratory pattern. Some winter in Central America, others travel as far as the southern tip of South America. If these species are to survive, we need to consider their wintering areas as well as their Vermont breeding grounds. This will require cooperation with organizations and governments far from Vermont.

Putting it All Together

Biophysical Regions of Vermont

When we look at the physical landscape, the upland, wetland, and aquatic natural communities, and the native species of Vermont, some patterns emerge.

The patterns can be described in terms of Vermont's eight biophysical regions. Each of the eight regions has a unique combination of climate, geology, topography, and vegetation. These regions were identified and mapped for the Vermont Biodiversity Project in conjunction with national ecoregional mapping efforts, and they formed the basis for our assessment of biodiversity in Vermont.

The regions are shown below. The shaded relief map makes it clear that each region has a characteristic topography.

All the regions, of course, extend well beyond Vermont's borders. The Champlain Valley extends northward and westward, joining the St. Lawrence Valley. The Green Mountains extend northward into Quebec and southward into Massachusetts and Connecticut. The Taconic Mountains extend south and west into New York, Massachusetts, and Connecticut. The Northern Vermont Piedmont extends into Quebec, while the Southern Vermont Piedmont extends southward with the Connecticut River Valley. And the Northeastern Highlands is a small part of a much larger boreal region that extends to the north and east. Vermont's biophysical regions thus fit into larger scale ecoregional planning efforts that take broad biodiversity patterns into account.

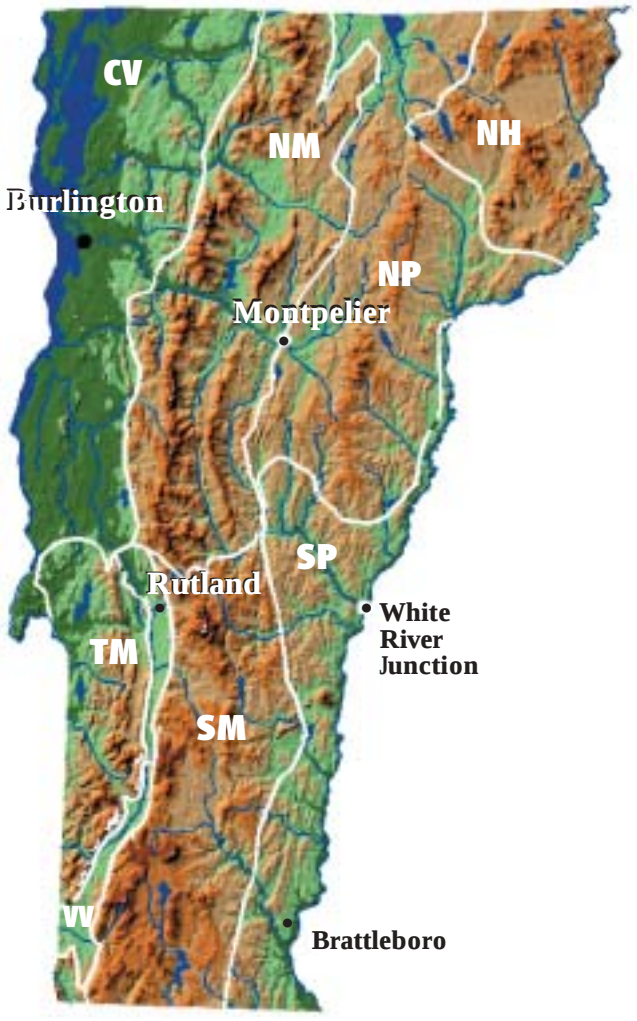
On the following two pages, the eight regions are described in terms of their geology, topography, climate, natural vegetation, and conservation status. Note that there are dramatic differences among regions in the amount of land conserved.

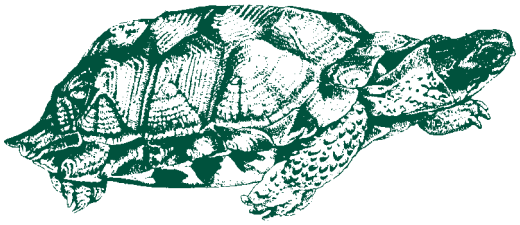
Biophysical Regions of Vermont

Key:

- **CV:** Champlain Valley
- **TM:** Taconic Mountains
- **VV:** Vermont Valley
- **NM:** Northern Green Mountains
- **SM:** Southern Green Mountains
- **NP:** Northern Vermont Piedmont
- **SP:** Southern Vermont Piedmont
- **NH:** Northeastern Highlands

Adapted from Girton, 1998





Biophysical Regions of Vermont

Northeastern Highlands

Geology: Acidic granite with some areas of calcareous rock

Topography: Hilly with large lowland areas

Climate: Cold with high rainfall

Natural Vegetation: Northern hardwoods, spruce and fir, large softwood swamps and bogs

Conservation Status: Forty-three percent of the region is conserved, in the Conte National Wildlife Refuge, West Mountain Wildlife Management Area, and private stewardship lands. Conserved lands protect Lowland Spruce-Fir Forest, Northern Hardwood Forest, Dwarf Shrub Bog, Dystrophic Ponds, and many other features.

Elizabeth Thompson

Northern Vermont Piedmont

Geology: Dominated by calcareous rocks in the uplands, with sand and gravel deposits in the river valleys

Topography: Rolling foothills and a major river valley

Climate: Cool with average rainfall

Natural Vegetation: Northern hardwoods, rich in many areas; small wetlands, lakes, and ponds

Conservation Status: Eight percent of the region is conserved. Groton State Forest is one of the largest areas of conserved lands, protecting Northern Hardwood Forests, Boreal Outcrops, Dwarf Shrub Bogs, and many other features. Smaller holdings in the regions protect Rich Fens, Northern White Cedar Swamps, and other communities and species.

Elizabeth Thompson

Elizabeth Thompson

Southern Vermont Piedmont

Geology: A combination of calcareous and non-calcareous rocks, with sand and gravel deposits in the valleys

Topography: Rolling foothills and major river valley

Climate: Warm and dry in the southeast; average in the north and west

Natural Vegetation: Oak and northern hardwoods; some pine in Connecticut River Valley

Conservation Status: Seven percent of the region is conserved, mostly in smaller holdings like Coolidge State Forest in Plymouth, Miller Town Forest in Vernon, The Nature Conservancy's Black Mountain Preserve in Dummerston, and several farms conserved by the Vermont Land Trust.

Southern Green Mountains ►

Elizabeth Thompson

Geology: Dominated by ancient rocks which are acidic

Topography: Broad high plateau with a few prominent peaks

Climate: Cool, high rainfall

Natural Vegetation: Northern hardwoods, spruce and fir at high elevations and cooler valleys; numerous lakes, ponds, and wetlands

Conservation Status: Thirty-three percent of the region is conserved, mostly in the Green Mountain National Forest. Conserved lands include Montane Spruce-Fir Forest, Northern Hardwood Forest, and many high-elevation lakes and ponds.

Northern Green Mountains

Geology: Dominated by acidic to neutral rocks, with small surficial deposits in valleys

Topography: Mountains and foothills

Climate: Cool; high precipitation at high elevations

Natural Vegetation: Northern hardwoods, spruce and fir, small alpine meadows

Peter Zika

Conservation Status: Twenty-six percent of the region is conserved, in the Green Mountain National Forest, Camels Hump and Mount Mansfield State Forests, the Long Trail, and many private holdings.

Champlain Valley

Geology: Uplands are dominated by calcareous rock, while the lowlands are covered with clay or sand.

Topography: Flat to rolling

Climate: Warm, lowest precipitation in the state

Natural Vegetation: Oaks and northern hardwoods, limestone communities, large lakeside wetlands, clayplain forests and sandplain forests

Elizabeth Thompson

Conservation Status: Nine percent of the region is conserved, in small holdings such as farms conserved by the Vermont Land Trust, shorelines conserved by the Lake Champlain Land Trust and Winooski Valley Park District, a number of Wildlife Management Areas, and preserves of The Nature Conservancy.

Elizabeth Thompson

Taconic Mountains

Geology: Slate, schist and phyllite, some marble and limestone

Topography: Hilly, dramatic

Climate: Warm, low rainfall

Natural Vegetation: Oaks and northern hardwoods, spruce and fir at highest elevations

Conservation Status: Ten percent of the region is conserved, including easements on private conservation lands like the Equinox Preservation Trust and Merck Forest, and preserves of The Nature Conservancy at High Pond and North Pawlet Hills.

Vermont Valley

Geology: Marble and limestone with karst features; significant postglacial features on valley sides

Topography: Flat to rolling, with streams, wetlands, and dry terraces

Climate: Warm, average rainfall

Natural Vegetation: Red maple swamps, seeps, fens, oak-pine-northern hardwood forests

Eric Sorenson

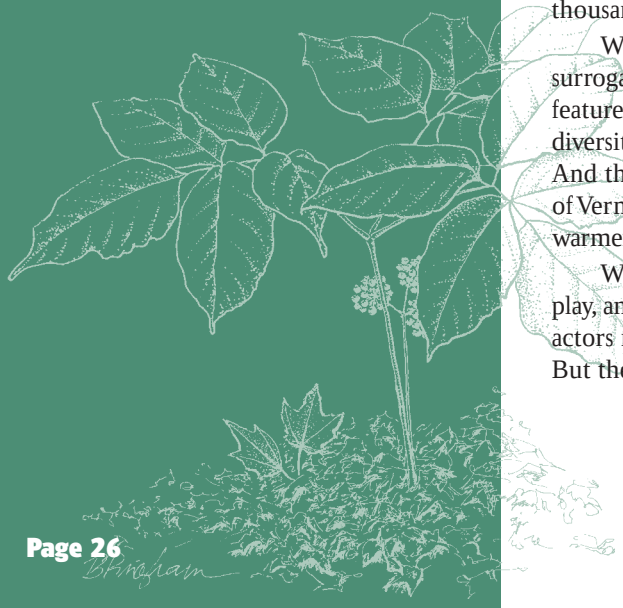
Conservation Status: About ten percent of the region is conserved (exact data are not available), including South Stream Wildlife Management Area in Pownal, Otter Creek Wildlife Management Area in Danby, and many farmland easements.

Chapter 5.

Biodiversity Conservation in Vermont:

Setting conservation goals and mapping biodiversity

Using a three-tiered approach, we believe we can identify a large percentage of the state's biological diversity and find good opportunities to protect it.



The vision of the Vermont Biodiversity Project is to maintain ecological integrity in a manner that ensures the long-term viability of all native species and natural community types in Vermont within their natural ranges.

We evaluated the conservation of biodiversity in Vermont by:

1. **Setting conservation goals**
2. **Mapping biodiversity**
3. **Evaluating conservation successes**

This chapter explains the first two steps, setting conservation goals and mapping biodiversity. Chapter 6 explains the third step, evaluating conservation successes.

The vision of the Vermont Biodiversity Project identifies two levels of biodiversity, the *species* level and the *community* level. We have added a third level, *enduring features*, to our analyses. Let us explain why.

At the species level, we know quite a bit about some species, like black bear and peregrine falcon, but for other species there are gaps in our knowledge. We know very little, for example, about most invertebrates, fungi, and bacteria, yet all these are crucial to the healthy functioning of our ecosystems.

Since we know these organisms are important but cannot protect them species by species, we use *surrogates*, or other measures that can substitute for species-specific knowledge. One of these surrogates is the natural community. Conservation biologists estimate that if we protected multiple viable examples of all natural communities, we would likely protect eighty to ninety percent of all native species in the process. This assertion has not been proven, but it makes good intuitive sense and most conservation practitioners embrace it.

