Hardwood Swamps of Vermont: Distribution, Ecology, Classification, and Some Sites of Ecological Significance

Red Maple-Black Ash Seepage Swamp, illustration by Libby Davidson

Eric Sorenson, Robert Popp, Michael Lew-Smith, Brett Engstrom, Marc Lapin, and Mark Ferguson

for

Nongame and Natural Heritage Program
Vermont Fish and Wildlife Department
Agency of Natural Resources
Waterbury, Vermont

March, 2004

Acknowledgements

This study of Vermont's hardwood swamps was funded by the United States Environmental Protection Agency through the Performance Partnership with Vermont Department of Environmental Conservation.

Julia Watson identified and contacted the numerous landowners with hardwood swamps on their properties. Ian Worley piloted the plane for aerial reconnaissance, as well as sharing his expertise on Vermont's landscape ecology during the flights. Everett Marshall and Jodi Shippee helped with many aspects of the project, including botanical and ecological issues, data management, and GIS mapping. Everett Marshall, Alan Quackenbush, Ted Allen, and Doug Blodgett all assisted in conducting breeding bird surveys. Kristen Rose conducted the majority of the field work for amphibian surveys. Leif Richardson provided information on hardwood swamps recently identified on state lands. Mark Rahill carefully identified many mosses and liverworts collected during field work. District Wildlife Biologists Kim Royar, Doug Blodgett, and John Gobeille shared their expertise during site visits or on wildlife use of hardwood swamps. Libby Davidson created the pen and ink illustrations of hardwood swamps. Laura Cadmus and Eric Hillmuth both provided assistance with GIS. Jenny Ramstetter and her Marlboro College ecology class helped sample a few southern Vermont swamps. Anne Turner entered most of the plot data. The Vermont Wetlands Office provided use of color infra-red aerial photos for Vermont and a stereoscope for identifying and mapping swamps.

Other ecologists and naturalists have contributed to the information on hardwood swamps contained in the Vermont Nongame and Natural Heritage Program database. These include Elizabeth Thompson, Chris Fichtel, Jerry Jenkins, and Ana Ruesink.

Most importantly, the Nongame and Natural Heritage Program and Vermont Fish and Wildlife Department thank all the landowners that provided access to their property and information about management and history of their swamps. This study would not have been possible without their assistance and generosity.

Table of Contents

BACKGROUND

Many Vermonters have at one time or another found their way into a swamp dominated by hardwood trees. Whether the visit was purposeful to explore the rich assortment of plant and animal life there or by surprise (Oh no! I'm sinking in the swamp!), the visit was likely memorable. These swamps are shady and cool in the summer, typically with a carpet of green mosses and lots of ferns. Many have water-filled hollows and low hummocks. A misplaced step in one of these hollows may result in sinking up to your knees in deep, dark, smelly, saturated, muck.

Hardwood swamps are typically very different from the upland forests that surround them in terms of the species of trees, shrubs, and herbs that are present, the types of soils, and their hydrology. There are also many differences between individual hardwood swamps, although these differences may be more subtle than between the sharply contrasting upland forests and swamps. Understanding these differences is part of the natural community concept and provides us with a strong tool for deciphering the complexity of the landscape around us.

A natural community is an interacting assemblage of plants, animals, and other organisms, their physical environment, and the natural processes that affect them. What makes natural communities such a useful ecological concept is that there is a pattern to their distribution. These assemblages of plants, animals, and other organisms found in natural communities repeat across the landscape wherever certain environmental conditions (climate, soil, and water) are found. This makes it possible for us to identify and describe *natural community types*, which are based on composite descriptions summarizing the characteristics of all known examples of a natural community type that have been studied.

There are currently over 80 natural community types recognized in Vermont by the Nongame and Natural Heritage Program of Vermont Fish and Wildlife Department. These include common types such as Northern Hardwood Forest and Alder Swamp, as well as rare community types such as Pitch Pine-Oak-Heath Rocky Summit and Red Maple-Black Gum Swamp. For much more detail about natural communities in Vermont, please read the book *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont*.[1]

The natural community types that are recognized in Vermont by the Nongame and Natural Heritage Program (NNHP) are the result of many years of observation and study by NNHP staff and by many biologists, ecologists, and naturalists around the state and the region. NNHP has been tracking natural communities since its inception in 1984, but 20 years prior to this time, many important natural communities around the state were identified by Dr. Hubert Vogelmann in his two reports on Natural Areas in Vermont (1964 and 1969).

Improving our understanding of the distribution of natural community types across the landscape gives us insight into the staggering complexity of the diversity of life and the natural world

[1] E.H. Thompson and E.R. Sorenson. 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. Published by The Nature Conservancy and Vermont Department of Fish and Wildlife, distributed by University Press of New England. Available at book stores.

around us. Natural communities are receiving considerable attention in recent years due to their importance as a planning tool for protecting biological diversity. It is readily acknowledged that it is impractical to develop specific plans to conserve each of the many thousands of species occurring in Vermont, especially those species that we know little about. However, it is likely that we can conserve most of these species by conserving multiple examples of all natural community types in relatively natural landscapes and by representing the full variety of each natural community type across its geographic range. Inventories such as this one are important for understanding that variety within a natural community type. Also, in order to be successful, this type of conservation planning will need to identify species that are not well conserved by this natural community net, and we must provide specific protections for them. Examples include animals that range over wide areas and species that are rare or at the edge of their range. Also, it is critical that the natural community classification be as detailed as possible and that it be consistent among states and across regions.

Toward this latter goal, the NNHP is working with ecologists from neighboring states, NatureServe, and The Nature Conservancy to refine regional and national classifications of natural community types. This inventory of Vermont's hardwood swamps contributes to this classification work.

INTRODUCTION

This statewide inventory focuses on swamps (forested wetlands) that are dominated by red maple (*Acer rubrum*), black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), yellow birch (*Betula alleghaniensis*), and other species of trees with broad, deciduous leaves. These wetlands are generally referred to as hardwood swamps.

Forested wetlands are the dominant wetland type in Vermont, as determined by the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) (Tiner, 1987). The National Wetlands Inventory project identified approximately 220,000 acres of palustrine wetlands[2] in Vermont, of which more than half (120,000 acres) are forested wetlands. Of these forested wetlands, the majority (58,600 acres) is broad-leaved deciduous wetland, a category that includes all of the swamps dominated by broad-leaved deciduous trees (NWI code PFO1), as well as mixed swamp types dominated by broad-leaved deciduous trees with some conifers (PFO1/4 and PFO1/2). These broadly defined wetland types include organic- and mineral-soil swamps and alluvial, floodplain forests.

The ecological value of hardwood swamps has long been recognized. They are known to provide a number of important wetland functions, including storage of floodwaters, surface water quality protection, shoreline stabilization, wildlife habitat, fish habitat, and rare, threatened, and endangered species habitat. Taken together, the natural community types that are included within the broad-leaved deciduous forested wetland class represent habitat for many plant and animal species and are an important component of biological diversity in Vermont.

[2] Palustrine wetlands include swamps, marshes, bogs, and fens. In contrast, riverine wetlands are all those associated with streams and rivers and lacustrine wetlands are deepwater wetlands associated with lakes and ponds.

An important regional study of red maple swamps in the northeastern United States was published in 1993 (Golet et al.) and provides excellent information on the distribution and ecology of hardwood swamps across the region. The current study, however, provides the first inventory, review, and analysis of Vermont's hardwood swamps.

For this current study, hardwood swamps are broadly defined as being dominated by hardwood or broad-leaved, deciduous trees (primarily maples, ashes, birches, and elms). Swamps that have a mixed canopy of hardwoods and softwoods (conifers) are also included in the study. Technically, only swamps with greater than 75 percent cover of hardwood tree species are considered hardwood swamps. Swamps with 25 to 75 percent cover of hardwoods and the remainder softwood cover are considered mixed swamps.

A common feature of almost all hardwood swamps in Vermont is the presence of red maple (*Acer rubrum*). Red maple is one of the most abundant and widespread trees in eastern North America. It occurs from southern Newfoundland, south to Florida, and west to eastern Texas and southern Manitoba, and is only absent from the prairie regions of the Midwest (Burns and Honkala, 1990). Red maple grows in a wide variety of site conditions and in Vermont is found throughout the spectrum of ecological conditions, from the excessively well-drained sandy soils of the Chittenden County sandplain forests to the wettest swamp forests. It has been rated as a moderately flood-tolerant tree, compared to green ash (*Fraxinus pennsylvanica*) and black willow (*Salix nigra*), which are more flood-tolerant, and yellow birch (*Betula alleghaniensis*) and white pine (*Pinus strobus*), which are less flood-tolerant (Teskey and Hinkley, 1978). Studies have shown that the abundance of red maple has increased substantially in the Northeastern United States since European settlement in the 1700s (Lorimer, 1977; McIntosh, 1972; Whitney, 1990). This is largely because red maple is an early- to mid-successional species, is able to persist in a wide range of soil and moisture conditions, and sprouts abundantly from stumps. These characteristics make red maple highly competitive in the more disturbed landscape of the past 300 years. Although it has increased in abundance throughout many disturbed upland forest types, red maple's prominence in hardwood swamps is not so much related to human disturbance, but rather is a "natural" phenomenon, because very few other tree species are able to survive in the saturated conditions of swamps.

PURPOSE

This inventory project was undertaken to investigate the distribution, quality, and variability of hardwood swamps across Vermont. The ecological information collected during the study was used to refine the classification of hardwood swamp natural community types and to identify some of the best examples of each community type in Vermont. Information about significant wetlands that were identified has been, or will be, provided to landowners, along with recommendations for management. This information will also be used to identify especially significant or threatened wetlands that warrant further conservation measures by the State of Vermont or by private conservation organizations.

The specific objectives of this project were to:

- Identify the extent, distribution, and variability of hardwood swamps in Vermont,
- Document vegetation composition, forest structure, and soil characteristics of hardwood swamps,
- Refine the natural community classification of hardwood swamp communities in Vermont based on data collection and analysis,
- Identify some of the best remaining examples of these natural community types,
- Notify landowners of the ecological significance of these wetland natural communities on their properties and provide them with management recommendations,
- Inform government and conservation planners of the significance of identified hardwood swamps,
- document rare plant species associated with these natural communities, and
- identify characteristic animals, especially breeding birds and amphibians, associated with each of these natural communities.

METHODS

The methods used in this inventory of hardwood swamp communities are similar in most regards to previous natural community inventories by NNHP (Thompson and Popp, 1995; Lapin, 1988; Sorenson et al., 1998a; Sorenson et al., 1998b). The inventory is divided into four stages: 1) landscape analysis, 2) landowner identification and contact, 3) field inventory, and 4) data compilation, analysis, and reporting. In addition to the traditional NNHP field inventory methods, a breeding bird survey and an amphibian survey were undertaken, and tree-core data were collected. Methods for these aspects of the study are described in the field inventory section below.

LANDSCAPE ANALYSIS

The purpose of the landscape analysis phase of the project was to identify particular swamps that were to be the focus for later, detailed field investigation. For several of the past statewide inventories of rare to uncommon community types conducted by NNHP (fens, clayplain forests, floodplain forests, and cedar swamps) the goal has been to identify all or most examples of the

community type in the state and then select the best examples for further detailed study. As a broad class, however, hardwood swamps are too common for that approach – there are more than 58,000 acres of hardwood swamp mapped in over 5,200 polygons by the National Wetlands Inventory in Vermont. Consequently, the approach for this project was somewhat different than past projects in that there was a need to sort out a very large number of potential study sites into a reasonable number that could be studied over a three year period and that represent the variability of hardwood swamps across Vermont.

The first step of landscape analysis was to review all exiting information on hardwood swamps contained in the NNHP Biotics database. This database contains over 5,000 records of rare plants, animals, and exemplary natural communities in Vermont, including records of 57 hardwood swamps that had been visited prior to the beginning of this study. A subset of these 57 swamps was selected for further field investigation based on whether they were high quality examples of particular community types, whether they were a rare community type, or whether additional quantitative or qualitative information was needed from the swamp.

The second step of landscape analysis, and the main source of information on identifying potential new hardwood swamps for study, was review of the National Wetlands Inventory maps for Vermont. Paper NWI maps on a U.S.G.S. topographic base map were checked for all areas of the state except for a few mountainous areas where few wetlands occur. Digital versions of these maps that include wetland types by polygon were not available for Vermont in 1999 when this project began. All swamps on the NWI maps typed as Palustrine Forested Broad-leaved Deciduous (PFO1), as well as mixed conifer swamps typed as Palustrine Forested Broad-leaved Deciduous and Needle-leaved Evergreen or Needle-leaved Deciduous (PFO1/4 and PFO1/2) were evaluated. Aerial photographs, especially the 1992-1994 set of color infrared photos (1:40,000) were viewed under a stereoscope for portions of the state where more information about a particular swamp or surrounding landscape was needed. Several general criteria were used to select swamps for further evaluation. Swamps were selected from all eight biophysical regions of the state. An attempt was made to select swamps to represent many topographic positions and many types of soil, surficial deposits, and bedrock. In general, larger wetlands were selected over smaller wetlands in a given area. And finally, swamps in relatively undisturbed landscapes were selected over those in highly developed or heavily logged landscapes.

Knowledgeable individuals, such as wildlife biologists, foresters, soil scientists, and naturalists were consulted for additional information and leads on other swamps that should be investigated.

Aerial reconnaissance in a small airplane was the final means for obtaining information for the landscape analysis. Prior to the flights, hardwood swamp locations obtained from the preceding steps were mapped on both 7.5' U.S.G.S. topographic quads (1:24,000 and 1:25,000) and on 1:100,000-scale topographic maps. The 1:100,000-scale maps were used for navigation and reference in the air. Aerial reconnaissance was carried out primarily during April and May, before leaf-out and when standing water in the swamps was readily visible. Reconnaissance information was recorded on a small tape recorder and later transcribed onto the master list. Oblique color print photographs were taken of most sites.

The products of the landscape analysis were a hardwood swamp master list and the set of topographic maps referred to above. Arranged by county and town, the master list contains site information, including quadrangle name and number, site name/location, site code, swamp size, site priority, description of site, and source of information. A total of 512 swamps were included in the master list.

LANDOWNER IDENTIFICATION AND CONTACT

It is the policy of Vermont Fish and Wildlife Department and the Nongame and Natural Heritage Program that privately owned sites will be visited only if specific permission from landowners has been obtained. In order to accomplish this, town clerks were contacted to identify landowners whose property included high and medium priority sites. These landowners were then contacted by a letter that explained the purpose of the inventory and asked for permission to visit their property. A total of approximately 600 landowners were contacted and provided return-stamped postcards for responding. Follow-up telephone calls were made to many landowners who did not respond and to landowners who indicated that they wanted more information.

FIELD INVENTORY

Field inventory was conducted in 1999 through 2002. Field methods consisted of both general observation of the site and quantitative vegetation sampling. Site observation entailed reconnoitering the swamp, developing a species list of vascular plants and bryophytes, periodically sampling organic soil depth with fiberglass chimney-sweep pole extensions, periodically sampling pH and conductivity of surface water with pocket meters, and noting characteristics of microtopography, hydrology (e.g., active seeps, flowing water), and vegetation patterns, including forest structure and tree diameter. In this way a general picture of the site was obtained and the variations and gradients present were observed. In smaller swamps, such reconnaissance may have covered much of the site, whereas in larger swamps a reconnaissance transect, the placement of which was based on aerial photo interpretation, was often used in an attempt to observe a great deal of the natural variation in the wetland in an expedient and relatively rapid manner. In some instances, permission was only available for a portion of the swamp and, therefore, site visits were restricted to these areas.

Quantitative Vegetation Sampling and Other Plot Data

Vegetation sampling followed standard methodology used by NNHP. Most plots were 400 square meters (20m x 20m). Plots were located in area of mature, representative vegetation. Both vegetative and biophysical data were collected. For each plot, vegetation cover was estimated by species by stratum for the following layers: emergent trees (T1), tree canopy (T2), small trees (T3), tall shrubs (S1), short shrubs (S2), herbaceous (H), and non-vascular (N). Species lists were constructed by stratum and percent cover was estimated for each species. Additionally for trees, diameters at breast height (dbh) for stems greater than 3.9 inches (10cm) were recorded. Unknown mosses and liverworts were collected and later identified, and voucher specimens will be deposited in the Pringle Herbarium at the University of Vermont. Two or more average-sized trees were cored to estimate stand age; most cores were read in the field and a subsample of the cores were further prepared and read again under a microscope. Biophysical data included soil profile description, depth of organic soil, degree of decomposition of organic soil layers by the von Post method, characterization of soil drainage and soil moisture regime,

and description of microtopography. The pH and conductivity of surface water was measured with field meters either in wet hollows or small holes dug in the swamp surface. Field meters were standardized each field day using three pH buffers (4.0, 7.0, and 10.0) and conductivity standard solution (447μS).

Taxonomy and nomenclature for vascular plants follows *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (Gleason and Cronquist, 1991). Bryophyte taxonomy follows Anderson, Crum, and Buck (1990) for mosses, except for Sphagnaceae, which follows Anderson (1990). Liverwort taxonomy follows Stotler and Crandall-Stotler (1977).

Breeding Bird Census

A breeding bird census was conducted in six of the hardwood swamps. The sampling protocol followed that used by the Vermont Institute of Natural Science in their Forest Bird Monitoring Program. Two to four listening stations were established at each of the six sites. The first station was established 100 meters into the community, and subsequent stations were located at 200-meter intervals. Care was taken that no station was less than 100 meters from the edge of the community type. Because of the small size of the communities that were sampled and concern about including birds from adjacent communities, there were fewer than the five listening stations that are recommended in the protocol. Four listening stations were established in Whiting Swamp, three in Conant Swamp, Maquam Wildlife Management Area, Mt. Tabor Floodplain Swamp, and Vernon Black Gum Swamps, and only two listening stations in Joslin Turn Swamp.

Each site was sampled twice during the breeding season - once during the first ten days of June and again seven to ten days later. In all cases both samples at a site were conducted by the same individual. All individuals conducting the sampling were skilled in identifying birds by song. The census began at dawn or very soon thereafter and entailed an observer listening at each station for a total of ten minutes before proceeding to the next station.

The data were evaluated to estimate the number of breeding individuals for each species at each site on a per listening station basis. For each listening station the number of breeding individuals was based on the type of observation. The following observations were tallied as two individuals: a singing male and any observation of a pair, family group, or nest. Alternatively, a calling individual and any visual observation (male or female) was tallied as a single individual. The number used was the higher of the two sampling times for each species. Once the number of individuals of every species was determined for all listening stations at the site, this total was divided by the number of listening stations. This provides a measure of the average number of individuals per listening station that allows direct comparison among the six sites. It also results in presentation of fractions of birds for most sites.

Amphibian and Reptile Survey

An amphibian and reptile survey was conducted in the same six hardwood swamps in which the breeding bird census occurred. Each site was visited on two or three occasions, generally based on the size of the wetland to be surveyed. Whiting Swamp, Conant Swamp, Mount Tabor Floodplain Swamp, and Vernon Black Gum Swamps were visited three times, while Maquam Bay WMA and Joslin Turn swamps were surveyed twice. Visits were spread out temporally

within the warm season (June-September) to attempt to detect a range of species that are not necessarily observable at the same time of year. For larger swamps, a different portion was surveyed on each visit. Three to five hours was spent surveying on each occasion.

Effort was focused primarily on areas of habitat interface, such as where uplands abut the swamp or where open pools and elevated land occur. Methods included searching for egg masses in open water, turning over logs and other cover materials, sweeping pools with a dipnet to find larvae, and listening for frog calls. Nearby portions of adjacent uplands were also searched in order to detect species that are seasonal users of swamps that may not be present within a swamp at the time of the survey. No quantitative methods were employed, as the focus of this survey was to detect presence/absence of as many species as possible. Recorded data included location of observations (i.e, within swamp/adjacent to swamp), detection of breeding, number of individuals observed for each species, and confidence level of identification.

Tree Age Measurements

In most study plots, one to three trees were cored using an increment borer. Trees chosen for coring were medium to large-sized canopy trees with no obvious external signs of interior rotting. When available, older looking trees, inside or outside of plots, were cored in order to get some idea of maximum age at a site. Furthermore, some trees were cored in different areas of a site that contained obviously different age class trees. Trees were cored at breast height and read in the field in most cases, although some cores that were difficult to read were brought back from the field, sanded, and read under a microscope. Tree ages and rates of growth were helpful in better understanding the history of natural and human disturbance at individual swamps and this information is included in site reports.

DATA COMPILATION, ANALYSIS, AND REPORTING

Information from the field inventory was compiled in site reports (see site reports organized by county and town in Appendix C) and in the manual (Geographic Manual File) and computerized (Biotics) databases of the Nongame and Natural Heritage Program. This information includes rank of the quality or ecological integrity of each site (A through D) compared to others in the state, information on any rare plants present, observations of wildlife use, and brief management guidelines to protect the natural community and species. In addition, the quantitative and qualitative vegetation and environmental data from 100 plots was entered into a Microsoft Access database and then converted to Microsoft Excel spreadsheets for analysis.

A map of wetland natural communities was made for each site that was visited during this inventory and also for those sites that were visited by NNHP staff prior to this inventory and included in the NNHP database. Natural community maps were made using ArcView GIS based on information in ecologists' field notes and field maps, digital topographic maps, digital NWI layers, and digital orthophotos. Attributes included for each polygon in this ArcView theme included site name, natural community type, acreage, and field ecologist's name. A separate point theme was developed based on this wetland natural community polygon theme. In this theme, a point was created at the centroid of each wetland polygon that represented a hardwood swamp natural community type. Attributes for this point theme were site name, natural community type, and a code for whether a vegetation plot was taken or simply a site visit conducted.

In order to help detect patterns in the vegetation among hardwood swamps, the vegetation and environmental data were analyzed using multivariate analyses techniques. These techniques included classification of the plots using Two-way Indicator Species Analysis (TWINSPAN) and ordination of the data using Detrended Correspondence Analysis (DCA). Both of these methods were developed by M.O. Hill at Cornell University (1979a and b) and analyses were run using the software package PC-ORD, version 4.2 (McCune and Mefford, 1999).

TWINSPAN was used to cluster or group hardwood swamp plots by similarity of the vegetation assemblages. TWINSPAN simultaneously classifies species and plots and displays both on a two-way table. In this two-way table, plots that are most similar based on their vegetation are grouped together. Vegetation species lists were edited to remove species that only occurred in one plot prior to analysis with TWINSPAN, as these rare species can introduce noise into the analysis.

Detrended Correspondence Analysis (DCA) was used in order to further explore the similarities and differences among hardwood swamp plots and to investigate relationships between plant communities and certain environmental variables. DCA ordinates species and sample plots using reciprocal averaging. The resulting graphs or ordinations of plots (hardwood swamps in this study) help to show similarities and differences between plots or groups of plots. Environmental parameters can be analyzed along with the plot ordinations to help elucidate the ecological basis behind plot groupings and the axes of the graphs.

Copies of this report and appropriate individual site reports are provided to landowners whose property was visited and contained a hardwood swamp of state or local significance. Copies of the full report with all site reports are also provided to all regional planning commissions, the Vermont Wetlands Office (Agency of Natural Resources), District Offices of the Agency of Natural Resources, the Vermont office of the U.S. Army Corps of Engineers, the Vermont Chapter of The Nature Conservancy, the Vermont Land Trust, and the U.S. Environmental Protection Agency.

RESULTS AND DISCUSSION

ABUNDANCE AND DISTRIBUTION OF HARDWOOD SWAMPS IN VERMONT

The U.S. Fish and Wildlife Service's National Wetlands Inventory has produced the most comprehensive maps available of wetlands distribution in Vermont. Only recently have these valuable maps been available digitally with attributes so that they can be used and analyzed with geographic information systems. All Palustrine Forested Broad-leaved Deciduous (PFO1), as well as all mixed conifer swamps typed as Palustrine Forested Broad-leaved Deciduous and Needle-leaved Evergreen or Needle-leaved Deciduous (PFO1/4 and PFO1/2) identified on the NWI maps for Vermont were analyzed in this study to provide information on the general abundance and distribution of hardwood swamps in Vermont. The distribution of this broad class of NWI-mapped wetlands was sorted by the eight biophysical regions of Vermont and the descriptive statistics for this data are shown in Table 1. The locations of the eight biophysical regions are shown in Figure 1.

There are several interesting conclusions that can be made from the information presented in Table 1. First, on the statewide scale, PFO1 wetlands occupy only 0.95 percent of the landscape, have a mean size of 11 acres, with the largest swamp being 4,235 acres (Cornwall Swamp). The Champlain Valley contains substantially more PFO1 wetland acreage (42,299 acres) and a much higher percentage of PFO1 wetland (3.5%) than does any other biophysical region. The sizes of individual wetlands in the Champlain Valley are also considerably larger than in any other region; the mean size is 18.8 acres with a standard deviation of 109. Many of these large Champlain Valley wetlands occur in the Otter Creek wetland complex of Addison and Rutland Counties and at the mouths of the Winooski, Missisquoi, and Lamoille Rivers. The flatter landscape, the warmer climate, the fine-textured soils, and the calcium-rich underlying bedrock of the Champlain Valley favor development of several hardwood swamp types. In contrast, the lowest percentage of PFO1 wetlands is found in the Northeastern Highlands (0.16%) and, on average, the smallest PFO1 wetlands are found in the Southern Vermont Piedmont (mean of 3.2 acres, standard deviation of 5.1). The Northeastern Highlands is one of the coldest regions of Vermont, and although there are substantial areas of forested wetland, most are softwood-dominated swamps. The very hilly terrain in the Southern Vermont Piedmont and several other regions results in most wetlands being much smaller than in the flat Champlain Valley and Vermont Valley.

It is important to note that in addition to hardwood-dominated swamps, the figures in Table 1 also include floodplain forests, which are mapped by NWI as "PFO1" but are not considered hardwood swamps in this report. Red Maple-Northern White Cedar Swamps are also included in these figures although they are not the subject of this report. Also, the computerized process (using ArcView GIS 3.2a) of dividing the NWI-mapped PFO1 polygons into the eight biophysical regions resulted in splitting NWI polygons that straddle the boundaries of the biophysical regions. Although there is likely little substantive change in the final presented results, this splitting of polygons does slightly increase the number of polygons and slightly decrease the average size of polygons in those regions affected.

Table 1. Descriptive statistics on the acreages of all Palustrine Forested Broad-leaved Deciduous NWI wetland polygons for the State of Vermont and the eight biophysical regions in Vermont.

Biophysical Region ➡ / Statistic ⬇	Champlain Valley	Northeast Highlands	Northern Green Mountains	Northern Vermont Piedmont	Southern Green Mountains	Southern Vermont Piedmont	Taconic Mountains	Vermont Valley	**State of Vermont**
Mean size (acres)	18.8	7.0	4.1	6.4	3.3	3.2	6.3	10.0	**11.0**
Standard Error	2.3	1.2	0.2	0.5	0.2	0.2	0.5	1.5	**1.0**
Standard Deviation	109.3	13.5	5.0	10.8	5.7	5.1	11.5	25.2	**72.0**
Sample Variance	11,952.8	182.7	25.1	116.9	32.3	26.4	132.4	633.3	**5,187.4**
Range (acres)	4,235.5	124.8	43.5	93.3	79.1	62.4	122.9	253.4	**4,235.5**
Maximum (acres)	4,235.6	124.9	43.7	93.5	79.2	62.6	123.1	253.5	**4,235.6**
Total PFO1 acreage	42,299.5	898.7	2,352.1	2,794.1	1,771.1	1,429.3	4,050.3	2,772.0	**58,367.1**
Number of Polygons	2,246	129	581	434	541	445	642	277	**5295**
Confidence Level (95.0%)	4.52	2.35	0.41	1.02	0.48	0.48	0.89	2.98	**1.94**
Size of Region (acres)	1,205,866	537,912	1,156,498	1,118,641	922,528	642,757	42,2040	146,676	**6,152,921**
Percent PFO1 by Region	3.51	0.16	0.2	0.25	0.19	0.22	0.96	1.89	**0.95**

DISTRIBUTION OF STUDY SITES

As part of this inventory, a total of 133 hardwood swamp sites were studied. All of these sites were visited, most during the course of the inventory project, although some were visited in prior years by NNHP staff, and information contained in the NNHP database was reviewed and included in this report. At the 133 sites, 163 distinct hardwood swamp areas (polygons) were identified and mapped. In other words, there were several distinct areas of hardwood swamp and some of the 133 sites. Figure 1 shows the locations of these 163 hardwood swamps and identifies the locations where quantitative vegetation plots were taken.

An additional 37 sites were visited at which there was either no hardwood swamp type present or, most commonly, the hardwood swamp had been flooded by beaver in recent years. Only limited information was collected at these sites.

Study sites were identified and visited in all eight biophysical regions, however, the few sites selected in the Northeastern Highlands turned out to be either small flooded hardwood swamps or natural community types other than the hardwood swamp types that are the subject of this study. Two of the larger wetlands identified as forested hardwood/softwood swamp (PFO1/4) on the NWI maps are actually Northern White Cedar Swamp with some hardwoods along the Clyde River and the Passumpsic River. Similarly, larger areas mapped as forested and shrub wetland (PFO1/SS1) on the NWI maps along the Moose River in Victory are actually floodplain communities, primarily Alluvial Shrub Swamp. Although there were several study sites in the Northern Green Mountains and Southern Green Mountains, the majority of the study sites were in the two Piedmont biophysical regions, the Taconic Mountains, the Vermont Valley, and especially the Champlain Valley. As shown in Table 1, the Champlain Valley contains almost three-quarters of the hardwood swamps in Vermont.

Site reports are provided in Appendix C for all of the sites visited during this project that were considered to be of state significance, as well as known state significant hardwood swamps from

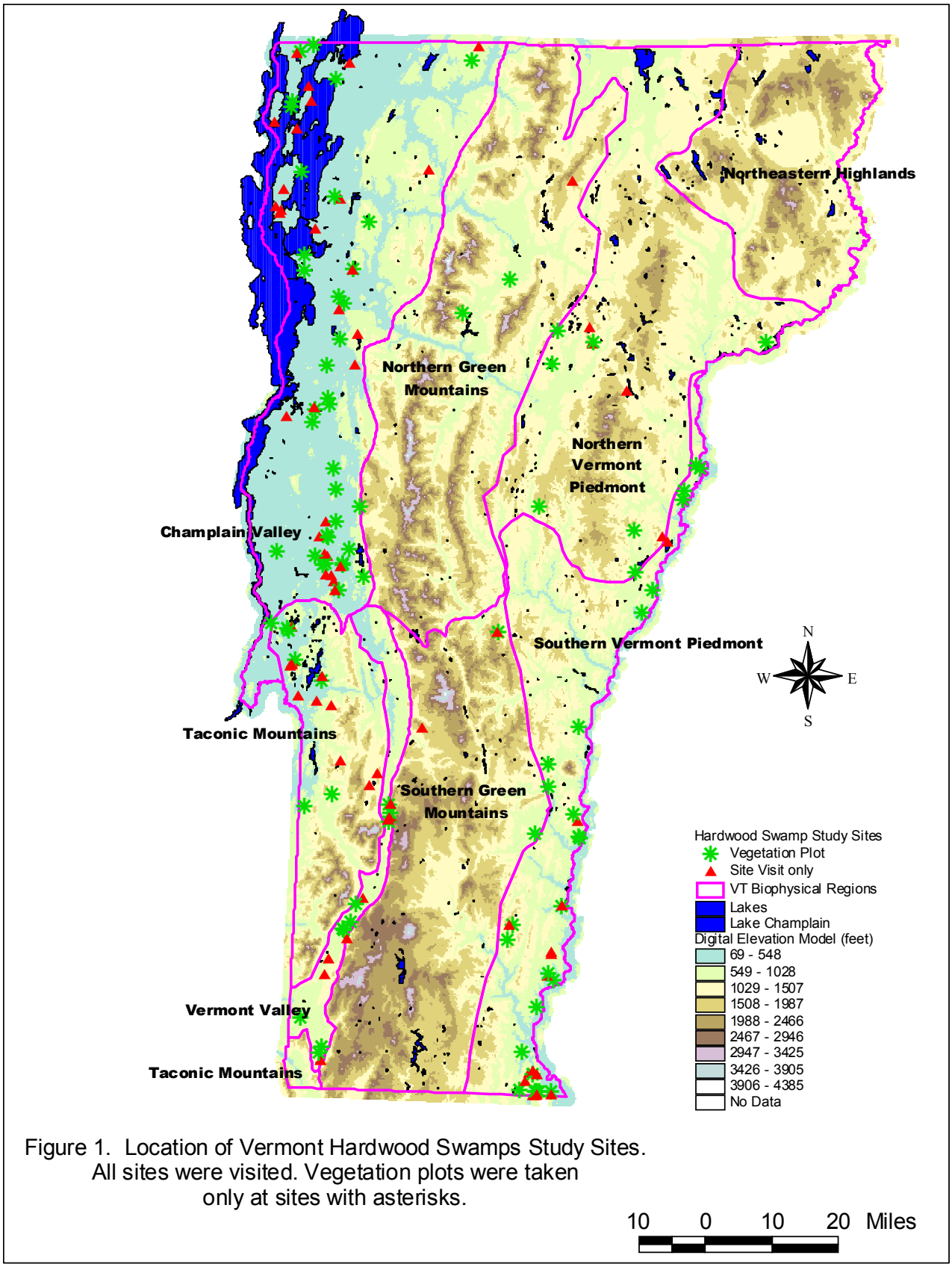


Figure 1. Location of Vermont Hardwood Swamps Study Sites. All sites were visited. Vegetation plots were taken only at sites with asterisks.

previous NNHP inventory work. Each site report provides a summary of the significant species and natural community types at the site, a general description of the hardwood swamp, general comments about the site, management guidelines, and a map showing the location of the site. The management guidelines are Nongame and Natural Heritage Program recommendations for landowners on protecting or enhancing the quality of the natural community or associated rare species. Many of the maps show the location of hardwood swamps occurring on private property. Permission of the landowners should be obtained before visiting these properties.

PLOT DATA ANALYSIS

A total of 100 vegetation plots were used for data analyses that are presented in this section. Several plots were eliminated from the analyses as it was determined by visual inspection of the vegetation data and preliminary multivariate analyses that these plots represented natural community types other than hardwood swamps.

A total of 467 species of plants were identified in the 100 vegetation plots. This includes 383 species of vascular plants and 84 species of bryophytes (mosses and liverworts). A list of these species is provided in Appendix A. Although the table containing this information is not presented in this report, it is available in a digital spreadsheet format (Microsoft Excel).[3] Percent cover was summed for each species in each plot and this data was used in the analyses. For both stages of multivariate analyses, those species that occurred only in one plot were deleted as these rare species can cause noise in the analyses. The resulting reduced table contained 100 plots and 349 species.

The first step in to classifying the 100 vegetation plots into community types was to use TwoWay Indicator Species Analysis (TWINSPAN). The two way ordered table resulting from this TWINSPAN identified four main types of hardwood swamps that appear to be ecologically meaningful. The full TWINSPAN table is presented in Appendix B. In this TWINSPAN table, the species (represented by six-letter codes) are in the left column, and the plots (represented by number codes) are in the top row. The vertical lines in the table show the groupings that are derived from the analysis, with the central solid line representing the primary division and the two dashed lines representing secondary divisions. The four TWINSPAN categories identified in the analysis are briefly described in Table 2, based on the dominant species present, species indicative of particular environmental conditions, and interpretation of what the environmental setting may be.

The second step in classifying the 100 plots was to ordinate the vegetation data using Detrended Correspondence Analysis (DCA). In DCA, the primary data matrix is the relative abundance (percent cover) of all plant species for each of the 100 plots. A secondary matrix of quantitative environmental and vegetation structure variables measured at each plot was included in the analysis in order to elucidate patterns between these variables and the distribution of swamp plots in the resulting DCA graph. Seven environmental/vegetation structure variables were included: elevation of the swamp, organic soil depth, total canopy cover, and total cover for tall shrubs, short shrubs, herbs, and bryophytes. In addition, the four TWINSPAN categories were

[3] Please contact Eric Sorenson, Nongame and Natural Heritage Program, Vermont Fish and Wildlife Department, (802) 241-3714 or eric.sorenson@anr.state.vt.us

Table 2. The four TWINSPAN swamp categories and the species characteristic of each.

TWINSPAN Category	Dominant and Indicator Species	Comments on Environmental Setting Based on Species	Number of Plots in this Category
1	red maple, red and black spruce, black gum, mountain holly, winterberry, highbush blueberry, cinnamon fern, three-seeded sedge, Sphagnum species	acidic, nutrient/mineral poor	27
2	red maple, black ash, yellow birch, hemlock, white pine, dwarf raspberry, cinnamon fern, three-seeded sedge, *Rhytidiadelphus triquetrus* (moss), *Calliergon cordifolium* (moss), Sphagnum species	acidic, some nutrient/mineral enrichment	14
3	red maple, black ash, yellow birch, cinnamon fern, crested wood fern, fowl mannagrass, water avens, foam flower, swamp saxifrage, golden saxifrage, spotted touch-me-not	significant nutrient and mineral enrichment	41
4	red maple, green ash, silver maple, winterberry, false nettle, blue flag, mosses few	nutrient enriched and periodically flooded	18

included in the secondary matrix as a categorical variable so that the results of the TWINSPAN could be compared with the DCA. Figure 2 shows the DCA graph of the 100 plots, with each plot coded to its TWINSPAN category, and vectors showing the two most important environmental/structural variables that were measured.

This ordination of the 100 plots in the DCA graph showed the same general groupings detected by TWINSPAN. Although the four broad types of hardwood swamps were well separated by this method, the ordination also illustrated that there was a continuum in variation among the plots and the swamps that they represent, as is expected in nature.

The environmental/vegetation structure variables measured at each plot can be related to the two axes in the DCA graph in Figure 2 by using correlation analysis. Total bryophyte cover was negatively correlated with Axis 1 (r^2=0.366). This means that those plots on the left side of Figure 2 generally have a greater percent cover of mosses and liverworts than do the plots on the right. This fits with the earlier observation that the category 4 swamps are periodically flooded, an environmental characteristic that excludes many bryophytes. There is a weaker correlation between elevation of the plots and Axis 1 (negative, r^2=0.102) and Axis 2 (positive, r^2=0.091). This fits with the fact that most of the plots in category 4 were in the lowlands of the Champlain Valley. A weak negative correlation between organic soil depth and Axis 1 was also found.

Field meters were used to measure the pH and conductivity of surface waters in many of the swamps visited. In order to correlate surface water pH with the DCA axes and the swamp plots it was necessary to reanalyze the set of 76 hardwood swamp plots for which pH was measured. Although that DCA graph is not presented here, it showed the same general distribution of plots as in the 100-plot ordination. However, pH was positively correlated with Axis 1 (r^2=0.242), meaning that the category 4 swamps had a higher pH than the category 1 swamps.