But protecting multiple examples of all natural communities may be difficult for two reasons: **1)** we do not yet have complete information on the location and distribution of natural communities statewide, and **2)** natural communities are dynamic systems that change over time. Records of vegetation change over thousands of years show that species assemblages do not remain the same – they change as the climate changes.

Global warming resulting from an increase in greenhouse gases will have a major influence on our ecosystems over the coming centuries. Right now, red spruce and balsam fir occur together in a community called spruce-fir forest, but in the next century we may see red spruce occurring more commonly with red oak, a species that is expected to become more abundant in Vermont as the climate warms. As more time passes, red spruce may disappear from Vermont altogether. We do not know how natural communities will change. What we do know is that the physical landscape that supports species and natural communities will not change very much. The bedrock, landforms, and most of the surface deposits in Vermont were produced more than 10,000 years ago, and will remain relatively stable over the next several thousand years.

With this in mind, we use *enduring features* of the physical landscape as another surrogate for biological diversity. We assume that if we protect a diversity of physical features over large areas, then we will have some assurance of protecting the full diversity of natural communities of the state, regardless of how they change over time. And this should assure us that we will protect a large percentage of the native species of Vermont, including southern species that may migrate into the state as it becomes warmer.

We can think of the physical landscape as a stage, the natural communities as a play, and the animals and plants as the actors in the play. From scene to scene the actors move in and out, and at the end of its run the play is replaced by another one. But the stage will remain in place for many years.

The Vermont Biodiversity Project assessed biodiversity at three levels:

Enduring features, the "stage," or physical features of the landscape that will survive centuries of climate change;

Natural communities, the "plays," or assemblages of species and their physical environments that occur together today; and

Native species, the individual "actors" which make up natural communities.

Using this three-tiered approach, we believe we can identify a large percentage of the state's biological diversity and find good opportunities to protect it.

We set specific conservation goals at each of these three levels. These goals will help us achieve the vision of the Vermont Biodiversity Project. These goals are recommendations of the Vermont Biodiversity Project and do not represent policies of the State of Vermont, Federal Government, or other partners in the project.

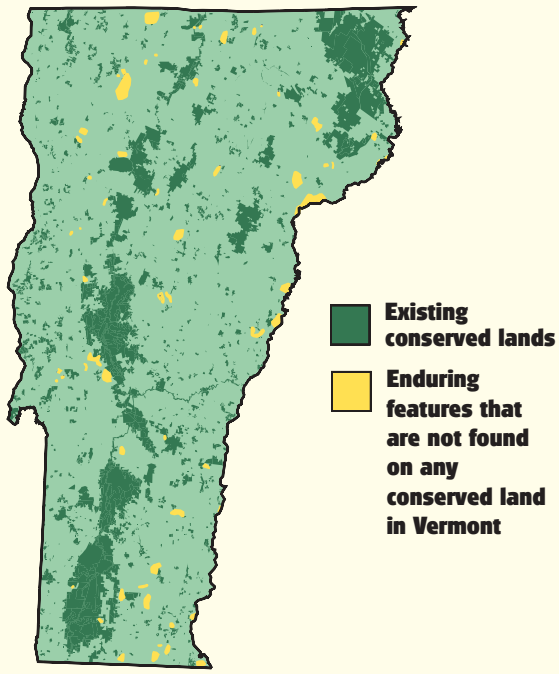
The three levels of analysis:

Enduring Features

► **Conservation Goal:** To ensure that the full diversity of Vermont's enduring physical features is protected in such a way that the natural communities and species that use those physical features, now and in the future, will be protected and remain viable over time.

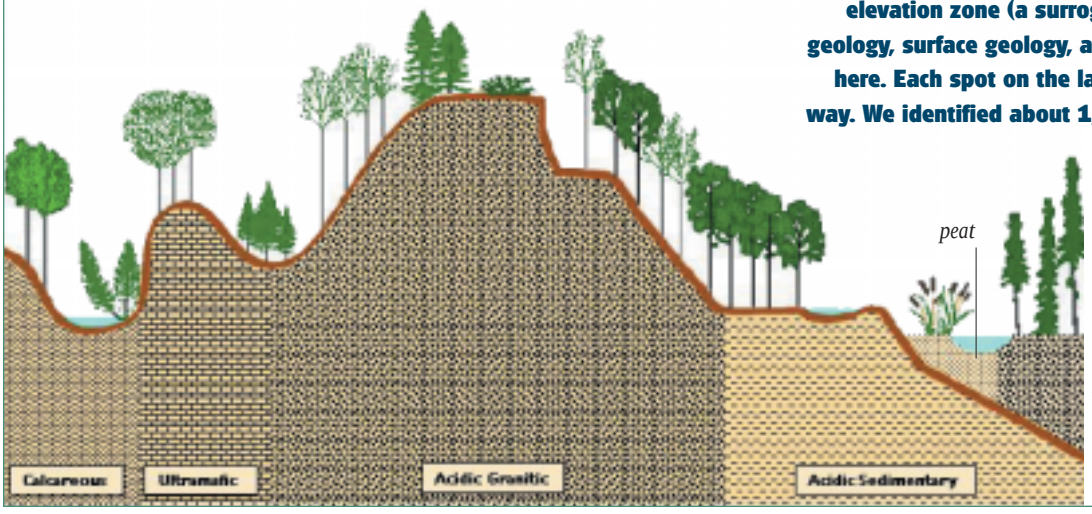
We assessed four components of the enduring landscape, **climate, bedrock geology, surface geology,** and **topography.** See Chapter 4 for an explanation of these four components. We looked at these in each of Vermont's eight biophysical regions, combining the four components into *Landscape Diversity Units.*

Complementary Landscapes



Once we had identified these units and classified all of Vermont using them, we looked at the conserved lands in the state and did an analysis, by biophysical region, to find the Landscape Diversity Units in each region that were not found on conserved land. We then delineated the areas that most efficiently captured those "missing" Landscape Diversity Units. We call these places "Complementary Landscapes."

Landscape Diversity Units



Landscape Diversity Units are defined based on elevation zone (a surrogate for climate), bedrock geology, surface geology, and topography, as shown here. Each spot on the landscape is classified this way. We identified about 1,400 Landscape Diversity Units, or unique combinations of elevation, bedrock type, surface geology type, and landform, throughout Vermont.

Natural Communities

Upland and Wetland Natural Communities

► **Conservation Goal:** To ensure that multiple viable examples of all 80 upland and wetland natural community types are protected in an ecological reserve system, at the appropriate scale, in each biophysical region in which the community naturally occurs.

With this goal in mind, we set more specific goals for each natural community type, depending on its rarity (S rank: see box), its geographical distribution, and its normal size. The Vermont Nongame and Natural Heritage Program has records of about 1200 significant examples of upland and wetland natural communities. We used this information to find out how well we have done in achieving our goals.

Specific goals of the Vermont Biodiversity Project are as follows (for definitions of ranks, see Appendix D):

Extremely rare communities (S1): Protect all occurrences in core reserves or natural areas.

Very rare communities (S2): Protect at least three viable examples in each biophysical region in which the community naturally occurs, and at least 25 percent of the total number of occurrences statewide, in core reserves or natural areas. Encourage careful stewardship of remaining examples.

Uncommon communities (S3): Protect at least three viable examples in each biophysical region in which the community naturally occurs, and at least 10 percent of the total number of occurrences statewide, in core reserves or natural areas. Encourage careful stewardship of remaining examples.

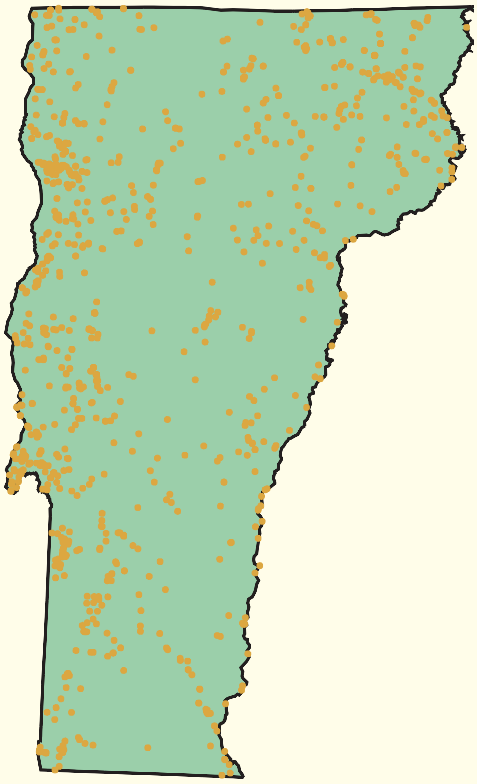
Widespread and common communities (S4 and S5): Protect at least three viable examples in each biophysical region in which the community naturally occurs, and at least 10 percent of the total number of occurrences statewide, in core reserves or natural areas. Encourage careful stewardship of remaining examples.

Exception: For the large dominant communities – what we call matrix communities – the goal is to protect one viable example per biophysical region in which it naturally occurs, in a core reserve or natural area. This one example will need to be large enough (tens of thousands of acres in some cases) to accommodate natural disturbance processes and the needs of wide-ranging mammals and forest-interior species. In some cases (as for Valley Clayplain Forest), major restoration efforts will be necessary in order to meet this goal, and we may need to protect multiple small sites rather than one large site.

Aquatic Natural Communities

► **Conservation Goal:** To protect all priority aquatic features from degradation and changes in species composition through water quality protection and other means, and to encourage careful stewardship of all remaining aquatic features.

Significant Natural Communities



Priority Aquatic Features

The same group of scientists who developed the classification of Vermont's aquatic communities also identified specific lakes, ponds, river reaches, and stream reaches that represent the best examples of each of the aquatic community types they described.

The lower Connecticut River is a priority aquatic feature because it hosts migrating Atlantic salmon and American shad as well as rare native mussels.

These areas represent high-quality habitat for many aquatic plants, invertebrates, and fish. Reptiles and amphibians were included in the aquatic community classification, but no specific areas were identified to protect these animals. Habitat assessments for these species should be done on a site-specific basis.

All aquatic systems, whether or not they are shown here as Priority Aquatic Features, should be protected from water quality degradation and the introduction of nuisance aquatic species. The Vermont Department of Environmental Conservation, Water Quality Division, can provide guidance on protection of aquatic systems.

Native Species

Rare Native Species

► **Conservation Goal:** To protect all viable occurrences of known rare plant and animal populations in Vermont.

The Vermont Nongame and Natural Heritage Program keeps track of 653 rare plant and animal species and has recorded specific locations for most of these.

The Vermont Biodiversity Project recommends the following conservation goals for rare species:

Globally rare (G1-G3) species:

G1 Species: Protect all occurrences (examples are Champlain beach grass, Jesup's milk-vetch, dwarf wedge mussel, and copper redhorse) in core reserves, natural areas, or stewardship lands managed for the species of interest.

G2 Species: Protect all occurrences (examples are Green Mountain Maidenhair fern, marcescent sandwort, Indiana bat, cobblestone tiger beetle) in core reserves, natural areas, or stewardship lands.

G3/S1 Species: Protect all viable (A-C rank occurrences) in core reserves, natural areas, or stewardship lands.

G3/S2 Species: Protect all A- and B- rank populations, and also protect one viable occurrence (A-C rank) in each biophysical region in which it occurs, in core reserves, natural areas, or stewardship lands.

G3/S3 Species: Protect all A-rank occurrences. If there are no A-rank occurrences, protect at least the best example in the state in core reserves, natural areas, or stewardship lands.

Rarity Ranks for Native Species

The state of Vermont ranks each native species in two ways, by global rarity (G rank) and by state rarity (S rank). The ranks are assigned using the following guidelines:

G1: Critically imperiled globally (on the order of 1-5 occurrences worldwide)

G2: Endangered globally (ca. 6-20 occurrences worldwide)

G3: Threatened globally: rare and/or local

G4: Apparently secure globally, though perhaps locally rare

G5: Demonstrably secure globally

S1: Very rare, generally 1 to 5 occurrences believed to be extant and/or some factor(s) making it especially vulnerable to extirpation from the state

S2: Rare, generally 6 to 20 occurrences believed to be extant and/or some factor(s) making it vulnerable to extirpation in the state

S3: Uncommon, believed to be more than 20 occurrences and/or there is some threat to it in the state

S4: Apparently secure in state, often with more than 100 occurrences

S5: Demonstrably secure in state

Occurrence rank: Each occurrence of a rare species (that is each distinct population or breeding group) is given a quality rank based on its size, vigor, and viability. Ranks are assigned using the following guidelines:

A: Excellent: population is clearly large enough and healthy enough to remain viable over time

B: Good: population is large and healthy, but may be vulnerable to changes over time

C: Fair: population appears viable at present but there are significant threats to its long-term viability

D: Poor: population is small or vulnerable, and is not expected to remain viable over time

E: Extant: population is known to exist at the site, but its condition is unknown

State rare (G4-G5, S1-S2) species

S1 and S2 Species: Protect all A- and B-rank occurrences, with at least one viable occurrence in each biophysical region in which the species occurs, in core reserves, natural areas, or stewardship lands.

Protection of these populations can be accomplished in a variety of ways. Some species, or some populations, may require protection in strictly managed core reserves or natural areas; others may be adequately protected in stewardship lands where some resource management (such as timber extraction) takes place.

Some species require relatively small areas of suitable habitat, while others require large, unfragmented areas. Some species (most plants and many invertebrates, for example) do not move around very much, while others (many large mammals, many fish, and many birds) travel great distances to feed, breed, or find suitable winter habitat. The needs of each species should be evaluated individually, and protection methods should suit its biology.

Common Native Species

► **Conservation Goal:** To maintain ecological integrity in a manner that ensures the long-term viability of all native species within their natural ranges.

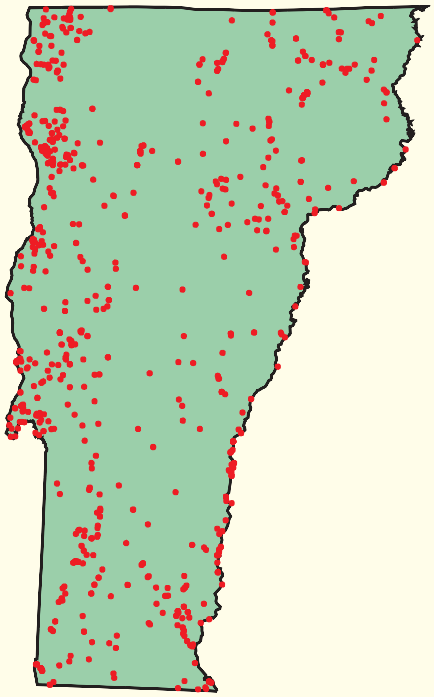
The goal for conserving common native species is a simple reiteration of the vision of the Vermont Biodiversity Project.

Achieving our conservation goal for common native species will require a variety of strategies. For most species groups (birds are a notable exception) we do not have good distribution data for common species. We must therefore rely on other conservation strategies to protect these species.

Some general guidelines follow:

- Large, unfragmented habitat patches are needed to protect habitat for forest-interior birds and other area-sensitive species.
- Connections between reserves and stewardship lands are necessary to ensure the movement and breeding success of many common species with large ranges.
- Roads act as barriers even to animals with small ranges, including many species of reptiles, amphibians, and invertebrates.
- Protecting multiple examples of all natural communities, including upland, wetland, and aquatic communities, will ensure that a large percentage of native species will be protected.
- Protecting the full range of physical habitats (enduring features) found in the state will ensure that a variety of habitats will be available over time, even in the face of global climate change.

Rare Plants & Animals



Native Species No Longer Found in Vermont

► **Conservation Goal:** To maintain ecological integrity in a manner that ensures the long-term viability of all native species within their natural ranges.

The goal for conserving extirpated native species (those that were once found here but are now gone) is the same as the goal for conserving common native species, and is a simple reiteration of the vision of the Vermont Biodiversity Project.

We are unable to establish more specific goals for extirpated species because we do not understand their habitat needs, nor do we know how they would respond to reintroduction here.

Among the species of concern are lynx, eastern timber wolf, and mountain lion (catamount or cougar). Although there have been several reliable reports of mountain lions in Vermont recently, the origin of the animals is unknown and biologists do not believe the species is naturally occurring or reproducing here.

Some very general guidelines for the restoration and conservation of these species follow:

- Large reserves are better than small reserves.
- Stewardship lands will be crucial to the success of these species in breeding and finding food.
- Connections between reserves will allow these species to return to suitable habitats in Vermont, to move about the landscape, and to maintain populations that are large enough to be viable over time.

Chapter 6.

Biodiversity Conservation in Vermont:

Evaluating Success

The data show that 19.2 percent of the state land is conserved, either by federal, state, or municipal agencies, or by private conservation groups.

We evaluated the conservation of biodiversity in Vermont by:
1. Setting conservation goals
2. Mapping biodiversity
3. Evaluating conservation successes

Chapter 5 explains the first two steps, setting conservation goals and mapping biodiversity. This chapter explains the third step, evaluating conservation successes.

Achieving the vision of the Vermont Biodiversity Project is something that all Vermonters can participate in. From protecting water quality by using vegetated stream buffers, to donating conservation easements, to providing state and federal land managers with input on biodiversity management, there are many opportunities to help.

This chapter focuses on the contribution of legally conserved lands, or lands that are formally protected from development through conservation easements, ownership by a conservation organization, or ownership by a federal or state agency. We evaluate these lands because we know where they are. We do not have a good inventory of all the private efforts that are going on all over the state, so we can't evaluate them here.

We begin by looking at existing conserved lands, and then look back at our specific conservation goals to see how well the conserved lands help achieve them. We then summarize the outstanding need for biodiversity conservation in Vermont.

Conserved Lands

The Vermont Biodiversity Project and its cooperators have developed a database of conserved lands in Vermont, including state, federal, municipal, and private lands. The database is updated regularly as new lands are conserved.

Each parcel of land in the database is tagged with specific information, including ownership and protection class as defined by the National Gap Analysis Program. Protection classes are defined as follows: Class 1 lands are managed in their natural state such that natural disturbance regimes are allowed to occur and natural resource extraction is prohibited; Class 2 lands are managed for their natural values but may receive uses that degrade the quality of natural communities present; Class 3 lands are protected from permanent conversion but are subject to extractive uses; and Class 4 lands are managed in ways that may preclude natural cover and the presence of native plant and animal assemblages.

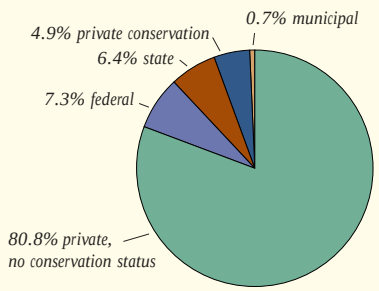
The data show that 19.2 percent of the state is conserved, either by federal, state or municipal agencies, or by private conservation groups.

The data also show that a very small percentage of conserved land in Vermont is protected at the highest level (Class 1 or Class 2). Most conserved land in the state allows for low intensity resource extraction, but is protected from permanent conversion to non-natural cover.

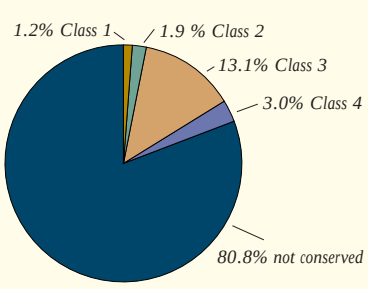
In the following pages, we evaluate how well these conserved lands fulfill our conservation goals.

Conserved Land in Vermont

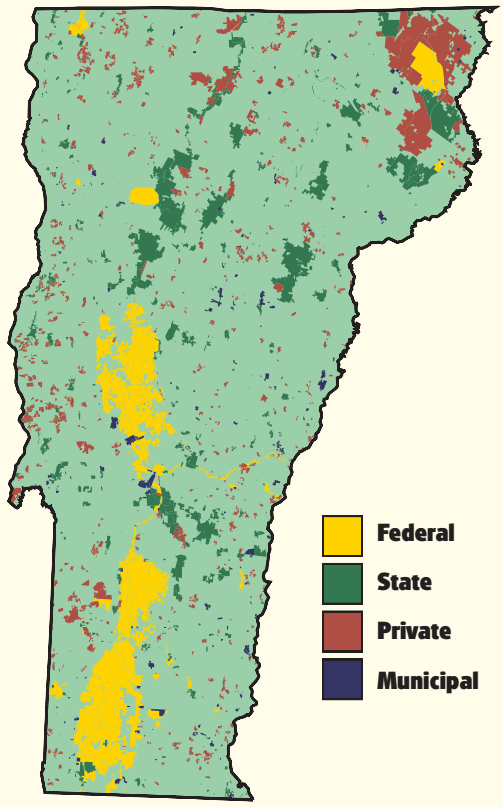
Percentage of state in six ownership classes.



Percentage of state in each of the four GAP classes plus unconserved land.

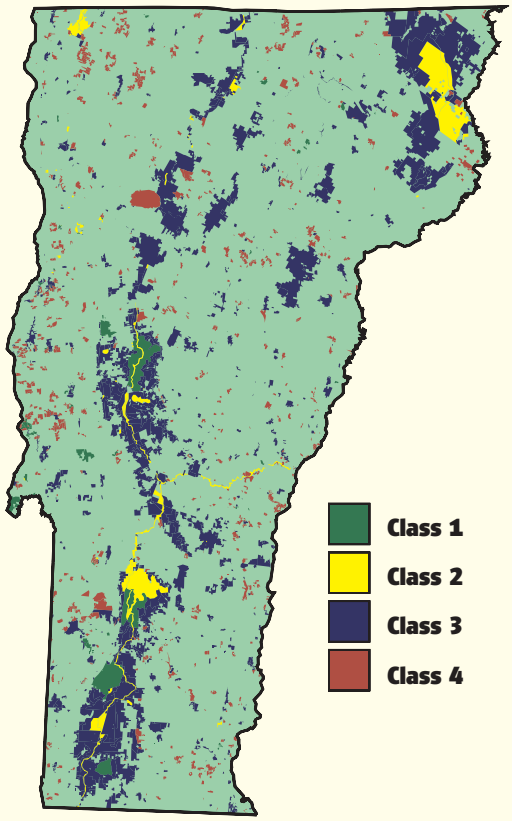


Conserved Lands by Owner



Federal lands include the Green Mountain National Forest, two national wildlife refuges, a national park, and military lands. State lands include state forests, state parks, wildlife management areas, and fishing access areas. Private conserved lands include those protected by The Nature Conservancy, Vermont Land Trust, and local and regional land trusts. Municipal lands are town forests, watershed areas, and town parks.

Conserved Lands by Protection Class



Class 1 lands are managed in their natural state such that natural disturbance regimes are allowed to occur and natural resource extraction is prohibited. Class 2 lands are managed for their natural values but may receive uses that degrade the quality of natural communities present. Class 3 lands are protected from permanent conversion but are subject to extractive uses. Class 4 lands are managed in ways that may preclude natural cover and the presence of native plant and animal assemblages.