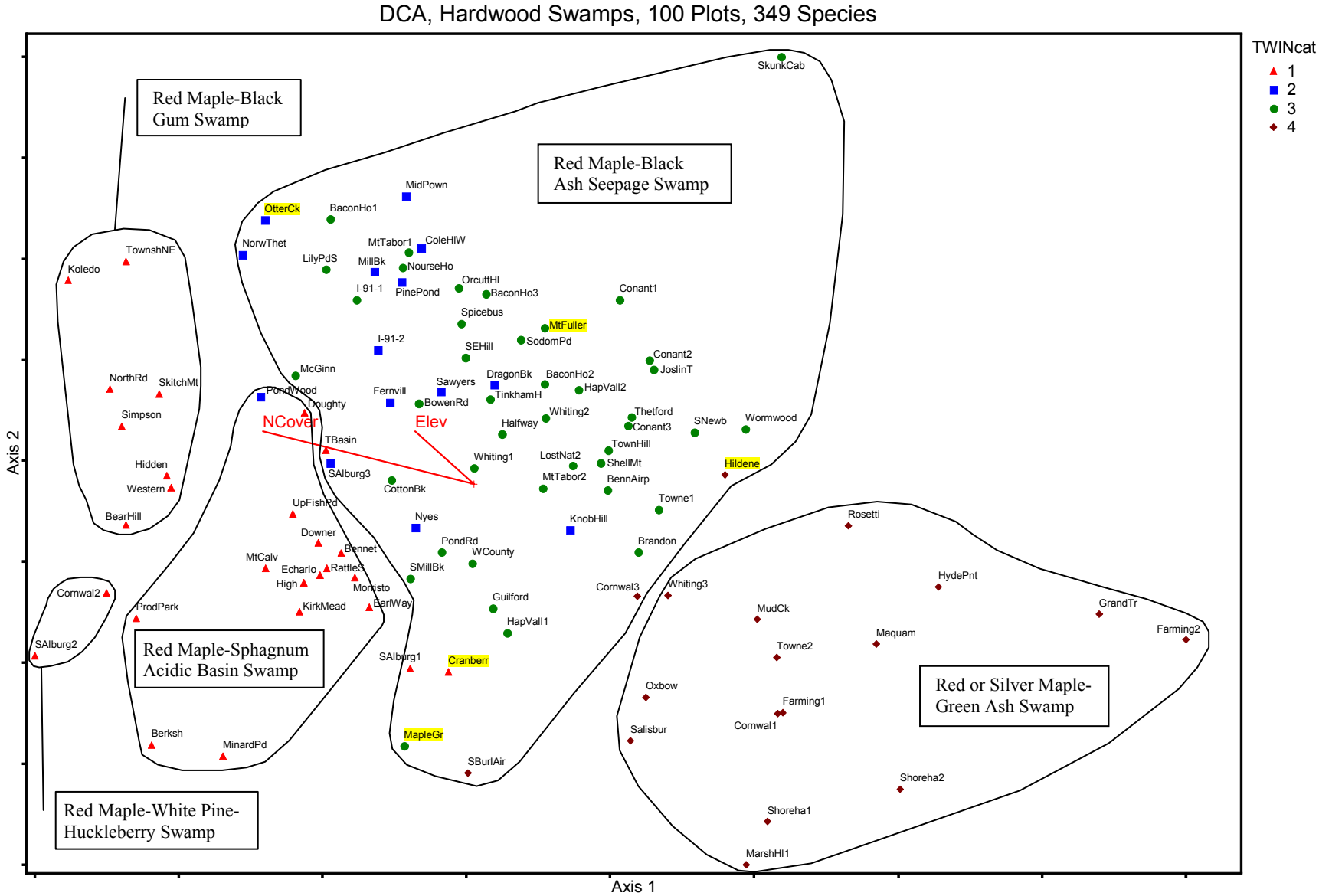


Figure 2. Detrended Correspondence Analysis graph of 100 hardwood swamp plots coded to their four TWINSPAN categories and showing vectors for two important environmental variables ("NCover" is total bryophyte percent cover for a plot; "Elev" is elevation of the plot). The hand-drawn polygons identify five of the natural community types that are described in the text. The Calcareous Red Maple-Tamarack Swamp plots are identified by yellow shading (xx).

Based on the foregoing analyses and taking into consideration the existing natural community classification for Vermont (Thompson and Sorenson, 2000) and the professional judgment of the authors, it was decided to recognize a total of six hardwood swamp natural community types and one variant. These community types are Red or Silver Maple-Green Ash Swamp, Red Maple-Black Ash Seepage Swamp, Calcareous Red Maple-Tamarack Swamp, Red Maple-Spagnum Acidic Basin Swamp and the Sandplain Swamp variant of this type, Red Maple-Black Gum Swamp, and Red Maple-White Pine-Huckleberry Swamp. The hand-drawn polygons and colored shading in Figure 2 separate the swamp plots into these six types that are described in detail in the next section.

The data analyses were clearly helpful in distinguishing five of these six natural community types. Red or Silver Maple-Green Ash Swamp fits closely with TWINSPAN category 4. Red Maple-Black Ash Seepage Swamp represents a combination of TWINSPAN categories 2 and 3, and includes the variation from swamps strongly enriched by minerals and nutrients (category 3) to those moderately enriched (category 2). Red Maple-Sphagnum Acidic Basin Swamp fits closely with TWINSPAN category 1 and represents the nutrient-poor end of the enrichment scale. Red Maple-Black Gum Swamp plots are also part of TWINSPAN category 1 and are closely related to Red Maple-Sphagnum Acidic Basin Swamp. The cluster of Red Maple-Black Gum Swamps in Figure 2 includes two Hemlock-Hardwood Swamps, which are very closely related. Although the Red Maple-White Pine-Huckleberry Swamp was not distinguished by TWINSPAN, the two plots from this community type were graphed separately in DCA and the type is very recognizable in the field. Calcareous Red Maple-Tamarack Swamp plots were not separated either by TWINSPAN or DCA, however all of these plots fall within the seepage category of swamps, which is appropriate. Additional study of Calcareous Red Maple-Tamarack Swamp is ongoing as part of a statewide inventory of swamps dominated by needle-leaved trees and additional plot data will be collected.

The decisions on which community types to recognize were based both on the data analyses and on professional judgement. The data analyses supported recognizing all of the community types except Calcareous Red Maple-Tamarack Swamp and the Sandplain Swamp Variant of Red Maple-Sphagnum Acidic Basin Swamp. However, both of these types are clearly recognizeable in the field due to distinct vegetation, vegetation structure, and characteristics of the physical environment in which they occur. Given the small number of plots from these types (5 plots from Calcareous Red Maple-Tamarack Swamps and one plot from Sandplain Swamp Variant) it is difficult to rely strictly on the data for decision making. Both of these types are believed to have significance for conservation of biological diversity and will therefore be recognized based on the qualitative and limited quantitative descriptions that are now available.

DESCRIPTIONS OF NATURAL COMMUNITY TYPES

As a result of this statewide hardwood swamp inventory, NNHP will now recognize seven types of hardwood swamps and one variant. Six of these community types and the variant are described below. Red Maple-Northern White Cedar Swamp is the seventh type and is not described here, as it was the subject of an earlier inventory project (Sorenson et al., 1998b). The only significant change in the types that will be recognized and tracked by NNHP is that the former Red Maple-Black Ash Swamp will now be split into two natural community types: Red Maple-Black Ash Seepage Swamp and Red Maple-Sphagnum Acidic Basin Swamp. In addition,

a Sandplain Swamp variant of the Red Maple-Sphagnum Acidic Basin Swamp will also be recognized. The following descriptions are taken in part from Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont (Thompson and Sorenson, 2000), although they have also been revised to incorporate new information from this study.

Red Maple-Black Ash Seepage Swamp

Red Maple-Black Ash Seepage Swamps are the most common type of hardwood swamp in Vermont. They occur in all biophysical regions, although they are least common in the Northeastern Highlands and in the Green Mountains. Red Maple-Black Ash Seepage Swamps are commonly the dominant community type in small basins in the hilly regions of Vermont, but they also occur as part of large and diverse wetland complexes in the relatively flat Champlain and Vermont Valley.

As the name suggests, these swamps are very closely associated with groundwater seepage, which is often visible as seeps and springs at the margins of the swamps. Red Maple-Black Ash Seepage Swamps occur in a variety of topographic settings, from basins to slope bases to streamsides. Red Maple-Black Ash Seepage Swamps are commonly the headwaters for intermittent or small perennial streams, as the groundwater discharge provides a regular flow of water. The shape of the basin in which the swamp occurs and the amount and seasonality of groundwater discharge are primary factors in determining the soil type that has developed in these swamps. The majority of swamps (39 out of 52 studied) had organic soil depths greater than 20 inches deep, and most of these (32 out of 39) had organic soils greater than 40 inches deep. These organic soils are generally well decomposed. Swamps with mineral soils or thin surface organic horizons generally occur in shallow basins and have intermittent groundwater flow, which allows organic material to dry out periodically and decompose more completely. Surface waters in Red Maple-Black Ash Seepage Swamps vary considerably in chemistry. Surface water pH ranges from 5.1 to 8.1 (40 samples), and conductivity ranges from 20 to 620µS. This variability is probably closely related to the chemistry of underlying bedrock and surficial geologic deposits. Hummocks and hollows are generally well developed in these swamps.

Red maple is typically the most abundant tree in the open canopy of these swamps. Black ash (*Fraxinus nigra*) is commonly a co-dominant tree species and is highly characteristic of the community type. Other trees commonly present include yellow birch (*Betula alleghaniensis*), American elm (*Ulmus americana*), hemlock (*Tsuga canadensis*), and white pine (*Pinus strobus*). Swamp white oak (*Quercus bicolor*) occurs in some swamps in the Champlain Valley. Typical shrubs include winterberry (*Ilex verticillata*), dwarf raspberry (*Rubus pubescens*), northern arrowwood (*Viburnum dentatum*), highbush blueberry (*Vaccinium corymbosum*), speckled alder

(*Alnus incana*), and in the south and warmer regions, spicebush (*Lindera bezoin*) and poison sumac (*Toxicodendron vernix*). Musclewood (*Carpinus caroliniana*) is an abundant tall shrub to short tree at some swamps. Cinnamon fern (*Osmunda cinnamomea*) is typically the most abundant herbaceous species. Other common species include sensitive fern (*Onoclea sensibilis*), goldthread (*Coptis trifolia*), Canada mayflower (*Maianthemum canadensis*), royal fern (*Osmunda regalis*), marsh fern (*Thelypteris palustris*), and crested fern (*Dryopteris cristata*). Herbaceous species that are present in varying amounts but reflect the mineral enrichment from groundwater seepage include fowl mannagrass (*Glyceria striata*), water avens (*Geum rivale*), delicate-stemmed sedge (*Carex leptalea*), foam flower (*Tiarella cordifolia*), swamp saxifrage (*Saxifraga pensylvanica*), golden saxifrage (*Chrysosplenium americanum*), naked miterwort (*Mitella nuda*), and spotted touch-me-not (*Impatiens capensis*). The bryophyte species are also indicative of some mineral enrichment: *Thuidium delicatulum*, *Climaceum dendroides*, *Rhytidiadelphus triquetrus*, and *Calliergon cordifolium* (in hollows). On the more acidic, raised hummocks *Sphagnum centrale*, *S. palustre*, and the liverwort *Bazzania trilobata* are more likely to be found.

Calcareous Red Maple-Tamarack Swamp

Calcareous Red Maple-Tamarack Swamps are a rare forested wetland type associated with calcium-rich groundwater seepage. They are closely related to Red Maple-Black Ash Seepage Swamps, although they also share characteristics with open fen communities. This community occurs primarily in the Vermont Valley, with examples also in the Champlain Valley and Southern Green Mountains. They are closely associated with calcium-rich bedrock types, such as limestone, dolomite, and marble. As with the more common seepage swamp type, Calcareous Red Maple-Tamarack Swamps occur along the margins of streams and in poorly drained depressions, which often form stream headwaters. Organic soils are permanently saturated, resulting in substantial accumulations of peat. Surface waters have circumneutral to slightly basic pH (7.2-7.6, 4 samples) and generally high conductivity (50-1,300µS, 3 samples). Microtopography is variable, ranging from flat, open fenny areas to more well-developed hummocks and hollows. Calcareous Red Maple-Tamarack Swamps may be the only wetland community type present in small basins or they may occur as part of large wetland complexes, intergrading with other wetland types such as Red Maple-Black Ash Seepage Swamp, Northern White Cedar Swamps, and Rich and Intermediate Fens.

Red maple and tamarack (*Larix laricina*) are the most abundant trees in a canopy that ranges from very open over the fenny areas to nearly closed. Other trees include black ash, yellow birch, and white pine. Characteristic shrubs that reflect the mineral-rich groundwater include alder-leaved buckthorn (*Rhamnus alnifolia*), shrubby

cinquefoil (*Potentilla fruticosa*), red-osier dogwood (*Cornus sericea*), and poison sumac. Other shrubs include highbush blueberry, northern arrowwood, dwarf raspberry, and poison ivy (*Toxicodendron radicans*). The herbaceous layer is rich in species, a feature common to many calcareous wetland types. Characteristic species include water avens, rough-leaved goldenrod (*Solidago patula*), yellow sedge (*Carex flava*), inland sedge (*Carex interior*), lakeshore sedge (*Carex lacustris*), delicate-stemmed sedge, and marsh marigold (*Caltha palustris*). Ferns are very abundant at some sites, especially royal fern (*Osmunda regalis*), cinnamon fern, and sensitive fern. Bryophytes include several species typically associated with fens, such as *Calliergonella cuspidata*, *Sphagnum warnstorfii*, *Campylium stellatum*, and the rare *Meesia triquetra*. *Sphagnum centrale* may form nearly complete cover on the tops of some hummocks. Successional trends in this community type are poorly understood. Tamarack is very shade intolerant and would not be expected to persist unless there is a regular disturbance that keeps the canopy open. Open canopy areas may be maintained by persistent groundwater discharge as in fens, or the openings could be the result of past land use history.

Red Maple-Sphagnum Acidic Basin Swamp

This is a previously undescribed type of hardwood swamp in Vermont. Red Maple-Sphagnum Acidic Basin Swamps occur throughout the state, although no examples are known from the Vermont Valley. These swamps occur in poorly drained basins and generally have deep, peaty organic soils. The mean organic soil depth from 14 swamps sampled was 10.8 feet. These organic soils are permanently saturated. Most swamps are small (mean of 13 acres based on 35 swamps) and occur in small perched basins. Surface watersheds are also small for these swamps, with a mean size of 95 acres for 23 swamps that were evaluated. There are generally no inlet streams and outlet streams are generally seasonal, at best. Some examples of this community type are found in larger wetland basins or associated with streams, but in these cases the Red Maple-Sphagnum Acidic Basin Swamp is above the influence of flooding from the stream. Red Maple-Sphagnum Acidic Basin Swamps are acidic (pH range from 3.7-5.8, 11 samples) and low in dissolved minerals (conductivity mean of 75µS, 9 samples). Although they receive surface water runoff, there is generally no evidence of groundwater seepage at the swamp margins. They have well-developed mossy hummocks and hollows that are also moss covered and generally lack standing water.

The tree canopy is dominated by red maple. Other trees species that are commonly present in lower abundance include yellow birch, hemlock, white pine, and red spruce (*Picea rubens*). Swamps that are dominated by hemlock or red spruce with a strong hardwood component are considered Hemlock-Hardwood Swamp and Red Spruce-Hardwood Swamp, respectively. There is clearly a continuum of variation between Red Maple-Sphagnum Acidic Basin Swamp and these two mixed-forest swamp types. The shrub layer of Red Maple-Sphagnum Acidic Basin Swamps is well developed and includes mountain holly, winterberry, highbush blueberry, wild raisin (*Viburnum cassinoides*), black chokeberry (*Photinia melanocarpa*), low sweet blueberry (*Vaccinium angustifolium*), sheep laurel (*Kalmia angustifolia*), swamp dewberry (*Rubus hispidus*), and speckled alder. Herbaceous cover is typically high, with cinnamon fern usually a strong dominant. Other species include three-seeded sedge (*Carex trisperma*), folliculate sedge (*Carex folliculata*), royal fern, marsh fern, northern bugleweed (*Lycopus uniflorus*), and on hummocks, Canada mayflower, wild sarsaparilla, and the boreal herbs goldthread (*Coptis trifolia*), star flower (*Trientalis borealis*), bunchberry (*Cornus canadensis*), and bluebead lily

(*Clintonia borealis*). The bryophyte cover is typically near 100 percent across both hummocks and hollows and is strongly dominated by sphagnum moss. Common hummock species include *Sphagnum centrale*, *Sphagnum magellanicum*, and *Sphagnum palustre*. On low hummocks and moist hollows *Sphagnum angustifolium*, *Sphagnum girgensohnii*, *Sphagnum fimbriatum* are all common. Other bryophytes include *Pleurozium schreberi* and *Bazzania trilobata*.

Sandplain Swamp Variant of Red Maple-Sphagnum Acidic Basin Swamp

This very rare swamp type is known from only a few locations on poorly drained sandy soils of Chittenden and northern Addison County. Additional examples may also occur in Franklin County and the Connecticut River valley based on soil types, but additional inventory is needed. Although sandy soils are generally well drained, these soils typically have an underlying impeding layer of silt or clay that retards drainage and results in seasonally high water tables, generally from fall through spring. The Sandplain Swamps are associated with small poorly drained areas (such as AuGres soils) in the Chittenden County sandplains and with larger areas of the sand-over-clay soils (such as Swanton soils) of the northern Addison County clayplain. There is usually a shallow organic soil horizon (mean thickness of six inches at two sites) over the sandy mineral soil.

Although Sandplain Swamps have similarities with both Red Maple-Sphagnum Acidic Basin Swamps and Red Maple-Black Gum Swamps, they are quite distinct. These swamps are all acidic – the soil pH of the only Sandplain Swamp measured was 4.6. These swamps all have small watersheds – the Sandplain Swamps occur in nearly level areas so watershed areas are extremely small. These swamps all occur in isolated basins or in shallow depressions and are not directly associated with flowing streams – the Sandplain Swamps near Otter Creek are an exception in that some may be seasonally flooded by the river. In contrast to the other types that remain saturated most of the year, Sandplain Swamps occur on sandy soils that become dry to moist during much of the summer season and this factor has a significant effect on vegetation.

Red maple is the dominant tree in the closed canopy of these swamps. Other trees present in varying amounts include white pine, gray birch (*Betula populifolia*), the rare black gum (*Nyssa sylvatica*), green ash, red oak (*Quercus rubra*), and occasionally, black oak (*Quercus velutina*) and pitch pine (*Pinus rigida*). Hemlock may also be present and in at least one example, the Sandplain Swamp grades into a sandy Hemlock-Hardwood Swamp. The shrub layer is well developed and is dominated by highbush blueberry, but also includes winterberry, wild raisin, mountain holly, black chokeberry, and swamp dewberry. The herbaceous layer is generally sparse and typically dominated by cinnamon fern. Other common herbs include Canada mayflower, royal fern, goldthread, and scattered three-seeded sedge. The uncommon folliculate sedge and skunk cabbage (*Symplocarpus foetidus*), which is restricted to the warmer valley regions of Vermont, are both characteristic species of these swamps. Mosses are also sparse, occur in patches in the wetter parts of these swamps, and may include *Sphagnum centrale*, *Sphagnum fallax*, and *Sphagnum fimbriatum*.