The Three Levels of Analysis

Enduring Features

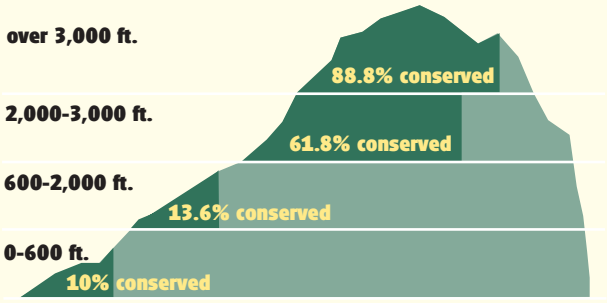
► **Conservation Goal:** To ensure that the full diversity of Vermont's enduring physical features, represented in the same proportions in which they are naturally found, is protected in such a way that the natural communities and species that use those physical features, now and in the future, will be protected and remain viable over time.

► **Successes:** Many of the landscape diversity units identified by the Vermont Biodiversity Project are found on conserved land. The highest elevations in Vermont are well protected. The Northeastern Highlands, Northern Green Mountains, and southern Green Mountains all have large areas of conserved land.

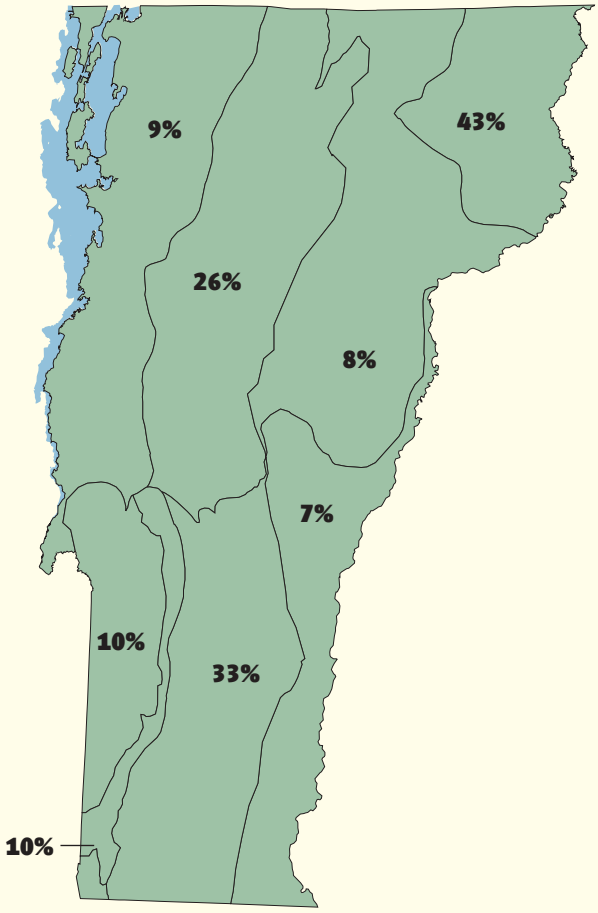
► **Needs:** The map of "Complementary Landscapes" shown in Chapter 5 identifies groups of Landscape Diversity Units that are not found on conserved lands. These should be protected. The lowest elevation zones in Vermont are not well conserved. More conservation attention should be paid to these low elevation areas to ensure that their physical features are represented. Certain biophysical regions, along with their unique combinations of climate, geology, and vegetation, are poorly represented in conserved lands. These include the Champlain Valley, Vermont Valley, and Northern and Southern Vermont Piedmont. More conservation attention should be paid to these biophysical regions.

Conserved Lands by Elevation

Percentage of each elevation zone in conserved lands. Much of Vermont's biodiversity is found at low elevations, but the lowest elevations are the least protected.



Conserved Lands by Biophysical Region



Natural Communities

Upland and Wetland Natural Communities

► **Conservation Goal:** To ensure that multiple viable examples of all 80 upland and wetland natural community types are protected in an ecological reserve system, at the appropriate scale, in each biophysical region in which the community naturally occurs.

► **Successes:** About 300 sites for significant natural communities (25 percent of the total number known) are found on conserved lands. A few communities that are well represented on conserved lands are Alpine Meadow, Subalpine Krummholz, Northern Hardwood Forest, Lowland Spruce-Fir Forest, Montane Spruce-Fir Forest, Boreal Calcareous Cliff, Dwarf Shrub Bog, Rich Fen, and Cold Air Talus Woodland. In addition, all wetlands, regardless of ownership, are protected by the Vermont Wetland Rules, which require permits for uses other than agriculture and forestry. Ongoing inventory and mapping of natural communities on all state land will identify more conserved examples of natural communities.

► **Needs:** More than 900 of the known sites for significant natural communities (75 percent of the total) are not conserved. For most communities the specific goals stated in Chapter 5 have not been met, either because the community is not protected in core reserves, or is not protected at the appropriate scale, or is not protected in all the biophysical regions where it normally occurs. One notable gap in conservation is Valley Clayplain Forest, once a matrix community in the Champlain Valley and now reduced to small fragments because of conversion of that landscape to agriculture. Successful protection of this natural community will require conservation of all remaining examples and restoration of some valley lands to forest. Another notable gap is Pine-Oak-Heath Sandplain Forest, much of which has been converted to housing and industrial developments. All remaining examples of this community should be conserved.

Aquatic Natural Communities

► **Conservation Goal:** To protect all priority aquatic features from degradation and changes in species composition through water quality protection and other means, and to encourage careful stewardship of all remaining aquatic features.

► **Successes:** Many Priority Aquatic Features are protected on conserved lands, where their watersheds are managed with aquatic resources in mind. These include some parts of the White River, the upper reaches of the West River, a number of smaller streams in the Southern Green Mountains, the upper reaches of Stevensville Brook in Mount Mansfield State Forest, the Nulhegan River, and the lower reaches of the Missisquoi River. Vermont's Agency of Natural Resources regulates water quality in a number of ways. The water quality in many areas has improved dramatically in recent decades as a result of good stewardship. Recently, a number of citizen groups have been established to protect watershed values.

► **Needs:** Some of the most important aquatic features of Vermont are highly threatened by water quality degradation and nuisance aquatic species. Aquatic systems are among the most vulnerable, the hardest to protect, and the least understood. We have much work to do in understanding and mitigating the effects of water pollution, streamflow alterations, and nuisance aquatic species.

Native Species

Rare Native Species

► **Conservation Goal:** To conserve all viable occurrences of known rare plant and animal populations in Vermont.

► **Successes:** More than 900 sites for rare plants and animals (29 percent of the total known) are found on conserved land. Among these are several nesting sites for peregrine falcon, habitat for spruce grouse, a breeding site for the cobblestone tiger beetle, a den site for eastern timber rattlesnake, summer habitat for Bicknell's thrush, and populations of calypso orchid, Champlain beachgrass, and Green Mountain maidenhair fern. Ongoing inventory of state lands will identify additional populations of rare species.

► **Needs:** Almost 2,300 sites for rare plants and animals (71 percent of the total known) are not on conserved land. Landowners voluntarily protect some of these, but in most cases the landowners are unaware of their existence. Many of these can be protected with simple actions like avoiding logging or mowing at the wrong time, but landowners need to know what they have and how best to conserve it.

Common Native Species

► **Conservation Goal:** To maintain ecological integrity in a manner that ensures the long-term viability of all native species within their natural ranges.

► **Successes:** Many common species are thriving in Vermont, with large, healthy populations. Red-winged blackbird, white-tailed deer, and smallmouth bass are animals we encounter commonly. Hophornbeam, hobblebush, and blue-bead lily are plants we can easily find in the woods.

► **Needs:** A number of species that are common today are in decline, or are in danger of going into decline. Butternut, a favorite tree in the Vermont woods, is declining rapidly due to an introduced fungal pathogen. Many common birds, like black-throated blue warbler and scarlet tanager, need large areas of interior forest to breed successfully. These large forest areas are becoming increasingly rare. The native mussels of Lake Champlain are in danger because of the recent arrival of the non-native zebra mussel, which covers and kills the natives. In order to address these problems, we need to protect large core reserves, natural areas, and stewardship lands in each biophysical region and we need to guard against the introduction of non-native species.

Native Species No Longer Found in Vermont

► **Conservation Goal:** To maintain ecological integrity in a manner that ensures the long-term viability of all native species within their natural ranges.

► **Successes:** 100 years ago, many of our native species had been greatly reduced or eliminated from Vermont due to the clearing of the land and overhunting. These include beaver, moose, white-tailed deer, black bear, and turkey, all of which have returned to Vermont in impressive numbers. Both the reforestation of the Northeast and active reintroduction efforts have benefited these and many other native species.

James Weaver/Cornell Laboratory of Ornithology

Peregrine Falcon

► **Needs:** Wolf, lynx, and mountain lion are three species that many citizens would like to see in Vermont again. If we are to see these species again, we will need to provide suitable habitat including large forested areas and connections among them, and we may need to reintroduce the species.

A summary of biodiversity conservation in Vermont

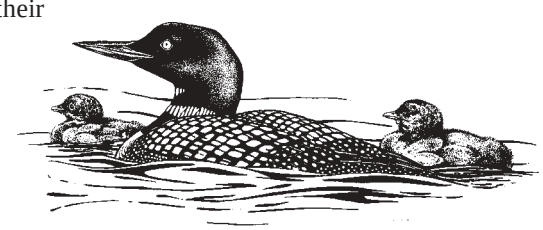
One simple way we can evaluate how well we have achieved our conservation goals is to look at a composite map of all Vermont's known biodiversity resources and compare it with existing conserved lands.

A quick scan of the map to the right makes two points: **1)** Vermont has some large areas of conserved land, including significant areas of wilderness. **2)** Many of the known biodiversity features are not found on conserved land – the lowlands are especially rich in biological diversity and are largely unprotected.

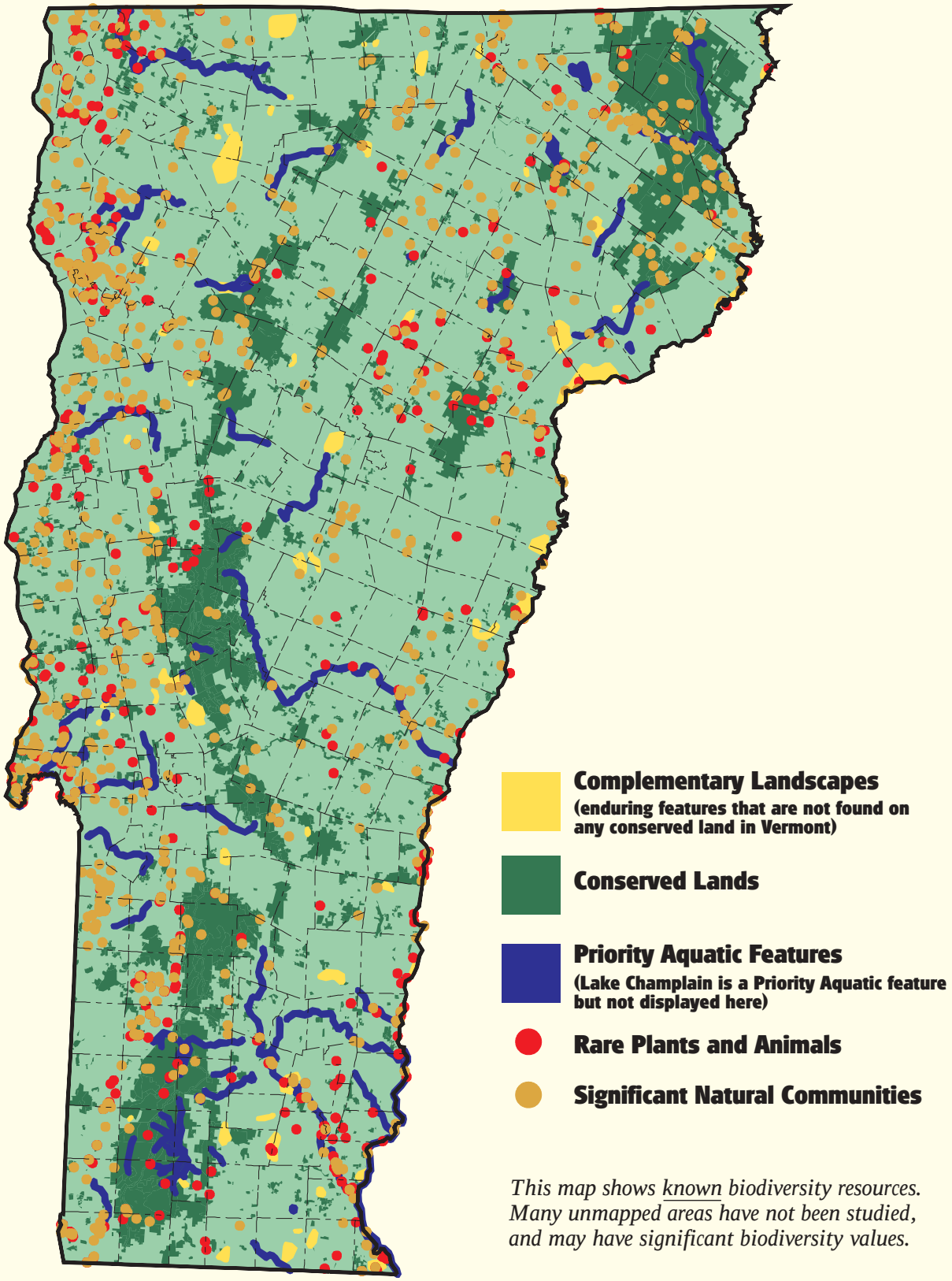
Vermonters can be proud of many conservation achievements, including the recent acquisition of the Champion International Paper Company lands, but there is still much work to do.

The Vermont Biodiversity Project recommends an ecological reserve system for Vermont that includes core reserves and natural areas where natural processes can work without human interference, stewardship lands where human activities compatible with natural processes can be pursued, and connecting lands to hold the reserve system together.

The Vermont Biodiversity Project encourages all Vermonters to contribute to the conservation of biodiversity by working to protect biodiversity in their own towns and watersheds.

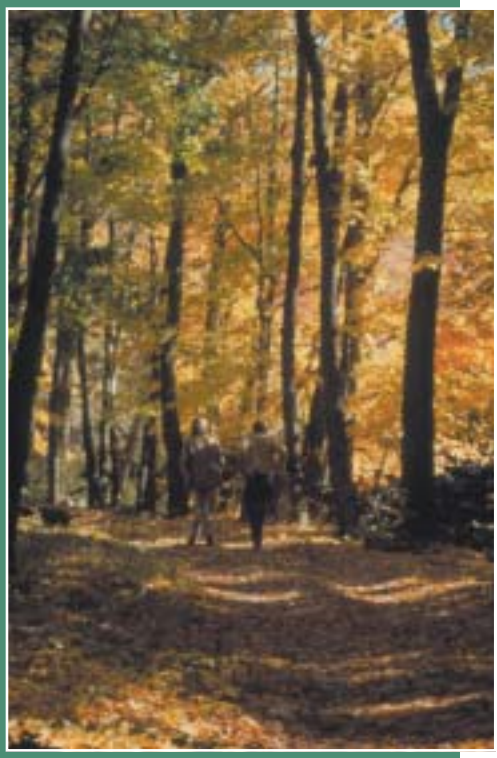


Biodiversity Conservation in Vermont: Resources and Conserved Lands



This map shows known biodiversity resources. Many unmapped areas have not been studied, and may have significant biodiversity values.

How to Use the Information in this Book



Whitney Beals

It is our hope that our children will have wild and beautiful places to enjoy.

The information in this book was created for use at both statewide and local levels. Some of the information is technical, and understanding it will require the assistance of conservation planners, professional biologists, and GIS experts, but much of the information is accessible and understandable to a variety of users. With this information,

Citizens can better understand and comment on conservation initiatives proposed by state and federal governments.

Individual Landowners can make informed decisions on land management and long-term conservation of their properties.

Local Governments can create town plans that take biodiversity into account and can make informed decisions about land purchases and zoning.

Watershed Associations can consider biodiversity in both terrestrial and aquatic environments as they work to protect water resources.

Local and Regional Land Trusts can prioritize where to focus their biodiversity conservation efforts and can influence management of state and federal lands.

Multi-town groups can share information to help with larger scale conservation efforts.

Regional Planning Commissions can provide better technical assistance to towns.

Statewide Conservation Organizations can work together to develop a statewide system of ecological reserves.

State Government can better plan for the management of its lands, and can acquire new lands for biodiversity conservation.

Federal Government can enhance its planning efforts for the management of biodiversity on its lands, and can acquire new lands for biodiversity conservation.

National and International Conservation Organizations such as The Nature Conservancy, the Trust for Public Lands, the Conservation Fund, the World Wildlife Fund, the Wildlands Project, and others, can contribute to the conservation of biodiversity on a continental and global scale.

Educational Institutions can help students of all ages learn more about their natural world and how to conserve it.

Appendix A is a list of resources for conservation planning. Appendix B is a "how-to" guide for local conservation planners.

It is our hope that this information is helpful, that Vermonters will continue to work toward conserving what is so special about this state, and that our children and grandchildren will have wild and beautiful places to enjoy.

Bibliography and Further Reading

Alverson, William, S., Walter Kuhlmann and Donald M. Waller. 1994. *Wild Forests: Conservation Biology and Public Policy.* Island Press.

Beattie, Mollie, Charles Thompson, and Lynn Levine. 1993. *Working With Your Woodlot: A Landowner's Guide.* University Press of New England.

Cogbill, C.V. 2000. Vegetation of the presettlement forests of northern New England and New York. Rhodora 102:250-276.

Department of Forests, Parks and Recreation. 1987. Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont.

Doll, Charles, David P. Stewart and Paul MacClintock. 1971. Surficial Geologic Map of Vermont. Vermont Geological Survey, Scale 1:250,000. State of Vermont.

Doll, Charles W, Wallace M. Cady, James P. Thompson, Jr., and Marland P. Billings. 1961. Centennial Geologic Map of Vermont: Vermont Geological Survey, Scale 1:250,000. State of Vermont.

Girton, Phil and David Capen. 1997. A report on biophysical regions in Vermont. Unpublished report prepared for the Vermont EcoMappping Roundtable.

Hunter, Malcolm L., Jr. 1990. *Wildlife, Forests, and Forestry: Principles of Managing Forests For Biologial Diversity.* Prentice Hall.

Hunter, Malcolm L., Jr. 1995. *Fundamentals of Conservation Biology.* Blackwell Science Publications.

Hurley, Janet. 2000. Vermont's Conserved Lands: an in-depth analysis of protected land parcels. Vermont Environmental Report, Summer 2000, pp. 26-27.

Johnson, Charles W. 1999. *The Nature of Vermont.* Second edition. University Press of New England.

Klyza, Christopher M. and Stephen C. Trombulak. 1999. *The Story of Vermont: A Natural and Cultural History.* Middlebury College Press and University Press of New England.

Kohm, Kathryn A. and Jerry F. Franklin. 1997. *Creating a Forestry for the 21st Century: The Science of Ecosystem Management.* Island Press.

Laughlin, Sarah B. and Douglas P. Kibbe. *The Atlas of Breeding Birds of Vermont.* University Press of New England.

Noss, Reed F. and Allen Y. Cooperrider. 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity.* Island Press.

Prasad, A. M. and L. R. Iverson. 1999-ongoing. A Climate Change Atlas for 80 Forest Tree Species of the Eastern United States. http://www.fs.fed.us/ne/delaware/atlas/index.html, Northeastern Research Station, USDA Forest Service, Delaware, Ohio.

Thompson, E. and E. Sorenson. 2000. *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont.* University Press of New England, Hanover, NH.

Trombulak, S.C. 1995. Ecological health and the Northern Forest. Vermont Law Review 19:283-333.

Vermont Biodiversity Project. 1998. A Classification of the Aquatic Communities of Vermont. A report prepared by the Aquatic Classification Working Group for The Nature Conservancy and the Vermont Biodiversity Project. 49 pp.

BOB KLEIN

Glossary

Acidic – containing a high proportion of hydrogen ions. In acidic soils, nutrients are less available to plants than they are in basic soils

Basic – containing a low proportion of hydrogen ions. In basic soils, nutrients are more available to plants than they are in acidic soils

Bedrock geology – the makeup of the rock underlying all till, sand, gravel, clay, or other surface deposits

Biodiversity – or *Biological Diversity* – the variety of life in all its forms, and all the interactions between living things and their environment. It includes ecosystem diversity, landscape diversity, community diversity, species diversity, and genetic diversity

Connecting areas – lands that connect core reserves with one another or with buffer lands, allowing for the free movement of animals and plants

Core reserve – a large area of land that is managed primarily for biodiversity

Corridors – see Connecting areas

Ecological Reserve system – core reserves, connecting areas, and buffer lands that together protect the biodiversity of a region

Extirpated – absent from an area where it once occurred

Natural Area – a relatively small area of land that is managed primarily for biodiversity

Stewardship lands – lands that are managed for biodiversity and also for human activities like resource extraction and recreation

Surficial geology or surface geology – the makeup of the materials such as clay, sand, gravel, and peat, that lie over bedrock

Viability – the ability of species and natural communities to maintain population numbers and genetic diversity over time

Appendix A

Resources for Biodiversity Planning, Education, and Advocacy

Technical Information, No Organizational Affiliation

Vermont Biodiversity Project

The vision of the Vermont Biodiversity Project is to maintain ecological integrity in a manner that insures the long-tem viability of all native species and natural community types in Vermont within their natural ranges

www.snr.uvm.edu/sal/vbp

Vermont Reptile and Amphibian Atlas

Distribution information, by town and specific location, on all Vermont's reptiles and amphibians. This information is regularly updated by professionals and trained volunteers. Training for volunteer participation in surveying is available and encouraged.

www.middlebury.edu/herpatlas

James S. Andrews, Biology Department
Middlebury College
Middlebury, VT, 05753
802-443-5648

Vermont Center for Geographic Information

Information on bedrock geology, elevation zones, landforms, representative landscapes, heritage sites, heritage hotspots, and priority aquatic features, as well as many other kinds of information.

http://geo-vt.uvm.edu/vbp/

http://geo-vt.uvm.edu/cfdev2/warehouse_new/theme_index.cfm

590 Main St.
University of Vermont
Burlington, VT 05405
802-656-4277

NatureServe (formerly Association for Biodiversity Information)

Information on the conservation status of many native plants, animals, and natural communities throughout the United States

www.natureserve.org

Consulting Foresters Association of Vermont

Foresters who can help develop land management plans

http://www.gwriters.com/cfav.html

State Agencies

Regional Planning Commissions

Advising both municipalities and the public on developmental and environmental issues. The Vermont Association of Planning and Development Agencies (website listed here) provides contact information for all 12 of Vermont's Regional Planning Commissions

www.vapda.org

Vermont Agency of Natural Resources

The Vermont Agency of Natural Resources is working to incorporate ecological reserves into its planning. You can learn more about this effort and can comment on it.

http://www.anr.state.vt.us/

103 South Main Street
Waterbury, VT 05671

Vermont Department of Fish and Wildlife

Manages Vermont's fisheries and wildlife resources, enforces the state's hunting and fishing laws, and studies and inventories nongame wildlife species and natural communities.

http://www.anr.state.vt.us/fw/fwhome/index.htm

802-241-3700

Nongame and Natural Heritage Program

Keeps track of information on rare species and significant natural communities throughout the state. Lists of rare plants and animals are available on the NNHP website

Mailing address and phone are as for Vermont Department of Fish and Wildlife

http://www.anr.state.vt.us/fw/fwhome/nnhp/index.html

Vermont Department of Forests, Parks and Recreation

Operates the Vermont State Parks system, manages state forests and natural areas, and provides assistance in the areas of forestry, recreation, and conservation education.

http://www.state.vt.us/anr/fpr/index.htm

802-241-3670

Vermont Department of Environmental Conservation

Administers most of the Agency's regulatory programs plus several voluntary pollution and waste reduction programs. Program areas include: air quality, environmental assistance, public facilities engineering, geology, environmental permits, solid waste, hazardous waste, surface water quality, watershed planning, stormwater management, and drinking water supply.

http://www.anr.state.vt.us/dec/dec.htm

802-241-3770

Federal Agencies

Lake Champlain Basin Program

The Lake Champlain Basin Program (LCBP) is a federal, state and local initiative to restore and protect Lake Champlain and its surrounding watershed for future generations.