Red Maple-Black Gum Swamp

Red Maple-Black Gum Swamp is a rare community type that is closely related to Red Maple-Sphagnum Acidic Basin Swamps. Red Maple-Black Gum Swamp differs from Red Maple-Sphagnum Acidic Basin Swamp by the abundance of black gum and several other more southern species and its restricted distribution to southern Vermont. Red Maple-Black Gum Swamps occur in small basins that are generally isolated from streams. These swamp basins have very small watersheds. The water table in these wetlands appears to be relatively stable and the deep organic soils (mean depth of 11 feet at six swamps) are saturated throughout the growing season. The surface waters in Red Maple-Black Gum Swamps are acidic (pH range from 3.7-4.9, 5 samples) and low in dissolved minerals (conductivity mean of 55µS, 4 samples), indicating that there is little enrichment of the surface waters through contact with mineral soils. Red Maple-Black Gum Swamps occur primarily in southeastern Vermont, although they are also known much less frequently from the southern Champlain Valley and Vermont Valley. Red Maple-Black Gum Swamps are more common in southern New England, for black gum is at the northern extent of its range in Vermont.

Red maple and black gum co-dominate the canopies of these swamp forests. Black gum may reach very old ages and the deeply fissured bark of these large-diameter trees can be very impressive. Other common trees include yellow birch, red spruce, hemlock, and white pine. Swamps dominated by hemlock mixed with black gum and other hardwoods are considered Hemlock-Hardwood Swamps. Highbush blueberry and winterberry are usually the most abundant shrubs, but mountain holly, wild raisin, sheep laurel, and mountain laurel (*Kalmia latifolia*) are also present in varying amounts. Cinnamon fern is the most abundant herb, with a cover of 15 to 65 percent. Other herbs are generally sparse, including three-seeded sedge, goldthread, Canada mayflower, starflower, partridge berry (*Mitchella repens*), and wild sarsaparilla. The state threatened Virginia chain-fern (*Woodwardia virginica*) and very rare Massachusetts fern (*Thelypteris simulata*) are also associated with these swamps. The well-developed hummocks and hollows are carpeted with sphagnum moss, including *Sphagnum girgensohnii*, *Sphagnum magellanicum*, *Sphagnum centrale*, and *Sphagnum angustifolium*. The liverwort *Bazzania trilobata* occurs on downed, rotting wood and stumps.

Red Maple-White Pine-Huckleberry Swamp

This rare and narrowly defined community type is also closely related to the more common Red Maple-Sphagnum Acidic Basin Swamp. Red Maple-White Pine-Huckleberry Swamps are currently only known from three locations in the Champlain Valley. In all of these examples the Red Maple-White Pine-Huckleberry Swamp community is part of a larger forested wetland complex with deep organic soils – the average organic soil depth at two sites was 10.8 feet. The examples of this community type are found in the central portion of the larger wetland complexes in which they occur. The Red Maple-White Pine-Huckleberry Swamp communities appear to be on slightly raised portions of the wetland surface relative to adjacent wetland communities, although this should be confirmed by surveying. Surface water is acidic (pH range from 3.8-4.0 based on two samples) and low in dissolved minerals (conductivity of 70µS at one site), indicating that there is little influence of groundwater at the surface of these wetlands. Hummocks are low (generally less than 10 inches) and the hollows do not contain standing water, although the soils appear to be permanently saturated.

The canopy is co-dominated by red maple and white pine, which together form a tall, closed canopy. Black spruce (*Picea mariana*) occurs as a small tree and tall shrub, along with regeneration of the canopy trees. Tall-shrub cover is sparse and includes winterberry, highbush blueberry, mountain holly, and wild raisin. A characteristic feature of these swamps is the dense cover of black huckleberry (*Gaylussacia baccata*) in the short shrub stratum. Other short shrubs include black chokeberry, Labrador tea (*Ledum groenlandicum*), sheep laurel, and low sweet blueberry. Tall cinnamon fern and low, creeping goldthread are the most abundant herbs. Others include starflower, bluebead lily, wild sarsaparilla, Canada mayflower, and pink lady's slipper (*Cypripedium acaule*). The low hummocks and moist hollows are completely moss-covered, with *Sphagnum magellanicum* and *Sphagnum capillifolium* on hummocks and *Sphagnum centrale* and *Sphagnum angustifolium* in hollows. Other bryophytes include Schreber's moss (*Pleurozium schreberi*), *Bazzania trilobata*, and *Sphagnum fimbriatum*.

Additional study of these swamps is needed to explain their vegetative differences from other acidic basin swamps. Both the Cornwall Swamp and South Alburg Swamp examples have relatively young forests (trees are 80 to 100 years old), although the trees are large and have grown relatively fast. This tree age and size, the low hummocks, and the dominance of black huckleberry may indicate that the surfaces of these swamps burned in the past. However, evidence of past fires has not been noted.

Red or Silver Maple-Green Ash Swamp

Red or Silver Maple-Green Ash Swamps share characteristics with both Red Maple-Black Ash Swamps and Lakeside Floodplain Forests. All known examples of Red or Silver Maple-Green Ash Swamps are found in the Champlain Valley, where they occur primarily adjacent to Lake Champlain, but also in the floodplains of rivers like Otter Creek, and in isolated depressions. The common hydrologic characteristics of these varied physical settings are a long period of spring flooding or inundation and saturated soils during the remainder of the growing season. The soils of Red or Silver Maple-Green Ash Swamps are typically well-decomposed organic matter of substantial depth, but shallow organic and mineral soils are present in some swamps, especially those where soils dry out seasonally. The ground surface of some swamps has distinct hummocks and water-filled hollows in some swamps, and is relatively flat in others.

The forest structure of Red or Silver Maple-Green Ash Swamps can resemble that of floodplain forests, especially when silver maple is the dominant tree and forms a high canopy of spreading crowns. In other cases, the canopy may be dominated by red maple and/or the hybrid between red and silver maples known as *Acer* x *fremanii*. Green ash is an important component of the canopy in all sites and may dominate in some. Other trees include swamp white oak (*Quercus bicolor*), black ash, yellow birch, slippery elm (*Ulmus rubra*), and American elm. Along with seedlings and saplings of the overstory tree species, shrubs include winterberry, silky dogwood (*Cornus amomum*), red-osier dogwood, meadowsweet (*Spiraea alba*), and speckled alder (*Alnus incana*). The aquatic shrub buttonbush (*Cephalanthus occidentalis*) is present in some of the wettest hollows. The most common herbs are sensitive fern, royal fern, marsh fern, spotted touch-me-not, rice cutgrass (*Leersia oryzoides*), false nettle (*Boehmeria cylindrica*), blue flag (*Iris versicolor*), lakeshore sedge, common hop sedge (*Carex lupulina*), drooping sedge (*Carex crinita*), halberd-leaved tearthumb (*Polygonum arifolium*), and nodding and frondose beggar's ticks (*Bidens cernua* and *B. frondosa*). There is less bryophyte cover in Red or Silver Maple-Green Ash Swamps than in any of the other hardwood swamps studied. Based on 15 vegetation plots, the mean cover of bryophytes was only 12 percent, with a range of zero to 40 percent. The likely explanation for this is that these swamps are periodically flooded and many mosses and liverworts are not adapted to this environment. The most frequently occurring mosses are *Hypnum lindbergii*, *Climaceum dendroides*, *Thuidium delicatulum*, and in wet hollows, *Calliergon cordifolium*. Sphagnum moss is not common, although *Sphagnum centrale* and other species may be found occasionally on hummock tops.

SUMMARY OF NATURAL COMMUNITY TYPE CHARACTERISTICS

Table 3 provides a summary of the characteristics of the six hardwood swamp community types and one community variant that were part of this study as well as Red Maple-Northern White Cedar Swamp that was studied previously. The distinctions between the swamps can be made both in terms of vegetation and environmental characteristics. The primary environmental variables are climate, hydrology, nutrient enrichment, and soil type. Red Maple-Black Gum Swamps, Red or Silver Maple Green Ash Swamps, and Sandplain Swamps are found only in the warmest regions of the state. Red Maple-Sphagnum Acidic Basin Swamps, Red Maple-Black Gum Swamps, Red Maple-White Pine Huckleberry Swamps, and Calcareous Red Maple-Tamarack Swamps have organic soils that are permanently saturated. Red or Silver Maple-Green Ash Swamps are seasonally flooded or inundated. Deep organic soils are common except in the Sandplain Swamp, which has sandy soils that become dry seasonally. There is a gradient in dissolved mineral enrichment from the highly enriched Calcareous Red Maple-Tamarack Swamps to the nutrient-poor Red Maple-Sphagnum Acidic Basin Swamps and Red Maple-Black Gum Swamps. Figure 3 shows the distribution of the hardwood study sites classified to natural community type.

Table 3. A comparison of the distribution, environmental variables, and vegetation of hardwood swamp types. For those factors based on data collected in this study, mean, range, and number of samples (n) are provided. Qualitative descriptions are based on interpretation of the study data and professional judgment.

Community Type	Biophysical Regions (A)	Elevation (feet)	Size (acres)	Hydrology/ Enrichment	Soils	pH	Conductivity (µS)	Characteristic Trees / Shrubs	Characteristic Herbs / Bryophytes
Red Maple-Black Ash Seepage Swamp	all; uncommon in NEH	mean: 697 range: 100-1600 n=52	mean: 70.0 range: 1.0-708.1 n=69	permanently to seasonally saturated; enriched by groundwater seepage	mostly organic soils, some with mineral soils	5.1-8.1 (n=40)	mean: 167 range: 20-620 n=34	red maple and black ash, with yellow birch, hemlock, and white pine / dwarf raspberry, winterberry (north) and spicebush and poison sumac (south)	cinnamon fern, fowl mannagrass, water avens, foam flower, swamp saxifrage, golden saxifrage, spotted touch-me-not / *Thuidium delicatulum*, *Climaceum dendroides*
Calcareous Red Maple-Tamarack Swamp	primarily VV, also CV, TM, and SGM	mean: 620 range: 200-1050 n=5	mean: 17.6 range: 2.4-76.2 n=15	permanently saturated; enriched by groundwater seepage	mostly deep organic, some with mineral soils	7.2-7.6 (n=4)	mean: 527 range: 50-1300 n=3	red maple and tamarack, with black ash / alder-leaved buckthorn, shrubby cinquefoil, and red-osier dogwood	water avens, rough-leaved goldenrod, lakeshore sedge, inland sedge, marsh marigold / *Campylium stellatum*, *Sphagnum warnstorfii*
Red Maple-Sphagnum Acidic Basin Swamp	all except VV	mean: 708 range: 410-980 n=14	mean: 13.2 range: 0.9-61.8 n=35	permanently saturated; acidic; minimal contact with groundwater	organic soil (20-215 inches deep, n=14)	3.7-5.8 (n=11)	mean: 75 range: 50-120 n=10	red maple with yellow birch, red spruce, and hemlock / mountain holly, winterberry, and highbush blueberry	cinnamon fern and three-seeded sedge / *Sphagnum angustifolium*, *S. girgensohnii*, *S. centrale*
Sandplain Swamp Variant	CV	mean: 240 range: 160-240 n=2	Chitt. Co. mean: 17 range: 7-25 n=3	seasonally saturated; acidic; few nutrients from sandy substrate	sandy soils with thin surface organic horizon	4.6 (n=1)	unknown	red maple with gray birch, black gum, and green ash / highbush blueberry, winterberry, wild raisin, mountain holly, and black chokeberry	sparse cinnamon fern, Canada mayflower, and goldthread / sparse *Sphagnum centrale*, *S. fallax*, and *S. fimbriatum*
Red Maple-Black Gum Swamp	primarily SVP, rare in CV and VV	mean: 863 range: 669-1040 n=6	mean: 2.9 range: 0.1-9.0 n=21	permanently saturated; acidic; minimal contact with groundwater	organic soils (69-189 inches, n=6)	3.7-4.9 (n=5)	mean: 55 range: 35-75 n=4	red maple and black gum with hemlock, red spruce and yellow birch / mountain holly, winterberry, highbush blueberry	cinnamon fern and three-seeded sedge, / *Sphagnum girgensohnii*, *S. centrale*, and *S. magellanicum*
Red Maple-White Pine-Huckleberry Swamp	CV	mean: 225 range: 100-350 n=2	mean: 68.8 range: 47.4-90.3 n=2	permanently saturated; acidic; minimal contact with groundwater	organic soils (125-133 inches, n=2)	3.8-4.0 (n=2)	70 (n=1)	red maple and white pine with black spruce/ black huckleberry, sheep laurel, highbush blueberry	cinnamon fern and goldthread / *Sphagnum angustifolium*, *S. centrale*, *S. capillifolium*
Red or Silver Maple-Green Ash Swamp	primarily CV, rare in VV	mean: 253 range: 100-435 n=15	mean: 130.9 range: 0.7-811.6 n=34	seasonally flooded; enriched by flooding and/or contact with mineral soil	deep organic soils to mineral soils	6.1-7.4 (n=10)	mean: 294 range: 110-540 n=7	red maple, silver maple, and green ash with yellow birch / winterberry	sensitive fern, royal fern, false nettle, blue flag, spotted touch-me-not, hop sedge / sparse *Hypnum lindbergii*, *Climaceum dendroides*
Red Maple-Northern White Cedar Swamp	CV, TM, VV, and occasional in NVP	mean: 463 range: 100-1200 n=54	5-1700, most are over 140 acres	permanently to seasonally saturated; enriched by groundwater seepage & flooding	deep organic soils	6.2-7.6	mean: 174 range: 80-340	red maple and northern white cedar with black ash and yellow birch / dwarf raspberry and winterberry	sensitive fern, royal fern, cinnamon fern, naked miterwort / *Thuidium delicatulum*, *Hylocomnium splendens*

(A): CV=Champlain Valley, TM=Taconic Mountains, VV=Vermont Valley, NGM=Northern Green Mountains, SGM=Southern Green Mountains, NVP=Northern Vermont Piedmont, SVP=Southern Vermont Piedmont, NEH=Northeastern Highlands

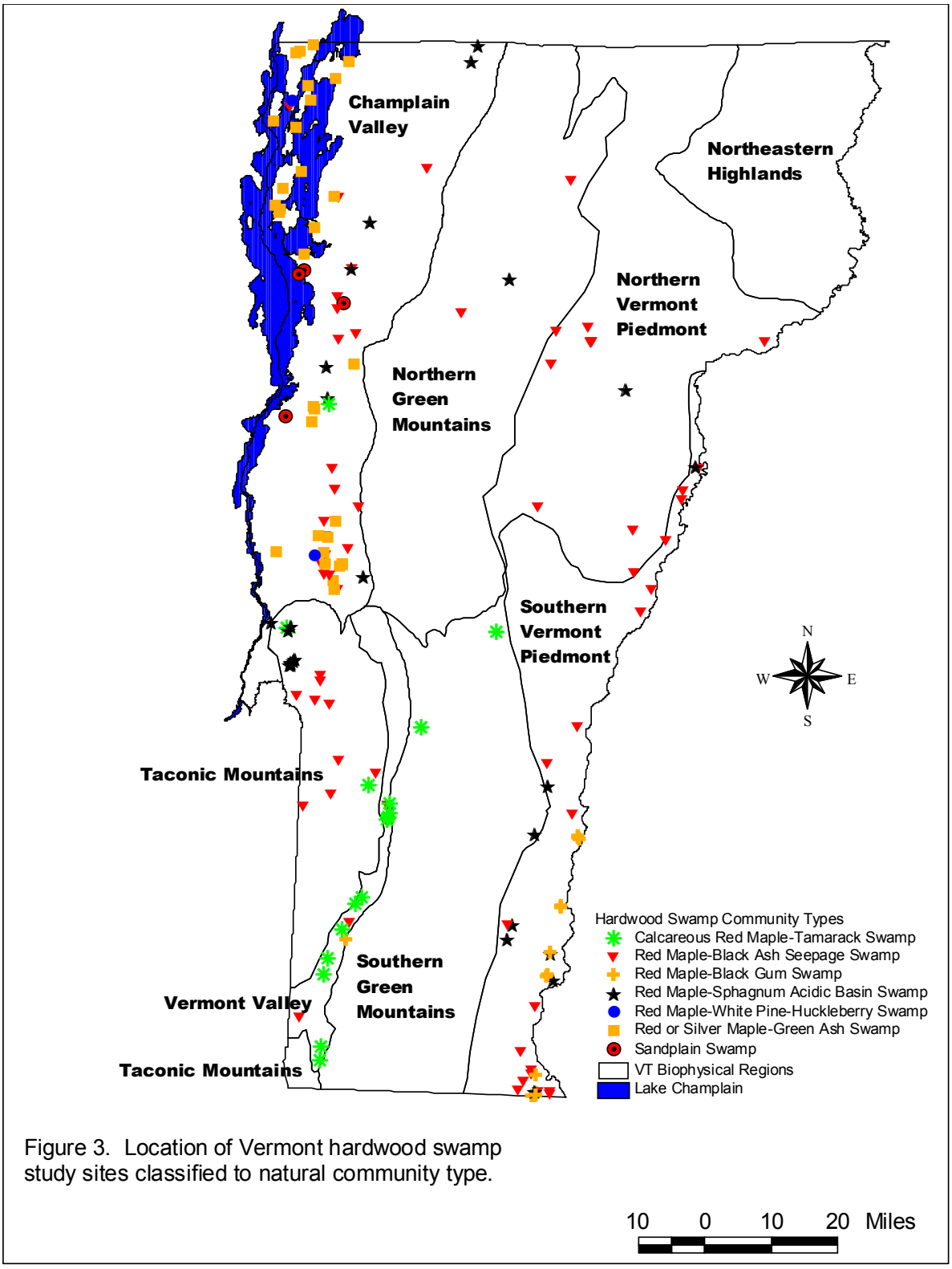


Figure 3. Location of Vermont hardwood swamp study sites classified to natural community type.

RELATIVE RARITY OF VERMONT'S HARDWOOD SWAMP COMMUNITY TYPES

The various types of hardwood swamps in Vermont have very different distributions across the landscape and vary in their relative abundance. Understanding and documenting the relative rarity of natural community types has long been a function of the Nongame and Natural Heritage Program and has important implications for setting conservation priorities. Understanding the reasons why a particular natural community type is rare can also be very helpful in developing conservation strategies. Community rarity may be a natural condition or it may be the result of human activity. Rarity is also a function of the area in which one looks for a community type.

Red Maple-Black Gum Swamp is an example of a community type that is rare in Vermont because one of the characteristic species (black gum) reaches the northern edge of its extensive southeastern United States range in Vermont, New York, New Hampshire, and Maine. Although these swamps are considered rare in Vermont and adjacent states, similar natural communities are more common further south.

Other communities are rare because the specific physical environmental conditions in which they occur are rare. Calcareous Red Maple-Tamarack Swamp is an example of this type of rarity. These swamps occur only in areas with underlying calcium-rich bedrock combined with topographic and hydrologic settings where there is permanent ground water discharge.

Human activity is also a cause of community rarity. The Sandplain Swamp Variant of Red Maple-Sphagnum Acidic Basin Swamp is found exclusively on poorly drained sandy soils, primarily in the Champlain Valley. As these swamps become relatively dry during summer months and have no stones, many examples have been cleared for agricultural uses, or more recently, have been drained and/or filled for development. No undisturbed examples of this community type are known at this time.