Lake Champlain Basin Program
http://www.lcbp.org
PO Box 204
54 West Shore Road
Grand Isle, Vermont 05458
802-372-3213 or 1-800-468-LCBP (NY and VT)

Natural Resources Conservation Service

As a locally guided federal agency, we are responsible for helping Vermonters to manage and sustain their natural resources. Ten field offices throughout the state.

http://www.vt.nrcs.usda.gov/

69 Union Street
Winooski, VT 05404
802/951-6796

United States Fish and Wildlife Service

Managing Missisquoi National Wildlife Refuge, Silvio O. Conte National Fish and Wildlife Refuge, Pittsford National Fish Hatchery, and White River National Fish Hatchery. Leading the Lake Champlain Ecosystem Team from offices in Essex.
Other offices at several sites throughout the state.

http://www.fws.gov/r5lcfwro/

Lake Champlain Fish and Wildlife Resources Office
Winston Prouty Federal Building
11 Lincoln Street
Essex Junction, Vermont 05452-3151

United States Geological Survey

Information on Water Quality in Lake Champlain

http://water.usgs.gov/pubs/FS/FS-047-99/

United States Forest Service, Green Mountain National Forest

Managing lands in the Green Mountains and Taconic Mountains. Four offices in Vermont

http://www.fs.fed.us/r9/gmfl/

231 North Main Street
Rutland, VT 05701
802-747-6700

United States Environmental Protection Agency

Mission: to protect human health and to safeguard the natural environment

http://www.epa.gov/epahome/index.html

EPA New England, Region 1
1 Congress Street, Suite 1100
Boston MA 02114-2023
888-372-7341

Nonprofit Organizations

Vermont Land Trust

Mission: to conserve land for the future of Vermont.

http://www.vlt.org/

8 Bailey Avenue
Montpelier, VT 05602
802-223-5234

The Nature Conservancy

Mission: to preserve the plants, animals and natural communities that represent the diversity of life on earth by protecting the lands and waters they need to survive.

http://www.nature.org

27 State Street
Montpelier, VT 05401
802-229-4425

The Orton Family Foundation and Orton Institute

Mission: to help citizens of rural America define the future, shape the growth and preserve the heritage of their communities.

http://www.orton.org/

http://www.communitymap.org/

138 Merchants Row, 2nd floor
Rutland, VT 05701
802-773-6336

Vermont Forum on Sprawl

Mission: to assist Vermont and Vermonters in achieving compact settlement surrounded by rural landscape while encouraging community and economic development to be consistent with this vision.

http://www.vtsprawl.org/index3.htm

110 Main Street
Burlington, VT 05401
802-864-6310

Keeping Track

Works with community groups to identify wildlife habitats through on-the-ground tracking. They can help you organize such an effort in your town, or provide information if such an effort is already underway.

www.keepingtrackinc.org

PO Box 444
Huntington, VT 05462
802-434-7000

Association Of Vermont Conservation Commissions

Promoting the formation of, and assisting, municipal conservation commissions.

http://www.uvm.edu/~envprog/epic/avcc.html

114 Sparrow Road
Adamant, VT 05640

Defenders of Wildlife

Information on laws relating to biodiversity in Vermont

http://www.defenders.org/bio-stve.html

Vermont Institute of Natural Science

Protecting Vermont's natural environment through education and research designed to engage individuals and communities in the active care of their environment. Three offices, in Woodstock, Manchester, and Montpelier.

http://www.vinsweb.org/

27023 Church Hill Road
Woodstock, VT 05091-9642
802-457-2779

Forest Watch

Saving and re-creating wild forests, advocating for wilderness in Vermont and the northeast

www.forestwatch.org

10 Langdon Street, Suite 1
Montpelier, Vermont 05602
802-223-3216

Northern Forest Alliance

A coalition of conservation organizations committed to protecting the northern forest of Maine, New Hampshire, Vermont, and New York.

43 State Street
Montpelier, VT 05602

http://www.northernforestalliance.org/

National Wildlife Federation, Northeastern Field Office

Education and Action to keep the wild in our world

http://nwf.org/

58 State Street
Montpelier, VT 05602
802-229-0650 Voice

The Wildlands Project

The Wildlands Project is working to restore and protect the natural heritage of North America. Through advocacy, education, scientific consultation, and cooperation with many partners, we are designing and helping create systems of interconnected wilderness areas that can sustain the diversity of life.

www.wildlandsproject.org

PO Box 455
Richmond
Vermont 05477
802-434-4077

Champlain Valley Clayplain Forest Project

www.clayplain.org

Marc Lapin
239 Cider Mill Road
Cornwall, VT 05753
802-462-2514

Rod and Betty Vallee

Appendix B

Conservation Planning: a Guide for Practitioners

How to Plan for Biodiversity Conservation

These guidelines, Steps One through Four below, assume you are a landowner, a town or regional planner, or a representative of an organization or agency that is interested in conserving biological diversity in a particular area, large or small. The following steps apply to all users of this information, but should be adapted to meet your specific needs.

Although this information is available to anyone, we strongly recommend that you seek the assistance of a professional conservation planner.

The margin notes illustrate how each of these steps was implemented in the fictional town of Ridgeville, Vermont.

Step One: Set Biodiversity Conservation Goals

1. Assemble all interested parties
2. Set general biodiversity conservation goals for your area. Coordinate this effort with other efforts going on in surrounding areas. We recommend beginning with the following minimum set of goals, and adding to them or modifying them based on local interests and needs:
   a. Secure adequate, long-term protection for all viable rare species populations known in the area.
   b. Secure adequate, long-term conservation for all rare (S1-S3) natural communities.
   c. Secure adequate, long-term protection for all common (S4-S5) natural communities that are not protected elsewhere in the biophysical region.
   d. Secure adequate protection for all Complementary Landscapes, or for landscapes that are equivalent in their physical characteristics.
   e. Protect any Priority Aquatic Sites with buffers and other measures that will maintain high water quality.
   f. Provide corridors for movement of animals and plants among conserved areas in your jurisdiction, and also between your jurisdiction and areas outside it.
   g. Encourage biodiversity-compatible forestry and biodiversity-compatible agriculture on lands that are not conserved primarily for biodiversity.
3. Communicate these goals to the people who can help implement them.

Step 1 Example

Ridgeville's planning commission and conservation commission met together and developed the following general biodiversity conservation goals:

a. Secure adequate, long-term protection for all rare species known in town.

b. Create a set of town natural areas that represents, as much as possible, all the natural communities found in the town and all the physical features found in the town. These areas will be accessible for low-impact recreation and education.

c. Ensure that the natural areas are connected with one another and are well buffered by land that is carefully managed.

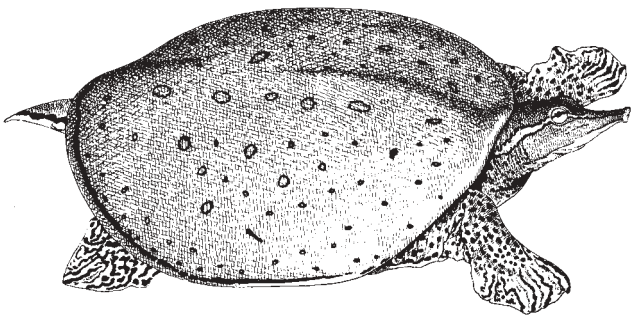
d. Protect any significant aquatic resources with buffers and other measures that will maintain high water quality.

e. Protect all wetlands.

f. Encourage responsible management of forest lands.

g. Encourage cluster development.

The Conservation Commission then held a public meeting to inform residents about these goals, and solicited their help in attaining them. They also began a series of articles in the Ridgeville Weekly to educate readers about biodiversity conservation and the natural history of the town.



Step Two: Gather basic, existing biodiversity resource information

1. Gather all the information on your area of interest from this book, the Vermont Biodiversity Project Website, the Vermont Center for Geographic Information, and the other sources listed in Appendix A.
2. Gather any other site-specific information you may have, such as aerial photographs, land cover maps, forest stand maps, and historical information.
3. Identify, as well as you can, the natural communities that occur in the area. If possible, obtain a map of natural communities.
4. Use the information checklist to identify information-gathering needs.
5. Using the information you have, list and map the known biodiversity resources such as heritage sites, priority aquatic sites, and complementary landscapes.
6. Gather any additional information that is needed. Note that this step may take a considerable investment of time, and that conservation action should not wait until every last piece of information is in. Instead, conservation action should be based on the best information available, and planning should continue as new information is gathered.

Checklist of information needed for biodiversity conservation planning

Maps:

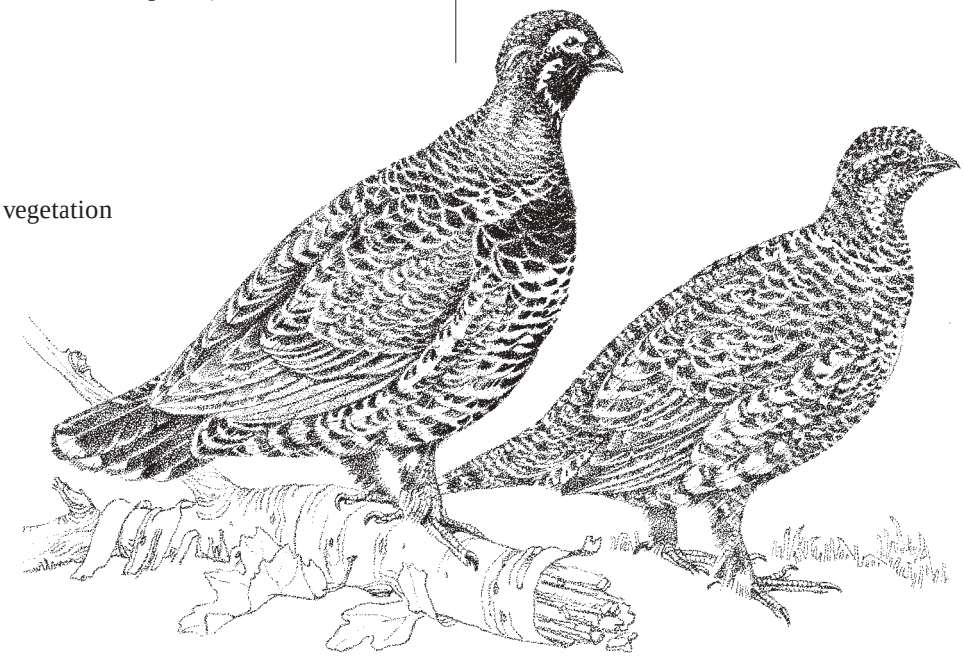
- Priority Aquatic Sites
- Complementary landscapes
- Conserved lands
- Significant Natural Communities
- Rare Species
- Bedrock Geology
- Surface Geology
- Landforms
- Landscape Diversity Units
- Soils
- Natural communities (not available in most places)
- Topography
- National Wetlands Inventory

Other information:

- Aerial photographs
- Orthophotos
- Information on presettlement vegetation (Cogbill 2000)

Step 2 Example

Caroline Stilley, a member of the Ridgeville Conservation Commission, is a retired high school teacher who has an interest in hiking and maps. She took on the job of gathering information. She started by visiting the Vermont Biodiversity Project web site, where she learned more about the project and how the maps were created. She then visited the Vermont Center for Geographic Information website and learned what information she could get. She did not have the technical expertise to download the maps, so the conservation commission asked for help from the Regional Planning Commission, which was able to provide the town with the maps. She also visited the local Natural Resources Conservation Service office. Within a couple of months, she had copies of all the maps presented in this report, just showing the town of Ridgeville and the towns immediately adjacent to it. She also had a map of wetlands in the town mapped by the National Wetlands Inventory.



Step Three: Gather site-specific information

1. For rare species, find out what you can about what the species needs to survive over the long term. How much habitat is needed? Is the population viable at its current size or should it be larger? What are the threats to the population? The Nongame and Natural Heritage Program can assist in gathering this information.
2. For all natural communities, find out whether the conservation goals have been met. If not, assess the viability of the natural community, and decide whether conserving it in an ecological reserve can effectively contribute to the overall conservation goals for natural communities in Vermont. If so, use the information on the natural scale of the community to decide how much land might be needed to conserve it. The Nongame and Natural Heritage Program can assist with this assessment. If the community has been adequately protected elsewhere, then use the information in *Wetland, Woodland, Wildland* (Thompson and Sorenson, 2000) to learn how the community can be managed to enhance its biodiversity value. Gather any existing maps of natural communities in the area, and if they do not exist, consider creating them.
3. For significant aquatic resources, consult the Vermont Department of Environmental Conservation for assistance in deciding how the resource can be managed to protect its biodiversity values. Often this will involve vegetated buffers to reduce inputs of nutrients and other pollutants.
4. For Complementary Landscapes, find out which Landscape Diversity Units are found in the area delineated, and find out whether these are protected elsewhere in your area of interest. In addition, study the landforms and Landscape Diversity Units of the area to see where unusual features are, and also to see what the characteristic physical features are.
5. Gather information on wildlife populations and movement in the area, focusing on shy, uncommon, and wide-ranging species such as bobcat, fisher, lynx, black bear, and moose. This information may be available through the Vermont Fish and Wildlife Department, a local tracking effort, or local hunters. The local game warden and the local police can often provide useful information on where mammals tend to cross roads.
6. Gather information from local naturalists, hikers, scientists and others who may have knowledge about other features and places of interest.
7. Gather information from the local historical society, or for larger areas, the Vermont State Archives, on historical vegetation and land use history in the area.
8. Conduct site-based field work to confirm information and gather new information about places that are little-known.

Step 3 Example

Ms. Stilley enlisted the help of five other people in the community to gather site-specific information.

Phil Geller, a computer expert, did a bit more research. He discovered that three Heritage sites occurred within the town. One was a natural community and two were rare species. Phil contacted the Vermont Nongame and Natural Heritage Program to learn more about these sites. The community was a red cedar woodland, a rare community that occurs on clifftops. One of the rare species was a grass that grows in rich northern hardwood forests, and one was a dragonfly that lives in rich fens. A significant aquatic site had been identified in town, a stretch of a small mountain stream. Phil contacted the Vermont Department of Environmental Conservation for advice on maintaining water quality in the stream.

There were no Complementary Landscapes in the town, but Wilt Stickman, who was especially interested in geology and soils, studied the landforms and geology and discovered an unusual geological formation (ultramafic rock on a cliff) in a remote part of town. He also confirmed his general impression that the gravel deposits in town were all in stream valleys where the development is heaviest.

Charlie Welly, a hunter who was new to town, interviewed other hunters in the area and learned that black bear were plentiful on a particular high ridge, and that they move north and south along that ridge to other towns. In the process of interviewing hunters, he learned about a population of wild ginseng, but did not learn exactly where it was.

Jim Olson, a professional forester and information sleuth, read about presettlement vegetation in the area and searched the state archives for more specific information. He also studied old aerial photographs to learn about land use history. He learned that certain trees, like beech and hemlock, had once been more common in 1790, and other trees, like aspen and birch, had been less common then. He also learned that most places below about 2000 feet elevation had been open land or very young forest when aerial photos were taken in 1943.

Barbara Bohr, a retired botanist, found a natural community map for one small area, a college reserve. It identified northern hardwood forest, rich northern hardwood forest, red oak-northern hardwood forest, and cattail marsh. She found this information very useful, and decided to map natural communities for the entire town. She will try to raise funds to have a professional assist with the mapping, but in the meantime she will begin the work herself.

Step Four: Implement the Goals

How the goals are implemented will vary depending on the size of the area, its geographic setting, and its political setting. We can only provide the most general guidance here. Successfully implementing conservation goals will require good, site-specific knowledge, good communication with all who stand to gain (or lose) from the planning, and carefully exploring multiple options. These general steps, borrowed from The Nature Conservancy, can provide a basic framework.

1. Identify the threats to the resources identified in Step 2.
2. Identify strategies to abate those threats in each case. The strategies may include purchasing land for conservation, conservation easements, zoning areas for conservation, educating landowners about the significance of their lands, engaging schoolchildren in long-term water quality monitoring, or promoting sustainable forestry.

Step 4 Example

The Conservation Commission hired a professional to help prepare maps of all the biodiversity features of interest in town. They then conducted a series of public meetings to ask townspeople to help them identify threats to all the resources. From this information, they developed a biodiversity conservation plan with several options for protecting each of the resource areas identified. This document will undergo review by the Planning Commission, and will be sent to each town resident for comment.

A Note About Conservation and Community

In the Foreword to this book, Charles Johnson notes that biodiversity is a 'controversial concept' and that the term can engender 'antagonistic' responses.

As citizens undertake to conserve biodiversity in their communities, it is always important to remember that controversy and conflict are natural elements of such efforts. Just as the natural world is diverse in its communities and life forms, the human community is diverse in its opinions, personal histories, and concerns. Conservation efforts at the community level need to be aware of the complexity and tension that will accompany this work, much as ecologists need to be aware of the same forces in natural systems.

This reality is not a reason to fear such efforts; it is in fact a force that, if honestly and thoughtfully faced, can build and strengthen communities and the environment in which communities happen.

Some tactical ideas and things to remember:

- **Lasting relationships with 'adversaries' are built first by being willing to learn from others. Once people trust that you want to learn from them, opportunities for teaching new ideas – like biodiversity – are vastly more possible and fruitful.**
- **The history of the land in any community includes many kinds of people who have used and cared for it in different ways. Learn about this history and invite all people who know the land and its intricacies to share that knowledge in creating a plan for its preservation.**
- **Getting to know the land in the most reverent sense keeps us humble; carry this humility into your work with other people to conserve the land.**
- **Understand both the official and unofficial politics of your community. You may be able to get the Planning Commission to bless your ideas, but real success depends on a more powerful blessing at the local coffee shop or village store.**
- **Cultivate support for your vision from longtime residents of the community. Be patient in finding those who will be supportive; you will find them.**
- **Hold a picnic or other type of public event on the land, open to all. (If the land is a wetland, hold it nearby.) Invite people to tell their stories about the place; the stories are an important part of the land's biodiversity.**
- **It may be useful to have skilled assistance in planning strategies, facilitating meetings, and understanding community dynamics. You cannot avoid difficult issues; if unresolved, they will infect the project, sometimes fatally. But with skilled help, you can keep the conversation respectful and inclusive.**
- **Find ways to invite children into your process through local schools or civic organizations. Their sense of wonder is contagious.**
- **If you get frustrated, take a walk on the land you are working to conserve. If you approach it with no agenda, it will tell you all you need to know.**

Appendix C:
Aquatic Natural Communities of Vermont

VASCULAR PLANT ASSEMBLAGES

Vascular plants of standing waters

- Dystrophic lake
- High-elevation acidic lake
- Mesotrophic-eutrophic lake
- Oligotrophic lake

MACROINVERTEBRATE ASSEMBLAGES

Macroinvertebrates of standing waters

- Dystrophic tannic lake
- Clear acidic/oligotrophic lake
- Oligotrophic lake
- Mesotrophic lake
- Eutrophic, oxygen limited lake

Macroinvertebrates of running waters

- Cold, headwater acidic mountain stream
- Cold, headwater mountain stream
- Moderately-sized mountain stream
- Lower reach of small river
- Small headwater marsh stream
- Medium-sized mid-reach meandering stream
- Small stream in the lower Champlain Valley
- Moderate to large river directly entering Lake Champlain
- Lake marsh outlet stream
- Spring seep

FISH ASSEMBLAGES

Fishes of standing waters

- Dystrophic lake
- High-elevation acidic lake
- Oligotrophic lake
- Mesotrophic-eutrophic lake

Fishes of running waters

- Brook trout assemblage
- Brook trout-slimy sculpin assemblage
- Brook trout-blacknose dace assemblage
- Common shiner-blacknose dace assemblage
- Bluntnose minnow-creek chub assemblage
- Pumpkinseed-bluntnose minnow assemblage
- American shad-Atlantic salmon assemblage

REPTILE AND AMPHIBIAN ASSEMBLAGES

Reptiles and Amphibians

- Seeps, springs, and margins of pools
- Vernal and semipermanent pools
- Permanent, still, or slow-moving water

Elizabeth Thompson

Appendix D:
Upland and Wetland Natural Communities of Vermont

Patch Size: these categories describe the typical size of individual contiguous occurrences of the community type, and the specificity with which the community type is associated with particular environmental conditions and ecological processes.

Matrix (M): a natural community type that is dominant in the landscape, occupying 1,000 to 100,000 contiguous acres. Matrix communities have broad ecological amplitude, occurring across a wide range of soil and bedrock types, slopes, slope aspects, and landscape positions. Regional scale processes such as climate typically determine their range and distribution.

Large Patch (L): a natural community type that occurs in the landscape on a scale of 50 to 1,000 acres and is usually associated with a single dominant ecological process or environmental condition such as fire or hydrology.

Small Patch (S): a natural community type that occurs in the landscape as small, discrete areas typically less than 50 acres, and for some types, consistently under an acre in size. Small patch communities occur where several ecological processes and environmental conditions come together in a very precise way.

State Rank: these ranks indicate the relative rarity of natural community types and are assigned by the Vermont Nongame and Natural Heritage Program.