The community classification system itself can also be a factor in the relative rarity of natural community types. If a community type is too broadly defined, many examples will fit the definition, and the type will be considered widespread and common. In contrast, if a community type is too narrowly defined, very few examples will fit the definition, and the type will be considered rare unnecessarily. The important balance in this process is to identify community types that are distinct and recognizable, that repeat across the landscape, and that have significance for conserving biological diversity or making management decisions. NNHP will continue to update community classification and rarity ranking as new inventories are completed. The rarity ranks for the all hardwood swamp community types are provided in Table 4.

Table 4. Relative rarity of Vermont hardwood swamp natural communities.

Community Type	Rarity Rank
Red Maple-Black Ash Seepage Swamp	S4
Calcareous Red Maple-Tamarack Swamp	S2
Red Maple-Sphagnum Acidic Basin Swamp	S3 (new community type)
Sandplain Swamp Variant	S1 (new variant of community type)
Red Maple-Black Gum Swamp	S2 (revised from previous rank of S1)
Red Maple-White Pine-Huckleberry Swamp	S1
Red or Silver Maple-Green Ash Swamp	S3 (revised from previous rank of S2)

S1: **very rare** in the state, generally with fewer than five high quality occurrences
S2: **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

RANKING OF INDIVIDUAL HARDWOOD SWAMPS

The Nongame and Natural Heritage Program has developed criteria for ranking individual occurrences of natural communities. The ranking criteria for hardwood swamps were reviewed as a result of this inventory project and they were rewritten. The new ranking criteria consider three factors associated with the ecological integrity and quality of each hardwood swamp: size of the swamp, the current condition of the swamp, and the condition of the landscape surrounding the swamp. Each of these factors is ranked independently and assigned appropriate weighting, and then the ranks are combined to create an overall rank for the swamp. Large size, a condition reflecting minimal human disturbance, and a surrounding landscape with intact natural communities and minimal fragmentation are all factors that contribute to a high rank. In general, the higher the rank, the more likely it is that the community will be viable over long time periods and the higher its conservation value. However, lower ranked natural communities may have high conservation value for other reasons, such as rare species occurrences or important wildlife habitat. Also, in highly developed areas of the state, such as the Champlain Valley, there may be no highly-ranked examples of some natural community types due to the fragmented landscape. In cases like this, the best remaining examples likely have the highest conservation value. The importance of size as a ranking factor for hardwood swamps was down-weighted because size varies considerably from one biophysical region to another and recognizing geographic difference among the swamps was considered much more important than recognizing only large swamps as having the highest conservation value. Current condition and landscape quality were both weighted equally.

Sites are ranked on a scale of A to D, with A-ranked sites being the highest quality. All A, B, and C ranked examples of very rare (S1) and rare (S2) community types (see Table 4) are considered to be of statewide significance. Similarly, all A and B ranked examples of uncommon (S3) and widespread (S4) community types and all A ranked examples of common (S5) natural community types are considered to be of statewide significance. Other swamps that do not meet these ranking criteria may still have many important wetland functions and be of high local significance. Quality ranks are provided along with all site reports in Appendix C.

BEAVER AND OTHER FORMS OF NATURAL DISTURBANCE IN HARDWOOD SWAMPS

The predominant forms of natural disturbance in hardwood swamps are seasonal flooding from adjacent rivers or lakes, wind, and beaver. These natural disturbances all have the effect of creating openings in the swamp forests, but they vary in their extent, frequency, and severity. Most examples of Red or Silver Maple-Green Ash Swamps are prone to spring and fall flooding from adjacent rivers or Lake Champlain. The plant species present in these swamps are generally well adapted to prolonged inundation, but even green ash and silver maple will be killed in years with especially long spring flooding. When this occurs, openings in the canopy are created and a succession of shrubs and saplings generally regrows in the extra sunlight that reaches the swamp floor. The standing dead trees provide important habitat for many species of insects, woodpeckers, brown creepers, and cavity nesting birds such as woodpeckers, chickadees, and wood ducks.

Hurricanes may affect swamps and blow down many trees at once, but the frequency of this type of disturbance is rare and the low topographic position and short stature of the swamp trees relative to the adjacent uplands may provide some protection. The primary effect of wind in hardwood swamps is to blow down individual trees and open small canopy gaps. This small-scale disturbance is evident in almost every swamp that has been visited. Swamp trees generally have very shallow root systems due to the saturated soil conditions and consequently are more susceptible to blow-down than adjacent trees in the uplands that have deeper root systems. There are three major effects of these blow-downs on swamp ecology. When trees tip over they pull up soil with their roots and effectively mix the soils in the swamp. In swamps with shallow organic soils, these tip-ups can bring mineral soil to the surface and increase dissolved mineral and nutrient availability to plants. Tip-ups are also the primary process by which the swamp microtopography of hummocks and hollows is formed. Wet hollows and raised hummocks provide a diversity of microhabitats that would not be found in swamps lacking microtopography. Canopy gaps also provide increased light to the swamp floor and opportunity for growth of suppressed seedlings and saplings.

Beaver are ubiquitous in Vermont and are a significant form of natural disturbance in hardwood swamps and other wetland types. Although beaver were extirpated from Vermont by 1850 (Thompson, 1853), they were reintroduced in 1921, and are now abundant in every major watershed. Almost any swamp that is associated with a stream or that forms the headwater of a stream is susceptible to beaver activity. A rough estimate beaver of activity in hardwood swamps can be obtained by analyzing the National Wetlands Inventory (US Fish and Wildlife Service) digital maps for Vermont. A total of 5,561 acres of NWI forested wetlands, consisting of 1,261 separate polygons, are composed primarily of dead trees (PFO5), mixed dead and broad-leaved deciduous trees (PFO1/5), or specifically designated as altered by beavers. This represents nearly one-tenth of the total area of broad-leaved deciduous swamps in Vermont, as identified by NWI. This suggests that beaver are a very important factor in the dynamics of forested wetland communities. These figures include some softwood swamps that have been altered by beaver, so the percentage would be somewhat lower for just hardwood swamps. These figures do not include any areas of NWI wetland mapped exclusively as emergent or scrub-shrub, and it is very likely that many of these areas have resulted from beaver activity as well. Also, the NWI maps for Vermont were produced based on October 1977 aerial photographs and so are over 26 years old.

Another way of roughly quantifying the number of hardwood swamps altered by beaver is to evaluate those swamps that were visited for this statewide inventory. A total of 170 swamps were visited that included at least some area dominated by hardwoods. Of these, beaver activity that involved flooding of hardwood swamp was noted at 35 swamps. This estimate of nearly 21 percent of swamps altered by beaver is twice as much as was estimated by using the NWI maps and is likely still a low estimate.

It is estimated that beaver population in Vermont has increased significantly in Vermont since 1977 (the photo data for the NWI maps), and may still be lower than the population before intensive beaver trapping by European settlers in the 1600s and 1700s (Kim Royar, personal communication).

Beavers' affect on hardwood swamps is dramatic. The damming of a stream and the creation of an impoundment generally kills all trees and most shrubs within the impounded area and the upslope area in which the water table is significantly raised. An impoundment that only lasts a season may not kill all of the herbaceous vegetation and bryophytes, but most impoundments are maintained for many years. Beaver will remain at a site as long as there is a supply of young hardwood trees for food near the impoundment. An impoundment may persist for years before the dam fails and the beaver pond drains. The resulting mud flats are quickly colonized by annuals, then perennials, and eventually woody plants. Important wildlife habitat is created by all phases of this beaver impoundment cycle, from standing dead trees for birds and insects, to the pond itself for fish and waterfowl, to mud flats for shorebirds, to emergent marsh and shrub swamp for many species of birds and small mammals. Although beaver are clearly part of the natural disturbance cycle in hardwood swamps, there may be situations for which management of the beaver at a particular swamp is advisable, such as the presence of rare plant species or an old-growth swamp forest. The presence of a road or culvert may also promote beaver activity in areas where it may oterhwise be unlikely, and beaver management in these areas may also be necessary.

RARE AND UNCOMMON PLANT SPECIES

An impressive number of rare or uncommon plant species (36) were documented to occur in hardwood swamps in Vermont (Table 5). This is largely attributable to at least seven different types of hardwood swamp community types being represented. These seven types correspond roughly to differing biological and physical conditions to which each species individually and collectively responds. Some of these conditions are fixed, for example elevation, bedrock, and some aspects of hydrology such as the presence of seepage, while others are more a matter of chance, such as the presence of exotics, the amount of canopy closure, and other aspects of hydrology. The latter two features may be altered by beavers or humans, while canopy closure may also be affected by random events, such as ice storms. Canopy closure varies across the different types, although Calcareous Red Maple-Tamarack and Red Maple-Black Gum Swamps tend to be intrinsically more open than the other types.

Although a number of the rare or uncommon plants occur in only one swamp type, slightly more than half occur in two or more of the types. Three swamp types: Red Maple-Sphagnum Acidic Basin, Red Maple-Black Gum, and Red Or Silver Maple-Green Ash have at least one-third of

their rare plants as unique to the type. Both Calcareous Red Maple-Tamarack and Red Maple-White Pine-Huckleberry Swamps have no unique rare or uncommon plants. In between lie Hemlock-Hardwood and Red Maple-Black Ash Seepage Swamps with 15 to 17% of their rare plants being unique to the type. Red Maple-Black Ash Seepage Swamps have the greatest number of rare or uncommon plants, but this is largely a result of being the most common swamp type in the state. Conversely, the rarest type, Red Maple-White Pine-Huckleberry Swamps, have the fewest associated uncommon or rare plants.

The number of uncommon or rare plants in Table 5 is a conservative estimate in that it is restricted to those species that most certainly occur in hardwood swamp types rather than in any of the associated wetland types that occur at the site. It does not include species that occur in either cedar or hardwood-cedar swamps that comprise the majority of the cover in the huge Otter Creek swamps. However, there are a number of rare species that occur in both one of the hardwood types and one of the cedar types. Table 5 is arranged roughly from those swamp types dependent upon seepage, either calcareous or somewhat enriched, to those that are isolated and oligotrophic. There is a concurrent trend in pH that starts high in the seepage type and tends to drop across the other types to a low in the more isolated basin swamps.

Perhaps the rarest species encountered from a range-wide perspective is the federally and state endangered Northeastern bulrush (*Scirpus ancistrochaetus*) which was found at two Hemlock-Hardwood Swamps. More southern in its distribution, the Northeastern bulrush barely extends into the two southeastern counties of Vermont. Interestingly, its typical habitat in Vermont is beaver influenced marshes, but the two populations discovered during this inventory occur in small, perched, basin wetlands that are more typical of its habitat farther south.

One other state endangered and three state threatened species are known to occur in hardwood-dominated swamps. The other endangered plant, sharp manna-grass (*Glyceria acutiflora*), occupies a similar habitat to the bulrush in two of the Hemlock-Hardwood Swamps. This species is currently known from only four sites; however, there are three other historic populations in the state that may still exist. The very rare, Virginia chain-fern (*Woodwardia virginica*) is known from a Red Maple-Black Gum Swamp and a Sandplain Swamp. The other two known populations in the state occur in different natural community types: pitch pine bog and conifer swamp. The uncommon to rare white adder's mouth (*Malaxis monophyllos* ssp. *brachypoda*) grows primarily in cedar and hardwood-cedar swamps throughout Vermont, and more rarely in other calcareous swamps or upland sites. This small, inconspicuous plant was discovered in five Red Maple-Black Ash Seepage Swamps and was already known from Red or Silver Maple-Green Ash Swamps. Despite these new populations, the adder's tongue is far from secure. Everywhere that it grows the population size is very small, often consisting of only one individual. The final state threatened plant, large whorled pogonia (*Isotria verticillata*) is something of an anomaly in that this orchid typically occurs in uplands, most often sandplains. Its presence at a Sandplain Swamp attests to the unusual conditions and supports our conclusion that Sandplain Swamp is a significant variant of the Red Maple-Sphagnum Acidic Basin Swamp type. Unfortunately, the plant has not been observed since 1988, and it may have been extirpated from this site.

Although none of the other species are state listed, at least five of them are very rare (S1) and may warrant legal protection in the future. Perhaps rarest of all is smooth winterberry (*Ilex laevigata*) whose only known population in the state is in a Red Maple-Black Gum Swamp. This close relative of our common winterberry (*Ilex verticillata*) is likely a new species for Vermont's flora, one that is more southern and coastal in its distribution. Nearly as rare is the eastern mannagrass (*Glyceria septentrionalis*) which was recently discovered in the state at three sites. One of these is a Red Maple-Sphagnum Acidic Basin Swamp; the others are a Vernal Pool and a Buttonbush Basin Swamp. This species is more southern and western in its distribution. Massachusetts fern (*Thelypteris simulata*) is restricted to the southern part of the state and the Champlain Valley, typically occurring in hemlock swamps. One population occurs in a Red Maple-Black Gum Swamp. The diminutive and early flowering spring cress (*Cardamine rhomboidea*) is known presently from only three sites in the state, but historically it occurred in at least five other locations. All three sites are different except that they are all wetlands that are influenced by seepage. One of the sites is classified as a Red Maple-Black Ash Seepage Swamp. The inconspicuous large marsh bedstraw (*Galium obtusum*) is known currently from only two sites, but historically from eleven sites. The bedstraw has not been seen for over 100 years at many of the historic sites so it may be gone from many or all of them. One of the two extant sites is a peatland while the other is a Red Or Silver Maple-Green Ash Swamp in the Champlain Valley.

Nine of the species are considered to be rare (S2) in the state. While all the previously discussed species except white adder's mouth occurred in only one type of hardwood swamp, the majority of the rare species occur in more than one type. The first four discussed are limited to only one type. Swamp fly honeysuckle (*Lonicera oblongifolia*) may be thought of as more typical of cedar or hardwood cedar swamps, but it was located in a single Red Maple-Black Ash Seepage Swamp. Green adder's mouth, however, may be thought of as having more broad requirements ranging from seepage swamps to uplands. Here it was found in two separate Red Maple-Sphagnum Acidic Basin Swamps. False hop-sedge (*Carex lupuliformis*), a sedge that is restricted to marshes and floodplain forests along Lake Champlain was located in a single Red or Silver Maple-Green Ash Swamp, a community type that is very closely related to Lakeside Floodplain Forest. Narrow blue-eyed grass (*Sisyrinchium angustfolium*) appears to have an affinity to disturbed areas although it is known historically from sphagnum bogs. The population from one of the Red Maple-Black Gum Swamps was last observed in 1990, and it is questionable whether it is still extant given this species' seeming dependence upon disturbance.

The remaining five rare plants occur in multiple hardwood swamp types. Black gum (*Nyssa sylvatica*), in addition to being an important constituent of Red Maple-Black Gum Swamps, also occurs in four other swamp types. It is absent only from Calcareous Red Maple-Tamarack and Red Maple-White Pine-Huckleberry Swamps. Black gum is more common to our south, and here in Vermont it is restricted to the Champlain, lower Connecticut, and Vermont Valleys. Although it typically occurs here at lower elevations, two sites discovered during the inventory are at 980 and 1020 feet and constitute an elevational range extension for Vermont. American hazelnut (*Corylus americana*), most typical of Clayplain Forest in the Champlain Valley, was located in a Sandplain Swamp in the Champlain Valley and a Red Maple-Black Ash Seepage Swamp in the central Connecticut Valley during the inventory. Two easily overlooked species, the diminutive yellow bartonia (*Bartonia virginica*) and the cryptic Virginia bugleweed (*Lycopus*

virginicus), each had two new locations discovered as a result of the inventory. Prior to the inventory, roughleaf goldenrod (*Solidago patula*) was known from only a few sites in Vermont although there are many historic locations. Nine new populations were discovered in three different swamp types as a result of the inventory, although it is most closely associated with Calcareous Red Maple-Tamarack Swamps of the Vermont Valley.

The remaining 17 species are all uncommon to rare (S2/S3) or uncommon (S3). Only four of these show fidelity to one swamp type. Both small beggar's ticks (*Bidens discoidea*) and Gray's sedge (*Carex grayi*) were found in a Red or Silver Maple-Green Ash Swamp. Both species are previously known from floodplain forests and marshes, but are apparently restricted to the Champlain Valley. The mountain fly-honeysuckle (*Lonicera villosa*) which occurs sporadically in both cedar and hardwood-cedar swamps, was observed in one red maple-black ash swamp. Stout wood-reed grass (*Cinna arundinacea*) typically occurs in clayplain and floodplain forests, but was observed in three red or silver maple-green ash swamps.

The remaining uncommon plants occurred in multiple swamp types and are fairly well represented throughout the state; only a few deserve special mention. Loesel's twayblade (*Liparis loeselii)* was located in nine separate swamps during the inventory. Vegetative twayblades (*Liparis* sp.) were located in two additional swamps and are most likely this species. Although the twayblade occurs in five different types, absent only from red maple-black gum and red maple-white pine-huckleberry swamps, it is most commonly associated with seepage types. Regardless of the type, however, this small orchid typically is found in the lagg or moat surrounding the swamp where the influences of seepage are most pronounced and nutrient levels are highest. Prior to this inventory nodding trillium (*Trillium cernuum*) was known primarily from hardwood-cedar and cedar swamps in the Champlain Valley and the Lake Memphremagog watershed. During this inventory it was discovered in four Red Maple-Black Ash Seepage Swamps and one Hemlock-Hardwood Swamp in addition to three Red or Silver Maple-Green Ash Swamps where it was previously observed. Spicebush (*Lindera benzoin*) and maleberry (*Lyonia ligustrina*) were the most ubiquitous of the uncommon species. While both species are restricted to the Champlain, Connecticut, and Vermont Valleys, they were broadly distributed throughout the same four hardwood swamp types. Spicebush occurs in a total of 18 swamps and maleberry in 12 swamps.

Table 5. Rare and uncommon plants of hardwood- dominated swamps in Vermont.