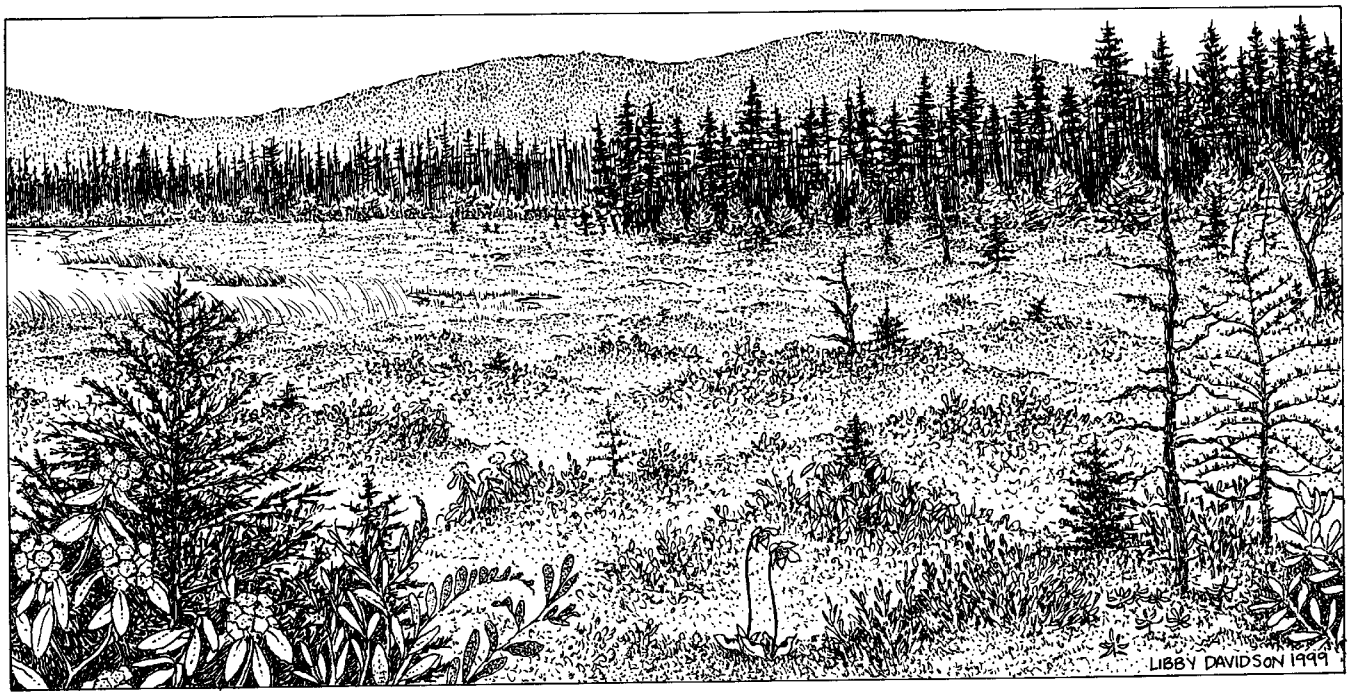
S1: extremely rare in the state, generally with fewer than five high quality occurrences.

S2: very rare in the state, occurring at a small number of sites or occupying a small total area in the state.

S3: high quality examples are uncommon in the state, but not rare; the community is restricted in distribution for reasons of climate, geology, soils, or other physical factors, or many examples have been severely altered.

S4: widespread in the state, but the number of high quality examples is low or the total acreage occupied by the community type is relatively small.

S5: common and widespread in the state, with high quality examples easily found.



Dwarf Shrub Bog

Natural Community Type	Patch Size	State Rank
Upland Natural Communities		
Upland Forests and Woodlands		
Spruce-Fir-Northern Hardwood Forest Formation: Forests of Vermont's Cooler Climate Areas		
Subalpine Krummholz	L	S1
Montane Spruce-Fir Forest	M	S3
Lowland Spruce-Fir Forest	M	S3
Montane Yellow Birch-Red Spruce Forest	M	S3
Red Spruce-Northern Hardwood Forest	M	S4
Boreal Talus Woodland	S	S3
Cold-Air Talus Woodland	S	S1
Northern Hardwood Forest Formation: Forests of Widespread Distribution in Vermont's moderate climate areas		
Northern Hardwood Forest	M	S5
Rich Northern Hardwood Forest	L	S4
Mesic Red Oak-Northern Hardwood Forest	L	S4
Hemlock Forest	S	S4
Hemlock-Northern Hardwood Forest	L-M	S4
Northern Hardwood Talus Woodland	S	S3
Oak-Northern Hardwood Forest Formation: Forests of Vermont's Warmer Climate Areas		
Red Pine Forest or Woodland	S	S2
Pitch Pine-Oak-Heath Rocky Summit	S	S1
Limestone Bluff Cedar-Pine Forest	S	S2
Red Cedar Woodland	S	S2
Dry Oak Woodland	S	S2
Dry Oak Forest	S	S3
Dry Oak-Hickory-Hophornbeam Forest	L	S3
Mesic Maple-Ash-Hickory-Oak Forest	L	S3
Valley Clayplain Forest	M	S2
White Pine-Red Oak-Black Oak Forest	L	S3
Pine-Oak-Heath Sandplain Forest	L	S1
Transition Hardwood Talus Woodland	S	S3
Open Upland Communities		
Upland Shores		
Riverside Outcrop	S	S4
Erosional River Bluff	S	S2
Lake Shale or Cobble Beach	S	S3
Lake Sand Beach	S	S2
Sand Dune	S	S1
Outcrops and Upland Meadows		
Alpine Meadow	S	S1
Boreal Outcrop	S	S4
Serpentine Outcrop	S	S1
Temperate Acidic Outcrop	S	S4
Temperate Calcareous Outcrop	S	S3
Cliffs and Talus		
Boreal Acidic Cliff	S	S4
Boreal Calcareous Cliff	S	S2
Temperate Acidic Cliff	S	S4
Temperate Calcareous Cliff	S	S3
Open Talus	S	S2

Natural Community Type	Patch Size	State Rank
Wetland Natural Communities		
Forested Wetlands		
Floodplain Forests		
Silver Maple-Ostrich Fern Riverine Floodplain Forest	L	S3
Silver Maple-Sensitive Fern Riverine Floodplain Forest	L	S3
Sugar Maple-Ostrich Fern Riverine Floodplain Forest	S	S2
Lakeside Floodplain Forest	S	S3
Hardwood Swamps		
Red Maple-Black Ash Swamp	L	S4
Red or Silver Maple-Green Ash Swamp	L	S2
Calcareous Red Maple-Tamarack Swamp	S	S2
Red Maple-Black Gum Swamp	S	S1
Red Maple-Northern White Cedar Swamp	L	S3
Red Maple-White Pine-Huckleberry Swamp	S	S1
Softwood Swamps		
Northern White Cedar Swamp	S	S3
Spruce-Fir-Tamarack Swamp	L	S3
Black Spruce Swamp	S	S2
Hemlock Swamp	S	S2
Seeps and Vernal Pools		
Seep	S	S4
Vernal Pool	S	S3
Open or Shrub-Dominated Wetlands		
Open Peatlands		
Dwarf Shrub Bog	S	S2
Black Spruce Woodland Bog	S	S2
Pitch Pine Woodland Bog	S	S1
Alpine Peatland	S	S1
Poor Fen	S	S2
Intermediate Fen	S	S2
Rich Fen	S	S2
Marshes and Sedge Meadows		
Shallow Emergent Marsh	S	S4
Sedge Meadow	S	S4
Cattail Marsh	S-L	S4
Deep Broadleaf Marsh	S	S4
Wild Rice Marsh	S	S3
Deep Bulrush Marsh	L	S4
Wet Shores		
Outwash Plain Pondshore	S	S1
River Mud Shore	S	S3
River Sand or Gravel Shore	S	S3
River Cobble Shore	S	S2
Calcareous Riverside Seep	S	S1
Rivershore Grassland	S	S3
Lakeshore Grassland	S	S2
Shrub Swamps		
Alluvial Shrub Swamp	L	S4
Alder Swamp	L	S5
Sweet Gale Shoreline Swamp	S	S3
Buttonbush Swamp	S	S2

Credits and Acknowledgements

This publication is the result of five years of work involving many scientists and decision makers. The research was directed by a steering committee made up of representatives from all the collaborating agencies and organizations. The following people served on the steering committee: For The Nature Conservancy: Elizabeth Thompson, John Roe, Chris Fichtel, and Bob Klein. For the Vermont Land Trust: Gil Livingston and Joan Allen. For the University of Vermont: David Capen. For Middlebury College: Stephen Trombulak. For Sweet Water Trust: Emily Bateson. For The Orton Family Foundation: Helen Whyte and Bill Shouldice. For the Vermont Agency of Natural Resources: Scott Darling, James Bressor, Mike Fraysier, Charles Johnson, and Bob Popp. For the Environmental Protection Agency: Beth Alafat and Rosemary Monahan. For the United States Fish and Wildlife Service: David Tilton. For the United States Forest Service: Clay Grove. For the United States Natural Resources Conservation Service: Kip Potter.

The actual research was carried out in the research labs of David Capen at the University of Vermont and Stephen Trombulak at Middlebury College, in the Vermont Department of Environmental Conservation, and in the office of ecologist Charles Cogbill. In Dr. Capen's lab, Charles Ferree conducted most of the research on physical diversity and also compiled other kinds of data, Ernie Buford compiled data on species distributions and conducted other analyses, Janet Hurley compiled data on conserved lands, and Sean MacFaden provided some of the maps in this report. Much of the data they used was provided by the Vermont Nongame and Natural Heritage Program. In Dr. Trombulak's lab, Jeremy Hertzig compiled data on species distributions. At the Department of Environmental Conservation, a group of aquatic biologists led by Richard Langdon compiled and analyzed data to produce a classification of the aquatic commuities of Vermont. Other members of that group were Steve Fiske, Jim Andrews, Susan Warren, Ken Cox, and Neil Kammen. Dr. Cogbill conducted research into the makeup of Vermont's presettlement forests.

A Technical Work Group supervised and conducted much of the research, and a Scientific Advisory Subcommittee provided advice and comment on the work. The Technical Work group varied over the life of the project, but included the following scientists at different times: Elizabeth Thompson, David Capen, Stephen Trombulak, Diane Burbank, Bob Popp, Eric Sorenson, Chris Fichtel, Charles Ferree, and Ernie Buford. The Scientific Advisory Subcommitte was made up of these scientists plus the following: Charles Cogbill, Marc Lapin, Brett Engstrom, Jim Andrews, John Roe, Scott Darling, Thom Villars, Richard Langdon, Eric Derleth, and Steve Fiske.

Elizabeth Thompson was the project leader and author of this book. All members of the Steering Committee and Scientific Advisory Subcommittee contributed ideas and editorial comments.

Gale Lawrence donated her services as editor of the manuscript, and Alan Parker copy edited the final draft.

Design by: Mirabile Design, Montpelier, Vermont

Printing by: Queen City Printers, Inc., Burlington, Vermont. Printed on recycled content paper with soy-based inks.

Artwork by: Libby Davidson, Darien McElwain, Linda Mirabile and Jonathan Leonard. Uncredited artwork is used courtesy of the Vermont Nongame and Natural Heritage Program.

Photos within the book are used courtesy of each of the photographers (see credits on each photo).

Cover photos were generously donated by Rod and Betty Vallee.

This work should be cited as follows:
Thompson, Elizabeth H. 2002. Vermont's Natural Heritage: Conserving Biodiversity in the Green Mountain State. A Report from the Vermont Biodiversity Project. 48 pp.

To obtain additional copies of this report, please contact one of the following organizations or agencies, or view the report on their web sites (contact information is found in Appendix A, pages 38-40):

Vermont Land Trust
The Nature Conservancy
The Orton Family Foundation and Orton Institute
Vermont Department of Fish and Wildlife
United States Fish and Wildlife Service
Vermont Biodiversity Project (web site only)