Common Name	Scientific Name	State Status	Notes
Calcareous Red Maple-Tamarack Swamp			
Small yellow lady's slipper	*Cypripedium parviflorum*	Uncommon	1 swamp
Showy lady's-slipper	*Cypripedium reginae*	Uncommon	2 swamps
Spicebush	*Lindera benzoin*	Uncommon	3 swamps
Loesel's twayblade	*Liparis loeselii*	Uncommon	1 swamp
Maleberry	*Lyonia ligustrina*	Uncommon	3 swamps
Roughleaf goldenrod	*Solidago patula*	Rare	5 swamps
Red Maple-Black Ash Seepage Swamp			
Short-awn foxtail	*Alopecurus aequalis*	Uncommon	2 swamps
Cuckoo flower	*Cardamine pratensis var. palustris*	Unc. to Rare	2 swamps
Spring cress	*Cardamine rhomboidea*	Very Rare	1 swamp
Long Sedge	*Carex folliculata*	Uncommon	3 swamps
False Cyperus	*Carex pseudocyperus*	Uncommon	2 swamps
Swamp Thistle	*Circium muticum*	Uncommon	2 swamps
American hazelnut	*Corylus americana*	Rare	1 swamp
Small yellow lady's slipper	*Cypripedium parviflorum*	Uncommon	Observed in 1972 & '91 in two swamps
Showy lady's-slipper	*Cypripedium reginae*	Uncommon	2 swamps
Mountain laurel	*Kalmia latifolia*	Uncommon	2 swamps
Spicebush	*Lindera benzoin*	Uncommon	11swamps
Loesel's twayblade	*Liparis loeselii*	Uncommon	5 swamps
Twayblade	*Liparis sp.*	Unc. or Rare	2 swamps
Swamp fly-honeysuckle	*Lonicera oblongifolia*	Rare	1 swamp
Mountain fly honeysuckle	*Lonicera villosa*	Uncommon	1 swamp
Virginia bugleweed	*Lycopus virginicus*	Rare	1 swamp
Maleberry	*Lyonia ligustrina*	Uncommon	4 swamps
White adder's mouth	*Malaxis monophyllos ssp. brachypoda*	Threatened	5 swamps
Black gum	*Nyssa sylvatica*	Rare	2 swamps
Roughleaf goldenrod	*Solidago patula*	Rare	2 swamps
Nodding trillium	*Trillium cernuum*	Uncommon	4 swamps
Red or Silver Maple-Green Ash Swamp			
Yellow bartonia	*Bartonia virginica*	Rare	Observed in 1993
Small beggar ticks	*Bidens discoidea*	Unc. to Rare	1 swamp
Cuckoo flower	*Cardamine pratensis var. palustris*	Unc. to Rare	Observed in 1993
Gray's sedge	*Carex grayi*	Uncommon	1 swamp
False hop-sedge	*Carex lupuliformis*	Rare	1 swamp
False Cyperus	*Carex pseudocyperus*	Uncommon	Observed in 1985
Stout wood reed-grass	*Cinna arundinacea*	Uncommon	3 swamps
American hazelnut	*Corylus americana*	Rare	1 swamp
Showy lady's-slipper	*Cypripedium reginae*	Uncommon	1 swamp
Large marsh-bedstraw	*Galium obtusum*	Very Rare	Observed in 1993
Loesel's twayblade	*Liparis loeselii*	Uncommon	1 swamp
White adder's mouth	*Malaxis monophyllos ssp. brachypoda*	Threatened	Observed in 1983 and '93 in two swamps
Black gum	*Nyssa sylvatica*	Rare	2 swamps

Common Name	Scientific Name	State Status	Location and Notes
Red or Silver Maple-Green Ash Swamp			
Yellow water-crowfoot	*Ranunculus flabellaris*	Uncommon	Observed in 1992
Nodding trillium	*Trillium cernuum*	Uncommon	Observed in 1992, '93, & '96 in three swamps
Red Maple-White Pine-Huckleberry Swamp			
Yellow bartonia	*Bartonia virginica*	Rare	1 swamp
Hemlock-Hardwood Swamp			
Short-awn foxtail	*Alopecurus aequalis*	Uncommon	1 swamp
Long Sedge	*Carex folliculata*	Uncommon	2 swamps
Small yellow lady's slipper	*Cypripedium parviflorum*	Uncommon	1 swamp
Sharp manna-grass	*Glyceria acutiflora*	Endangered	2 swamps
Spicebush	*Lindera benzoin*	Uncommon	3 swamps
Loesel's twayblade	*Liparis loeselii*	Uncommon	1 swamp
Virginia bugleweed	*Lycopus virginicus*	Rare	1 swamp
Maleberry	*Lyonia ligustrina*	Uncommon	3 swamps
Black gum	*Nyssa sylvatica*	Rare	1 swamp
Northeastern bulrush	*Scirpus ancistrochaetus*	Endangered	2 swamps
Roughleaf goldenrod	*Solidago patula*	Rare	2 swamps
Nodding trillium	*Trillium cernuum*	Uncommon	1 swamp
Red Maple-Sphagnum Acidic Basin Swamp, including Sandplain Swamp Variant			
Yellow bartonia	*Bartonia virginica*	Rare	1 swamp
Long sedge	*Carex folliculata*	Uncommon	4 swamps
Swamp Thistle	*Circium muticum*	Uncommon	1 swamp
Eastern mannagrass	*Glyceria septentrionalis*	Very Rare	1 swamp
Large whorled pogonia	*Isotria verticillata*	Threatened	Observed in 1988 in 1 Sandplain Swamp
Loesel's twayblade	*Liparis loeselii*	Uncommon	1 swamp
Green adder's mouth	*Malaxis unifolia*	Rare	2 swamps
Black gum	*Nyssa sylvatica*	Rare	2 swamps
Virginia chain-fern	*Woodwardia virginica*	Threatened	1 Sandplain Swamp
American hazelnut	*Corylus americana*	Rare	1 Sandplain Swamp
Gray's sedge	*Carex grayi*	Uncommon	Observed in 1982 in 1 Sandplain Swamp
Red Maple-Black Gum Swamp			
Yellow bartonia	*Bartonia virginica*	Rare	1 swamp
Long sedge	*Carex folliculata*	Uncommon	2 swamps
Smooth winterberry	*Ilex laevigata*	Very Rare	1 swamp
Mountain laurel	*Kalmia latifolia*	Uncommon	1 swamp
Spicebush	*Lindera benzoin*	Uncommon	1 swamp
Maleberry	*Lyonia ligustrina*	Uncommon	2 swamps
Black gum	*Nyssa sylvatica*	Rare	8 swamps
Yellow water-crowfoot	*Ranunculus flabellaris*	Uncommon	1 swamp
Narrow blue-eyed grass	*Sisyrinchium angustfolium*	Rare	Observed in 1990
Massachusetts fern	*Thelypteris simulata*	Very Rare	1 swamp
Virginia chain-fern	*Woodwardia virginica*	Threatened	1 swamp

INVASIVE AND EXOTIC PLANT SPECIES

Although no systematic inventory was conducted for the presence and abundance of invasive and exotic plants, their presence was noted when they were encountered. A total of nine invasive or potentially invasive plant species and four naturalized, exotic plant species were noted during the inventory (Table 6). Five of the invasive species are included as Class B species under Vermont's Noxious Weed Quarantine Rule (6 V.S.A., Chapter 84, Pest Survey, Detection and Management). This means that they are considered to pose a serious threat to the state, and their sale, distribution, or movement within the state is prohibited. Three others are on the Watch List, which indicates that they potentially pose a threat, but their status is still under review. There is one species that although considered as non-native to Vermont, does not appear to pose any threat at present. Lastly, there are the four naturalized, exotic plants that are ubiquitous throughout our region, but especially in early successional or highly disturbed habitats

The two most abundant invasive plants are the two buckthorns: glossy (*Rhamnus frangula*) and common (*R. cathartica*). This duo occurred in 19 and 16 swamps, respectively. Although both buckthorns pose a serious threat to natural communities, the glossy buckthorn is more of a concern in wetlands since it tolerates wetter conditions than its cousin. Common buckthorn is more likely to encroach on wetlands from the edge. Morrow's honeysuckle (*Lonicera morrowii*), Japanese barberry (*Berberis thunbergii*), and common barberry (*B. vulgaris*) occur in seven, three, and one swamp, respectively. Although the honeysuckle can severely impact natural communities and the two barberries can also be detrimental, they all prefer drier, more open conditions and are unlikely to proliferate in swamps with intact canopies and hydrology. The next three species, reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), and common reed (*Phragmites australis*) are more problematic in open wetlands and pose a minimal threat to swamps with intact, closed canopies. Both grasses apparently have both native and introduced strains, and it is presumably the latter that spreads extensively, especially in disturbed areas. Ninebark (*Physocarpus opulifolius*), although native to our west and south, is apparently escaped from cultivation in New England, but is presently not considered to be invasive.

The presence of the four naturalized species is generally correlated with the presence of disturbance and the proximity to roads, lawns, and dwellings. It should be recognized, however, that many types of natural disturbance, such as beaver activity and seasonal flooding, also encourage the establishment of these more ruderal species. This is supported by their greatest abundance being concentrated in the two swamp types that are most affected by beaver and seasonal flooding: Red Maple-Black Ash Seepage Swamps and Red or Silver Maple-Green Ash Swamps.

Not surprisingly the more isolated basin type of swamps are less impacted by invasive exotics since there is less of a hydrologic connections with other wetlands. The presence of exotics is also a function of swamp size and how isolated the swamp is from human activities. Generally speaking, those swamps in or near urban areas are more heavily infested than those swamps that are in more rural areas. Proximity to roads is also a factor. However, even the most remote swamps can harbor populations of exotic plants, presumably brought there by birds, animals, or hikers.

Overall, the most heavily impacted hardwood swamp type in terms of exotics is the Red Maple-Black Ash Seepage Swamps, followed by Red Or Silver Maple-Green Ash Swamps. Aside from their size and location, these two swamp types presumably harbor more exotics because of their hydrology and more neutral, or at least less acidic, conditions. The hydrological connections of these types via streams, rivers, or lakes readily permit the movement of exotics into these wetlands. The buckthorns and honeysuckle seemingly prefer the less acidic conditions in these swamps as evidenced by their much lower abundance in most of the other swamp types. Far behind these two types in the number of swamps with exotics is the Calcareous Red Maple-Tamarack type. This is largely a result of this type being less abundant than the other two. Otherwise, one would expect more infestations, especially by honeysuckle and the buckthorns because of the more calcareous and mineral-rich conditions associated with this type.

Exotics were apparently absent from Red Maple-White Pine-Huckleberry Swamps. Glossy buckthorn occurred in four of the Red Maple-Sphagnum Acidic Basin Swamps. One of these is in a very urban setting, while two others are adjacent or quite near to major roads. The fourth swamp, Earl's Way, is quite remote, and the presence of glossy buckthorn is something of an enigma. Surprisingly, two of the Red Maple-Black Gum Swamps also harbor small populations of glossy buckthorn. In addition to being in isolated basins, both of these swamps are located in fairly remote areas of the state, approximately one-quarter and one-half mile from the nearest roads. These infestations in relatively remote swamps may be the result of dispersal of seeds by birds, racoons, or other animals. Since all three of these swamps are quite acidic, however, the buckthorn is unlikely to spread widely, especially if the canopy cover and natural hydrology are maintained.

Table 6. Invasive and exotic plants of hardwood swamps in Vermont.

Community Type / Species Common Name	Scientific Name	State Status	Frequency
Calcareous Red Maple-Tamarack Swamp			
Japanese barberry	*Berberis thunbergii*	Watch List	1 Swamp
Morrow's honeysuckle	*Lonicera morrowii*	Class B	1 Swamp
Purple loosestrife	*Lythrum salicaria*	Class B	2 Swamps
Reed canary grass	*Phalaris arundinacea*	Watch List	2 Swamps
Ninebark	*Physocarpus opulifolius*	None	1 Swamp
Common buckthorn	*Rhamnus cathartica*	Class B	2 Swamps
Glossy buckthorn	*Rhamnus frangula*	Class B	3 Swamps
Common nightshade	*Solanum dulcamara*	Naturalized	3 Swamps
Red Maple-Black Ash Seepage Swamp			
Japanese barberry	*Berberis thunbergii*	Watch List	2 Swamps
Common barberry	*Berberis vulgaris*	Watch List	1 Swamp
Ground ivy	*Glechoma hederacea*	Naturalized	1 Swamp
Morrow's honeysuckle	*Lonicera morrowii*	Class B	4 Swamps
Purple loosestrife	*Lythrum salicaria*	Class B	1 Swamp
Reed canary grass	*Phalaris arundinacea*	Watch List	3 Swamps
Common buckthorn	*Rhamnus cathartica*	Class B	10 Swamps
Glossy buckthorn	*Rhamnus frangula*	Class B	10 Swamps
Common nightshade	*Solanum dulcamara*	Naturalized	11 Swamps
Common dandelion	*Taraxacum officinale*	Naturalized	4 Swamps
Red or Silver Maple-Green Ash Swamp			
Morrow's honeysuckle	*Lonicera morrowii*	Class B	2 Swamps
Moneywort	*Lysimachia nummularia*	Naturalized	2 Swamps
Purple loosestrife	*Lythrum salicaria*	Class B	2 Swamps
Reed canary grass	*Phalaris arundinacea*	Watch List	6 Swamps
Common reed	*Phragmites australis*	Class B	1 Swamp
Common buckthorn	*Rhamnus cathartica*	Class B	4 Swamps
Common nightshade	*Solanum dulcamara*	Naturalized	11 Swamps
Common dandelion	*Taraxacum officinale*	Naturalized	2 Swamps
Red Maple-Sphagnum Acidic Basin Swamp			
Glossy buckthorn	*Rhamnus frangula*	Class B	4 Swamps
Common nightshade	*Solanum dulcamara*	Naturalized	1 Swamp
Red Maple-Black Gum Swamp			
Glossy buckthorn	*Rhamnus frangula*	Class B	2 Swamps

BREEDING BIRD SURVEY

A total of 56 species were observed, and presumed to be nesting, at the six hardwood swamps that were surveyed (Table 6). The locations of the six sites are shown in Figure 4. Of the 56 species, 30 species were observed at only one of the six sites. Seventeen species were observed from at least half the sites (three or more), while only four occurred at all six sites. Only a single uncommon species was noted during the inventory. A blue-gray gnatcatcher was heard calling on June 19, 2001 at Maquam WMA. Although the habitat fit the species preference for wet bottomlands near Lake Champlain or the Connecticut River, it was not determined whether the species was nesting.

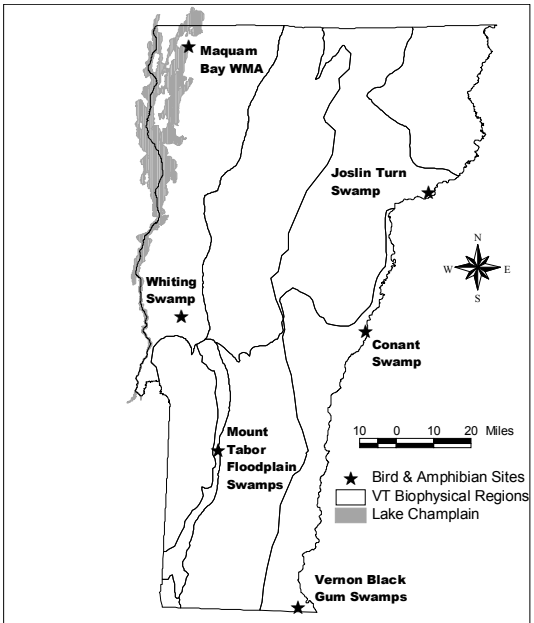


Figure 4. Location of the six hardwood swamps surveyed for breeding birds and amphibians.

Those 17 species occurring in at least half the sites might be considered to be reasonable indicators of hardwood swamps although the majority of these have higher fidelity to forests in general, with only a few of the bird species showing a preference for deciduous forest, and fewer still for hardwood swamps. Perhaps the most characteristic species of the hardwood swamp community types is the northern waterthrush, which occurred at all six sample sites and was the second highest species in numbers. However, this species is apparently characteristic of swamps of other types as well, since it was the most abundant bird in both hardwood-cedar and cedar swamps (Sorenson, et. al, 1998b). The northern waterthrush's special habitat requirements are described as wet, shady, and brushy areas with open water and hummocks (DeGraaf and Yamasaki, 2001), conditions found in many swamps associated with streams or with large wet hollows. There are some striking differences, however, in the dominant avian species among the swamp types. The next most abundant species in the two cedar types was the winter wren, which occurred in only two of the hardwood swamps and was common in only one. The three most abundant species of cedar swamps (yellow-bellied flycatcher, Swainson's thrush, and dark-eyed junco) were all completely absent from the hardwood swamps. The most abundant species of the hardwood-cedar type, the great crested flycatcher, was well represented in this study as well, occurring in four of the hardwood swamps. It was notably absent from cedar swamps.

Since all of the six swamps sampled are ranked as either excellent or good quality, many of the nesting species encountered in this survey might be expected to occur in other similar quality examples of this community type. The absence of those species that are most sensitive to human disturbance might indicate some level of impairment in the swamp or the surrounding landscape. Alternatively the presence of species that are associated with disturbed or human-influenced environments, such as starlings and cowbirds, might be a better indication of impaired conditions in these swamps. Overall, this study does not provide adequate data to use birds as indicators of swamp impairment, but this could be done with further study.

Table 6. Average number of birds per species per listening station for six hardwood swamps.

Site	Conant Swamp	Joslin Turn Swamp	Maquam WMA	Mount Tabor Floodplain	Vernon Black Gum Swamp	Whiting Swamp	Avg. # of individuals per listening station	Frequency
Number of Listening Stations	3	2	3	3	3	4		
Species								
Common Yellowthroat	2	2	0.67	3.33	0.67	4	**2.11**	6
Northern Waterthrush	2.67	3	2	1.33	0.67	2	**1.95**	6
Veery	2	1	2	2.67	1.33	2.5	**1.92**	6
Red-eyed Vireo	1.33	2	1.33	0.67	1.33	0.5	**1.19**	6
Black-capped Chickadee	0.67	1	2	1.33	0.33	0	**0.89**	5
American Robin	0.33	1	0.33	1.33	0	0.75	**0.62**	5
Hairy Woodpecker	1	1	0	0.67	0.33	0.5	**0.58**	5
Eastern Wood Pewee	1.33	0	2.67	0.67	0	3.5	**1.36**	4
Great Crested Flycatcher	4	1	1.33	0	0.67	0	**1.17**	4
Blue Jay	1	0	0.33	2	0	1.5	**0.81**	4
Blue-headed Vireo	1.33	1	0	0.67	0.67	0	**0.61**	4
Hermit Thrush	0.33	0	0	1.33	0.67	1	**0.56**	4
Ovenbird	0	2	0	2	1.33	0	**0.89**	3
American Crow	1.67	0	0.67	0	0	1	**0.57**	3
Brown Creeper	0.67	0	0	0.67	0	1	**0.39**	3
White-breasted Nuthatch	0	1	0	0.67	0	0.25	**0.32**	3
Pileated Woodpecker	1	0.5	0	0	0	0.25	**0.29**	3
Yellow Warbler	0	0	2.67	0	0	2	**0.78**	2
Song Sparrow	0	0	2.67	0	0	2	**0.78**	2
Northern Parula	0	2	0	0	1.33	0	**0.56**	2
White-throated Sparrow	1.33	2	0	0	0	0	**0.56**	2
Canada Warbler	0	0	0	0	2.67	0.5	**0.53**	2
Winter Wren	0	2	0	0.67	0	0	**0.45**	2
Black-throated Green Warbler	0	1	0	0	1.33	0	**0.39**	2
American Goldfinch	0	0	1	0	0	1	**0.33**	2
Scarlet Tanager	0.33	0	0	0	1.33	0	**0.28**	2
Black-throated Blue Warbler	0	3	0	0	0	0	**0.5**	1
Mourning Dove	0	0	0	0	0	2.5	**0.42**	1
Alder Flycatcher	0	2	0	0	0	0	**0.33**	1
Warbling Vireo	0	2	0	0	0	0	**0.33**	1
Swamp Sparrow	0	0	0	0	0	2	**0.33**	1
Red-winged Blackbird	0	0	0	0	0	1.5	**0.25**	1
Yellow-throated Vireo	1.33	0	0	0	0	0	**0.22**	1
Northern Flicker	0	1	0	0	0	0	**0.17**	1
Common Raven	0	1	0	0	0	0	**0.17**	1
Ruby-crowned Kinglet	0	1	0	0	0	0	**0.17**	1
Gray Catbird	0	0	0	0	0	1	**0.17**	1
Cedar Waxwing	0	1	0	0	0	0	**0.17**	1
Black and White Warbler	0	1	0	0	0	0	**0.17**	1
Chestnut-sided Warbler	0	1	0	0	0	0	**0.17**	1
Northern Cardinal	0	0	0	0	0	1	**0.17**	1
Chipping Sparrow	0	1	0	0	0	0	**0.17**	1
Brown-headed Cowbird	0	0	0	0	0	1	**0.17**	1
American Redstart	0	0	0.67	0	0	0	**0.11**	1
Blackburnian Warbler	0	0	0	0.67	0	0	**0.11**	1
Nashville Warbler	0	0	0	0.67	0	0	**0.11**	1
Northern Oriole	0	0	0.67	0	0	0	**0.11**	1
Ruffed Grouse	0	0.5	0	0	0	0	**0.08**	1
Yellow-bellied Sapsucker	0	0.5	0	0	0	0	**0.08**	1
Ruby-throated Hummingbird	0	0	0	0	0.33	0	**0.06**	1
Tufted Titmouse	0.33	0	0	0	0	0	**0.06**	1
Blue-gray Gnatcatcher	0	0	0.33	0	0	0	**0.06**	1
Wood Thrush	0.33	0	0	0	0	0	**0.06**	1
Common Grackle	0	0	0.33	0	0	0	**0.06**	1
Great Blue Heron	0	0	0	0	0	0.25	**0.04**	1
Downy Woodpecker	0	0	0	0	0	0.25	**0.03**	1
Average Number of Birds per Station	25	38.5	21.67	21.33	15	25.25		
Total Number Bird Species per Swamp	20	28	17	17	15	25		

The common yellowthroat, the most abundant species, and one that occurred at all six sites, typically nests amidst low, dense vegetation in wet areas. This type of habitat was well represented along edges and in disturbed areas in the swamps sampled. Another bird that prefers openings, the American robin, was present at five of the sites in moderate numbers. Either or both of these species could easily be absent from the interior of a high quality swamp with minimal recent beaver activity or windthrow events. The blue-headed vireo prefers coniferous or at least mixed forest. It occurred at four of the sites in moderate numbers, an indication of the presence of a number of pine and/or hemlock in many of the swamps. This species would be expected to be absent from swamps that have a more complete deciduous cover.

As would be expected, the species occurring at all six sites generally had the highest average number of individuals per station (Figure). However, there were some exceptions. The most notable among these include the following species:

- The Eastern Wood Pewee was the fourth most abundant species, but it was absent from two of the sites. Its abundance is attributable to very high numbers of individuals at two of the large Champlain Valley swamps (Whiting and Maquam). Since the pewee is a species of openings and edges, its abundance at these sites may be more a refection of the condition of the swamps than a locational preference.
- The Great-crested Flycatcher was similarly absent from two sites, but also had very high numbers of individuals. This is attributable to an extremely high number of individuals present at a single site, Conant Swamp. There is no obvious reason for this except perhaps the site's proximity to the Connecticut River. This species prefers floodplains and occurred in moderate abundance at Joslin Turn and Maquam, both of which are associated with floodplains.
- The Ovenbird was among the more plentiful species, but occurred at only three of the sites. It was quite abundant at each of these. Two of these sites are small, especially Vernon, which is comprised of three individual swamps, and it, is possible that some of these birds were actually nesting in the adjacent upland forest.
- The Yellow Warbler and Song Sparrow were both included in the ten most abundant species, but occurred at only two sites. Interestingly, both species occurred at the same two large Champlain Valley sites (Whiting and Maquam) in the same high abundance. Since both of these species are ubiquitous throughout the state (Laughlin and Kibbe, 1985), their abundance at these two sites is likely a reflection of the presence of their preferred habitat: shrubby or brushy near water rather than any geographic preference.
- Although both the Hairy Woodpecker and American Robin were observed at five of the six sites, their numbers were moderate at each of these so they were not among the ten most abundant species.
- Similarly, the Blue-headed Vireo and Hermit Thrush occurred at two-thirds of the sites, but only in moderate abundance.

With only six swamps sampled statewide no apparent trends can be discerned from the data. In addition to a broad range in size (40 to 500+ acres), there were differences in location (Champlain, Connecticut, and Vermont Valleys) and in swamp community type. The hardwood swamp types represented in the bird survey were Red Maple-Black Ash Seepage Swamp (Conant, Joslin Turn, and Whiting), a mixture of this type and Calcareous Red Maple-Tamarack

(Mount Tabor Floodplain), Red or Silver Maple-Green Ash Swamp (Maquam), and Red Maple-Black Gum Swamp (Vernon).

Joslin Turn Swamp on the Connecticut River had the highest number of species (28) and also the highest number of individual birds per station (38.5). This was surprising since it was the smallest site with an area of only 40 acres. Close behind this in species (25), but far behind in individuals (26.75), was Whiting Swamp, a very large Champlain Valley swamp consisting of over 500 acres. Next in both categories was Conant Swamp, a 68 acre Connecticut River Valley swamp, with 20 species and 25 individuals per station. This was closely followed by Maquam and Mt. Tabor Floodplain Swamp, which had nearly identical numbers for both categories (17 species and approximately 21.5 individuals per station). The former is a large Champlain Valley swamp of 150 acres while the latter is 269 acres and situated in the Vermont Valley. The site with the fewest number of species (15) and the lowest number of individuals (15) was the Vernon Black Gum Swamp. Situated at the southeast corner of the state, this site is actually comprised of a number of separate black gum swamps. The three surveyed for this inventory comprise about 47 acres.

AMPHIBIAN AND REPTILE SURVEY

A total of 14 amphibian and reptile species were observed at the six hardwood swamp sites visited during this study (Table 7). The locations of these six swamps is shown in Figure 4. More detailed discussion of the species observed and habitat values for the six sites are presented in the site reports in Appendix C. The mean number of species per site was 4.8. Two sites, Mount Tabor Floodplain Swamp and Vernon Black Gum Swamp, had the highest value of nine species, reflecting their large size and high quality of habitat. However, the lowest species richness value was observed at half the sites, Whiting Swamp, Joslin Turn, and Conant Swamp, with only two species each. Joslin Turn and Conant Swamp are both small swamps and may not provide sufficient diversity of habitat to support a large number of species. In addition, Conant Swamp is largely surrounded by agricultural lands, limiting the upland habitat available to amphibians that would use the wetland seasonally. It is not entirely clear why so few amphibian species occurred at Whiting Swamp; however, like Conant Swamp, the adjacent uplands have been largely cleared. Interestingly, there was little overlap of species occurrence among these amphibian-poor sites, with only the wood frog occurring at two of these three swamps.

The most ubiquitous species was the wood frog, being detected at five of the six sites. It may have been observed at the sixth site as well, but this could not be confirmed. The green frog was second, occurring at four sites. Six species were recorded from only a single study site, representing almost half of those species observed. These were the spotted salamander, blue-spotted salamander, garter snake, two-lined salamander, dusky salamander, and wood turtle. The later three require small to medium sized streams, a habitat feature that is not common to all hardwood swamps. These six species were not evenly distributed among sites. Half of the unique species occurrences were from Mount Tabor Floodplain Swamp, while two were from Vernon Black Gum Swamp. This, again, indicates the higher quality of these sites for amphibians and reptiles. The mean number of sites at which each species occurred was 2.1, reflecting the high number of unique species occurrences (six of fourteen).

Table 7. Amphibian and reptile species occurrences among the six survey sites. "X" indicates that the species was observed in the swamp and "(X)" indicates that the species was observed in the adjacent uplands but is expected to use the swamp.

Species	Hardwood Swamp Site					
	Whiting Swamp	Maquam WMA	Joslin Turn	Conant Swamp	Mt. Tabor Floodplain	Vernon Black Gum Swamp
Wood Frog		(X)	X	X	X	X
Green Frog		X		X	X	X
Northern Leopard Frog	X	X				
Gray Treefrog					X	(X)
Spring Peeper		(X)				X
American Toad		(X)	X		(X)	X
Spotted Salamander					X	
Blue-spotted Salamander	(X)					
Eastern Newt					X	X
Redback Salamander					X	X
Two-lined Salamander					X	
Dusky Salamander						X
Garter Snake						(X)
Wood Turtle					X	
Total Species	2	5	2	2	9	9

Although abundance was not measured for amphibians and reptiles in this study, more northern leopard frogs were observed than any other species, although they occurred at only two sites. This is likely due in part to the life history of this species. Upon metamorphosis, young-of-year leopard frogs forage in the open and are highly visible. The Champlain Valley, where both sites in which this species were observed are located, is a highly productive region for this species. Evidence of breeding within the hardwood swamps was detected for only two species, the spotted salamander and the wood frog. Eggs of these two amphibians are easily observed and identified in the field, a characteristic not shared by many of the other species. Blue-spotted salamander and spring peeper are the most likely additional hardwood swamp breeders, but their eggs are not easily detected.

All the amphibian and reptile species observed in this study are considered common and widespread in Vermont, with the exception of the blue-spotted salamander and the wood turtle. The blue-spotted salamander is rare, particularly outside of the Champlain Valley. It typically breeds in lowland areas, such as swamps and oxbows, making it a likely occupant of swamps with sufficient open water. However, it can be very difficult to detect during most of the year. The wood turtle, although widespread in Vermont, is uncommon here and is vulnerable to habitat loss, as well as loss of breeding adults. The occurrence of these two species at hardwood swamp sites is encouraging, and should be included in land conservation planning efforts.

None of the species encountered are clearly indicators for hardwood swamps, as most are generalists found in a wide variety of wetlands and tend to orient to particular habitat features more than natural community types. Several, such as the redback salamander, green frog, eastern newt, and two-lined salamander, are occasional or seasonal users of hardwood swamps, but do not depend on them for breeding purposes. The blue-spotted salamander may be the closest to an indicator species, due to its dependence on lowland wetlands and similar water bodies. Inventory efforts would need to focus on this species to reliably detect it.

THREATS TO HARDWOOD SWAMPS

There are numerous threats to hardwood swamps in Vermont. These threats can be separated into three main categories, in order of increasing severity: 1) temporary impairment of the condition of the swamp or its associated upland buffer; 2) permanent alteration and impairment of the swamp condition; and 3) wetland loss due to filling, draining, or clearing. Logging of hardwood swamps and their adjacent upland buffer zones are in most cases temporary alterations of the swamp ecology. Removal of overstory trees may change the species composition of the swamp forest, promoting early successional species. Other temporary changes include alteration of organic soil accumulation by removal of woody debris, changing tree tip-up dynamics that create hummocks and hollows, and altering wildlife habitat for amphibians and other groups. Cutting in the upland buffer zone can change surface runoff characteristics and alter wildlife habitat values. Permanent swamp alteration may be associated with heavy logging equipment entering wetlands when soils are not frozen and creating ruts or compaction of organic soils that change wetland hydrology. Similarly, logging may introduce invasive exotic plant species that are very difficult to control and may proliferate in the swamp. Both alteration of hydrology and introduction of exotic plant species are usually permanent alterations and can be associated with many other activities besides logging. Permanent loss of hardwood swamps is most often associated with development, which results in wetland fill.

Although many hardwood swamps are protected under the Vermont Wetland Rules as Class Two wetlands, there are also many small hardwood swamps that were not initially mapped on the National Wetlands Inventory maps and are therefore designated as Class Three wetlands. Although these Class Three wetlands do not receive protection under the Vermont Wetland Rules, they may be protected by other local, state, or federal wetland protection programs.[4]

A recent summary of project data provided by the Wetlands Office of the Vermont Department of Environmental Conservation provides more detail on the type and extent of alterations documented in hardwood swamps over the period from 1990 through 2002. For the total of 897 projects that required Conditional Use Determinations over this period, 120 (13%) were associated with hardwood swamps. Thirteen acres of hardwood swamp were lost, 26 acres of hardwood swamp were impaired, and 36 acres of 50 foot buffer zone were lost (these figures are based on category totals of 113 acres, 208 acres, and 245 acres, respectively). For the total of 5,613 projects that were reviewed over this period (many did not require Conditional Use Determinations), 681 (12%) were associated with hardwood swamps. These projects resulted in 17 acres of Class Two hardwood swamp loss (total Class Two wetland loss of 159 acres), 150 acres of Class Two hardwood swamp impairment (total Class Two wetland impairment of 433

[4] For information on the Vermont Wetland Rules and wetland protection, contact the Wetlands Office, Vermont Department of Environmental Conservation, 802-241-3770, http://www.anr.state.vt.us/dec/waterq/wetlands.htm

acres), 28 acres of Class Three hardwood swamp loss (total Class Three wetland loss of 178 acres), and 11 acres of Class Three hardwood swamp impairment (total Class Three wetland impairment of 95 acres). These figure likely under-represent Class Three wetland impacts as these wetlands are not regulated under the Vermont Wetland Rules. The primary activities resulting in loss of hardwood swamps were commercial and residential development and road construction. Agricultural conversion was the activity that resulted in the largest area of Class Two hardwood swamp impairment over this 13-year period. Forested wetlands that are converted to agriculture are not considered "lost" under this program, as the potential exists for restoration. However, it would be very difficult and expensive to effectively restore a functioning hardwood swamp, its component species, and ecological processes after it has been converted to agricultural use.

It is clear that the threats are not equal to all hardwood swamp community types. The widespread Red Maple-Black Ash Seepage Swamp is much more common than other types of hardwood swamps and therefore is under less threat than rarer types. In general, the swamp types with deep organic soils (such as Red Maple-Sphagnum Acidic Basin Swamp) or those with longer duration of flooding (such as Red or Silver Maple-Green Ash Swamp) are less conducive to development or other human uses and are therefore less threatened. In contrast, the very rare Sandplain Swamp Variant has easily cleared and drained sandy soils, generally occurs in the more populated areas of the state, and is highly threatened.

CONCLUSIONS

Hardwood swamps, when considered as a broad class of wetlands, are common across Vermont. However, when evaluated more closely, there is considerable variation in the vegetation, hydrology, soils, nutrient enrichment, and distribution of these forested wetlands. Each of the six hardwood swamp natural community types (and the one variant) identified in this report has its own set of component species and environmental conditions. Understanding the distribution and relative rarity of each community type and the rare species and threats associated with each type helps us to set conservation priorities to protect all species of plants and wildlife associated with these communities. Although hardwood swamps occupy only approximately one percent of the Vermont land area, it is significant to note that nearly 500 plant species (vascular plants and bryophytes) have been documented in these swamps in this study. This represents nearly one-fifth of the total number of vascular plant species (2,000) and bryophytes (600) known to occur in Vermont.

The objectives of this inventory have been to identify the distribution and variability of hardwood swamps in Vermont, to refine the community classification, to document rare plants and some of the characteristic animals, to notify landowners of the significance of swamps that they own, and to identify some of the best examples of hardwood swamp communities in Vermont. The project has completed these objectives. However, it is important to note, that given the widespread distribution of hardwood swamps in Vermont, this is not a complete inventory. It is expected that more state-significant examples of all hardwood swamp community types will be documented with further inventory, although it is likely that more of the common types will be found than of the rare types. This emphasizes the importance of continued inventory throughout the state.

Natural community-based inventory provides quantitative information on vegetation and environmental characteristics of the communities studied. This information is critical to refining the community classification for Vermont. For this study and previous natural community inventories, the quantitative data has been analyzed in order to revise only the community types that are the subject of the particular study. In order to effectively refine the entire community classification, it will be necessary in the future to include data from multiple inventories in the analyses. For example, during the ongoing study of softwood swamps, data from the previous cedar swamp study and this hardwood swamp study should be included in the analyses to provide a more "seamless" classification of all forested swamp types.

RECOMMENDATIONS FOR CONSERVATION

The long term conservation of the biological diversity occurring in hardwood swamps will depend primarily on the continued good stewardship provided by private landowners. Hardwood swamps are generally small (state average of 11 acres) and the vast majority of these swamps are privately owned. By continuing to learn about the ecology, hydrology, soils, plants, animals, and history of human use of swamps, landowners can better gauge the effects that nearby land uses will have on the swamps and plan accordingly. Landowners are encouraged to call the Nongame and Natural Heritage Program, the Vermont Wetlands Office, and district Wildlife Biologists with questions about particular swamps and their management.

Regulations such as the Vermont Wetland Rules and Section 404 of the U.S. Clean Water Act (implemented by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency) will continue to be important for protection of Vermont's wetlands, including hardwood swamps. Although these programs and others can be very effective in protecting wetlands, there are many wetlands and many activities that are not covered by these regulations. For example, small wetlands that have not been identified on the National Wetlands Inventory maps are not initially protected under the Vermont Wetland Rules. Small hardwood swamps were especially difficult to identify using the 1977 photographs that these NWI maps were based on, and consequently, many small hardwood swamps are not protected under the Vermont Wetland Rules. The federal Clean Water Act does not provide any protection to wetland buffer zones, which are especially important for maintaining water quality and wildlife habitat of swamps.

Almost all hardwood swamps in Vermont have been altered by human activities. Swamps that are subject to only natural disturbance processes, especially wind, develop and mature differently than those that are actively managed by people. These swamps that mature under natural ecological processes provide a critical baseline for our understanding of the ecology and natural variability of hardwood swamps. Although careful logging is definitely compatible with maintaining many hardwood swamps, it is very important that there be high quality examples (good size and unfragmented landscapes) of all hardwood swamp community types that are not logged but instead are allowed to mature. It is a conservation goal to conserve representative examples of all hardwood swamp community types in all biophysical regions in which they occur and to allow these swamps to mature under natural ecological processes, with minimal human disturbance. Whenever possible, these representative examples should be conserved in unfragmented landscapes. Many of these representative examples can be conserved on public lands, although cooperation with interested private landowners is also be critical to conservation success.

REFERENCES

Anderson, L.E. 1990. A checklist of *Sphagnum* in North America North of Mexico. The Bryologist 93: 500-501.

Anderson, L.E., H.A. Crum, and W.R. Buck. 1990. List of the mosses of North America north of Mexico. The Bryologist 93: 448-449.

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. Vol. 2, 877 p.

DeGraaf, R.E. and M. Yamasaki. 2001. New England Wildlife: Habitat, Natural History and Distribution. University Press of New England, Hanover. 482 p.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. The New York Botanical Garden. 911 p.

Golet, F.C., A.J.K. Calhoun, W.R. DeRagon, D.J. Lowry, and A.J. Gold. 1993. Ecology of Red Maple Swamps in the Glaciated Northeast: A Community Profile. Biological Report 12. U.S. Fish and Wildlife Service. 151 p.

Hill, M.O. 1979a. DECORANA– a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Ithaca, NY: Ecology and Systematics, Cornell University.

Hill, M.O. 1979b. TWINSPAN – a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ithaca, NY: Ecology and Systematics, Cornell University.

Lapin, M. 1998. Champlain Valley Clayplain Forests of Vermont: Some Sites of Ecological Significance. Nongame and Natural Heritage Program, Vermont Fish and Wildlife Department, Waterbury, Vermont. 65 p.

Laughlin, S.B. and D.P. Kibbe, editors. 1985. The Atlas of Breeding Birds in Vermont. Vermont Institute of Natural Science. Published by University Press of New England. Hanover and London. 456 p.

Lorimer, C.G. 1977. The presettlement forest and natural disturbance cycle of northeastern Maine. Ecology 58: 139-148.

McCune, B. and M.J. Mefford. 1999. Multivariate Analysis of Ecological Data, Version 4.20. MjM Sofware, Gleneden Beach, Oregon, U.S.A.

McIntosh, R.P. 1972. Forests of the Catskill Mountains, New York. Ecological Monographs 42: 143-161.

Sorenson, E., M. Lapin, B. Engstrom, and R. Popp. 1998a. Floodplain Forests of Vermont: Some Sites of Ecological Significance. Nongame and Natural Heritage Program, Vermont Fish and Wildlife Department, Waterbury, Vermont. 175 p.

Sorenson, E., B. Engstrom, M. Lapin, R. Popp, and Steve Parren. 1998b. Northern White Cedar Swamps and Red Maple-Northern White Cedar Swamps of Vermont: Some Sites of Ecological Significance. Nongame and Natural Heritage Program, Vermont Fish and Wildlife Department, Waterbury, Vermont. 261 p.

Stotler, R. and B. Crandall-Stotler. 1977. A checklist of the liverworts and hornworts of North America. The Bryologist 80: 405-425.

Teskey, R.O. and T.M. Hinkley. 1978. Impact of water level changes on woody wetland and riparian communities. Vol. 4 and 5. Eastern deciduous forest region. U.S. Fish and Wildlife Service Biological Services Program FWS-OBS 78/87. 54p.

Thompson, E.H. and R.G. Popp. 1995. Calcareous Open Fens and Riverside Seeps of Vermont: Some Sites of Ecological Importance. Nongame and Natural Heritage Program, Vermont Fish and Wildlife Department, Waterbury, Vermont. 87 p.

Thompson, E.H. and E.R. Sorenson. 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. Published by The Nature Conservancy and Vermont Department of Fish and Wildlife, distributed by University Press of New England. 456 p.

Tiner, R.W. 1987. Preliminary National Wetlands Inventory Report of Vermont's Wetland Acreage. U.S. Fish and Wildlife Service Report. Newton Corner, Massachusetts.

Thompson, Z. 1853. Natural History of Vermont. Reprinted by Charles E. Tuttle Company, 1972.

Vogelmann, H.W. 1964. Natural Areas in Vermont: Some Ecological Sites of Public Importance. Report 1. Agricultural Experiment Station of Vermont, Burlington. 29 p.

Vogelmann, H.W. 1969. Vermont Natural Areas. Report 2. Central Planning Office and Interagency Committee on Natural Resources, State Office Building, Montpelier. 30p.

Whitney, C.G. 1990. The history and status of hemlock-hardwood forests of the Alleghany Plateau. Journal of Ecology 78: 443-458.

Appendix A: Plant species identified in the 100 Hardwood Swamp Vegetation Plots

Bryophyte Species (most species do not have common names)

Scientific Name	Letter Code
Amblystegium riparium	Ambripa
Atrichum undulatum	Atrundu
Aulacomnium palustre	Aulpalu
Bazzania trilobata	Baztri
Brachythecium acuminatum	Braacum
Brachythecium reflexum var. reflexum	Brarefl
Brachythecium rivulare	Brarivu
Brachythecium rutabulum	Braruta
Brotherella recurvans	Brorecu
Bryhnia novae-angliae	Brynova
Bryum pseudotriquetrum	Brypseu
Calliergon cordifolium	Calcord
Calliergonella cuspidata	Calcusp
Calliergon giganteum	Calgiga
Callicladium haldanianum	Calhald
Calypogeja trichomanis	caltrc
Campylium stellatum var. stellatum	Camstel
Cirriphyllum piliferum	Cirpili
Climacium dendroides	Clidend
Conocephalum conicum	Concon
Dicranum flagellare	Dicflag
Dicranum polysetum	Dicpoly
Dicranum scoparium	Dicscop
Drepanocladus aduncus var. aduncus	Dreadun
Drepanocladus vernicosus	Drever
Eurhynchium pulchellum var. pulchellum	Eurpulc
Fissidens adianthoides	Fisadia
Helodium paludosum	Helpalu
Herzogiella striatella	Herstri
Homalia trichomanoides	Homtric
Hylocomium splendens	Hylsple
Hylocomiastrum umbratum	Hylumbr
Hypnum curvifolium	Hypcurv
Hypnum fertile	Hypfert
Hypnum imponens	Hypimpo
Hypnum lindbergii	Hyplind
Hypnum pratense	Hypprat
Leptodictyum riparium	Lepripa
Leucobryum glaucum	Leuglau
Moerckia hibernica	Moehib
Pallauiania lyellii	pallye
Plagiomnium ciliare	Placili
Plagiomnium cuspidatum	Placusp
Plagiomnium ellipticum	Plaell
Plagiothecium laetum	Plalaet
Plagiomnium medium var. medium	Plamedi
Plagiochila porelloides	Plapor
Plagiomnium rostratum	Plarost
Pleurozium schreberi	Pleschr
Pohlia nutans	Pohnuta
Polytrichum commune var. commune	Polcomm
Polytrichum ohioense	Polohio
Polytrichum strictum	Polstri
Pseudobryum cinclidioides	Psecinc
Ptilium crista-castrensis	Pticris
Rhizomnium appalachianum	Rhiappa
Rhizomnium gracile	rhigra
Rhizomnium magnifolium	Rhimagn
Rhizomnium punctatum	Rhipunc
Rhodobryum roseum	Rhorose
Rhytidiadelphus squarrosus	Rhysqua
Rhytidiadelphus triquetrus	Rhytriq
Sphagnum angustifolium	Sphangu
Sphagnum capillifolium	Sphcapi
Sphagnum centrale	Sphcent
Sphagnum cuspidatum	Sphcusp
Sphagnum fallax	Sphfall
Sphagnum fimbriatum var. fimbriatum	Sphfimb
Sphagnum flexuosum var. flexuosum	Sphflex
Sphagnum girgensohnii	Sphgirg
Sphagnum magellanicum	Sphmage
Sphagnum palustre	Sphpalu
Sphagnum russowii	Sphruss
Sphagnum squarrosum	Sphsqua
Sphagnum subsecundum var. subsecundum	Sphsubs
Sphagnum subtile	Sphsubt
Sphagnum tenerum	Sphten
Sphagnum teres	Sphtere
Sphagnum warnstorfii	Sphwarn
Sphagnum wulfianum	Sphwulf
Tetraphis pellucida	Tetpell
Thuidium delicatulum	Thudeli
Thuidium recognitum	Thureco
Trichocolea tomentella	Tritom
Warnstorfia exannulata var. exannulata	Warexan

Herbaceous Species

Scientific Name	Common Name	Code
Adiantum pedatum	Common Maidenhair	Adiped
Agrimonia gryposepala	Common Agrimony	Agrgry
Agrostis gigantea	Redtop	Agrgig
Agrostis perennans	Upland Bentgrass	Agrper
Alisma plantago-aquatica	Common Water plantain	Alipla
Amelanchier sanguinea	Bush Shadbushes	Amesan
Amphicarpaea bracteata	Hog Peanut	Ampbra
Anemone canadensis	Canada Anemone	Anecan
Anemone quinquefolia	Wood Anemone	Anequi
Angelica atropurpurea	Angelica	Angatr
Apios americana	Groundnut	Apiame
Aralia nudicaulis	Wild Sarsaparilla	Aranud
Aralia racemosa	Spikenard	Ararac
Arenaria lateriflora	Grove Sandwort	Arelat
Arisaema triphyllum	Jack-in-the-pulpit	Aritri
Asclepias incarnata	Swamp Milkweed	Ascinc
Aster acuminatus	Acuminate Aster	Astacu
Aster divaricatus	White Wood Aster	Astdiv
Aster lanceolatus	Tall White Aster	Astlan
Aster lateriflorus	Calico Aster	Astlat
Aster novi-belgii	New York Aster	Astnov
Aster puniceus	Pumice Aster	Astpun
Aster umbellatus	Umbellate Aster	Astumb
Athyrium filix-femina	Lady Fern	Athfil
Bartonia virginica	Common Bartonia	Barvir
Bidens cernua	Nodding Beggar's-ticks	Bidcer
Bidens connata	Lobed Beggar's-ticks	Bidcon
Bidens discoidea	Small Beggar's-ticks	Biddis
Bidens frondosa	Frondose Beggar's-ticks	Bidfro
Bidens tripartita	Three-parted Beggar's-ticks	bidtri
Boehmeria cylindrica	False Nettle	Boecyl
Brachyeletrum erectum	Harry Woods' Grass	Braere
Bromus ciliatus	Fringed Brome	Brocil
Calamagrostis canadensis	Common Bluejoint Grass	Calcan
Caltha palustris	Marsh Marigold	Calpal
Carex arctata	Arching Sedge	Cararc
Carex bebbii	Bebb's Sedge	carbeb
Carex blanda	Charming Sedge	Carbla
Carex bromoides	Brome-like Sedge	Carbro
Carex brunnescens	Brownish Sedge	Carbru
Carex canescens	Hoary Sedge	Carcan
Carex comosa	Bristly Sedge	Carcos
Carex crinita	Long-hair Sedge	Carcri
Carex cristatella	Crested Sedge	Carcrt
Carex debilis	Feeble Woodland Sedge	Cardeb
Carex disperma	Two-fruited Sedge	Cardis
Carex echinata	Little Prickly Sedge	Carech
Carex flava	Yellow Sedge	Carfla
Carex folliculata	Folliculate Sedge	Carfol
Carex gracillima	Graceful Sedge	Cargra
Carex grayi	Gray's Sedge	Cargri
Carex gynandra	Gynandrous Sedge	Cargyn
Carex interior	Inland Sedge	Carinr
Carex intumescens	Bladder Sedge	Carint
Carex lacustris	Lakeshore Sedge	Carlac
Carex laxiflora	Loosely-flowered Sedge	Carlax
Carex leptalea	Delicate-stemmed Sedge	Carlep
Carex leptonervia	Few-nerved Sedge	Carlev
Carex lupulina	Common Hop Sedge	Carlup
Carex lurida	Garish Sedge	Carlur
Carex normalis	Right-angle Sedge	Carnor
Carex pallescens	Pale Sedge	Carpal
Carex paupercula	Poor Sedge	Carpau
Carex pedunculata	Peduncled Sedge	Carped
Carex pensylvanica	Woodland Sedge	Carpen
Carex prairea	Prairie Sedge	Carpra
Carex projecta	Projecting Sedge	Carpro
Carex pseudocyperus	Cyperus-like Sedge	Carpse
Carex retrorsa	Retrorse Sedge	Carret
Carex rosea	Roseate Sedge	Carros
Carex scabrata	Rough-stemed Sedge	Carsca
Carex scoparia	Pointed Broom Sedge	Carsco
Carex sprengelii	Sprengel's Sedge	Carspr
Carex stipata	Stipitate Sedge	Carsti
Carex stricta	Common Tussock Sedge	Carstr
Carex tenera	Slender Sedge	Carten
Carex trisperma	Three-seeded Sedge	Cartri
Carex tuckermanii	Tuckerman's Sedge	Cartuc
Carex vulpinoidea	Foxtail Sedge	Carvul
Castanea dentata	Chestnut	Casden
Chelone glabra	Turtlehead	Chegla
Chrysosplenium americanum	Golden Saxifrage	Chrame
Cicuta bulbifera	Bulblet Water-hemlock	Cicbul
Cicuta maculata	Spotted Water-hemlock	Cicmac
Cinna arundinacea	Stout Woodreed	Cinaru
Cinna latifolia	Drooping woodreed	Cinlat
Circaea alpina	Small Enchanter's Nightshade	Ciralp
Cirsium muticum	Swamp Thistle	Cirmut
Clintonia borealis	Bluebead Lily	Clibor
Coptis trifolia	Goldthread	Coptri
Cornus canadensis	Bunchberry	Corcan
Cuscuta gronovii	Common Dodder	Cusgro
Cypripedium acaule	Pink Ladyslipper	Cypaca
Cypripedium calceolus	Yellow Ladyslipper	Cypcal
Cypripedium reginae	Showy Ladyslipper	Cypreg
Dalibarda repens	Dewdrop	Dalrep
Danthonia spicata	Common Oatgrass	Danspi
Decodon verticillatus	Water Willow	Decver
Deparia acrostichoides	Silvery Spleenwort	Depacr
Dryopteris carthusiana	Spinulose wood Fern	Drycar
Dryopteris cristata	Crested Wood Fern	Drycri
Dryopteris intermedia	Evergreen Woodfern	Dryint
Dryopteris marginalis	Marginal Wood Fern	Drymar
Dulichium arundinaceum	Three-way Sedge	Dularu
Echinocystis lobata	Wild Cucumber	Echlob
Eleocharis palustris	Marsh Spikerush	Elepal
Eleocharis tenuis	Slender Spikerush	Eleten
Elymus hysterix	Bottlebrush Grass	Elyhys
Elymus virginicus	Virginia Wild-rye	Elyvir
Epigaea repens	Trailing Arbutus	Epirep
Epilobium ciliatum	Ciliate Willowherb	Epicil
Epilobium coloratum	Colored Willowherb	Epicol
Epilobium leptophyllum	Bog Willowherb	Epilep
Epilobium strictum	Downy Willowherb	Epistr
Epipactis helleborine	Helleborine	Epihel
Equisetum arvense	Common Horsetail	Equarv
Equisetum fluviatile	River Horsetail	Equflu
Equisetum scirpoides	Dwarf Scouring Rush	Equsci
Equisetum sylvaticum	Wood Horsetail	Equsyl
Eupatorium maculatum	Common Joe-pye Weed	Eupmac
Eupatorium perfoliatum	White Boneset	Eupper
Eupatorium rugosum	White Boneset	Euprug
Euthamia graminifolia	Grass-leaved Goldenrod	Eutgra
Festuca subverticillata	Nodding Fescue	Fessub
Fragaria vesca	Wood Strawberry	Fraves
Fragaria virginiana	Common Strawberry	Fravir
Galeopsis ladanum	Red Hemp-nettle	Gallad
Galium asprellum	Rough Bedstraw	Galasp
Galium palustre	Marsh Bedstraw	Galpal
Galium tinctorium	Dyer's Bedstraw	Galtin

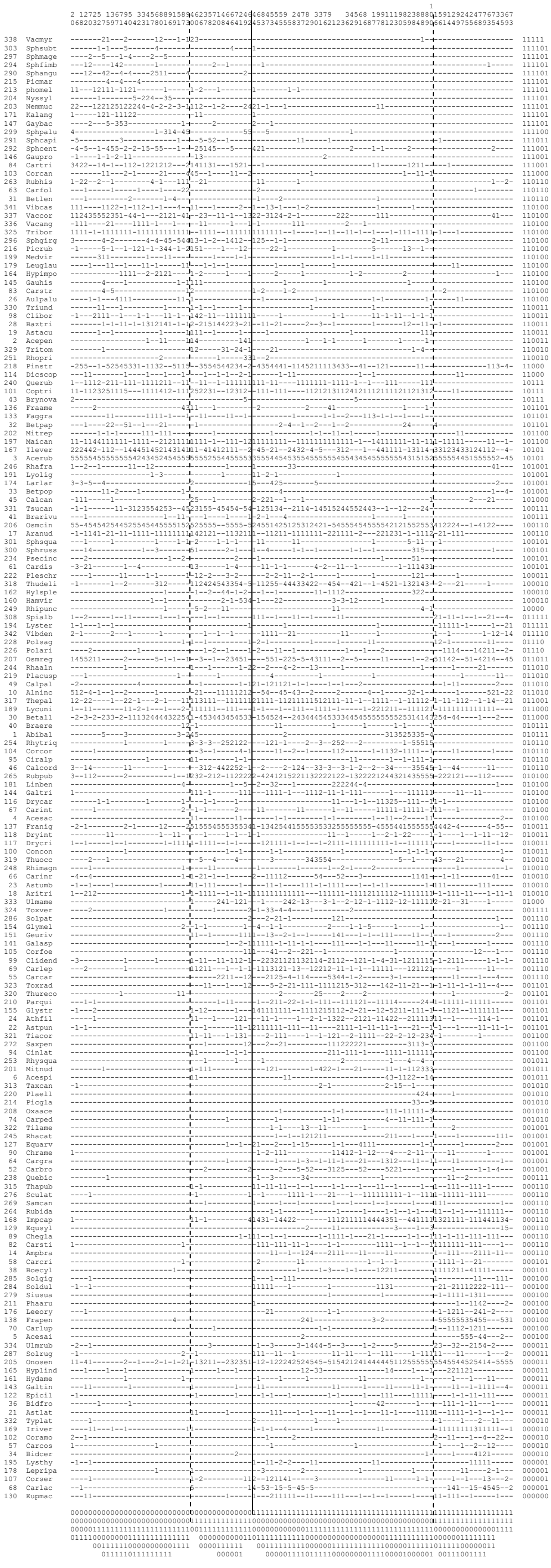
Scientific Name	Common Name	Code
Galium triflorum	Three-flowered Bedstraw	Galtri
Gaultheria hispidula	Creeping Snowberry	Gauhis
Gaultheria procumbens	Wintergreen	Gaupro
Geum aleppicum	Yellow Avens	Geuale
Geum canadense	White Avens	Geucan
Geum macrophyllum	Large-leaved Avens	Geumac
Geum rivale	Water Avens	Geuriv
Glechoma hederacea	Ground-ivy	Glehed
Glyceria borealis	Northern Mannagrass	Glybor
Glyceria canadensis	Canadian Mannagrass	Glycan
Glyceria grandis	Great Mannagrass	Glygra
Glyceria melicaria	Slender Mannagrass	Glymel
Glyceria striata	Fowl Mannagrass	Glystr
Gymnocarpium dryopteris	Common Oak Fern	Gymdry
Habenaria clavellata	Club-spur Orchid	Habcla
Habenaria dilatata	Bog-candles	Habdil
Habenaria hyperborea	Northern Green Orchid	Habhyp
Habenaria lacera	Ragged Fringed Orchid	Hablac
Habenaria psycodes	Purple-fringed Orchid	Habpsy
Hydrocotyle americana	Pennywort	Hydame
Hypericum prolificum	Shrubby St. John's-wort	Hyppro
Hypericum punctatum	Spotted St. John's-wort	Hyppun
Impatiens capensis	Spotted Touch-me-not	Impcap
Iris versicolor	Blue Flag	Iriver
Juncus effusus	Common Rush	Juneff
Juncus nodosus	Needle-fruited Rush	Junnod
Lactuca biennis	Blue lettuce	Lacbie
Laportea canadensis	Wood Nettle	Lapcan
Leersia oryzoides	Rice Cutgrass	Leeory
Lemna minor	Common Duckweed	Lemmin
Lilium canadense	Canada lily	Lilcan
Linnaea borealis	Twin-flower	Linbor
Liparis loeselii	Loesel's Twayblade	Liploe
Luzula acuminata	Acuminate Woodrush	Luzacu
Lycopodium lucidulum	Shining Clubmoss	Lycluc
Lycopodium obscurum	Tree Clubmoss	Lycobs
Lycopus americanus	American Water Hore-hound	Lycame
Lycopus uniflorus	Northern Bugleweed	Lycuni
Lycopus virginicus	Southern Water-horehound	Lycvir
Lysimachia ciliata	Fringed Loosestrife	Lyscil
Lysimachia nummularia	Moneywort	Lysnum
Lysimachia terrestris	Swamp Candles	Lyster
Lysimachia thyrsiflora	Tufted Loosestrife	Lysthy
Lythrum salicaria	Purple Loosestrife	Lytsal
Maianthemum canadense	Canada Mayflower	Maican
Matteuccia struthiopteris	Ostrich Fern	Matstr
Medeola virginiana	Wild Cucumber	Medvir
Mentha arvensis	Field Mint	Menarv
Mimulus ringens	Common Monkey-flower	Mimrin
Mitchella repens	Partridge Berry	Mitrep
Mitella diphylla	Common Miterwort	Mitdip
Mitella nuda	Naked Miterwort	Mitnud
Monotropa uniflora	Indian Pipes	Monuni
Onoclea sensibilis	Sensitive Fern	Onosen
Osmunda cinnamomea	Cinnamon Fern	Osmcin
Osmunda claytoniana	Interrupted Fern	Osmcla
Osmunda regalis	Royal Fern	Osmreg
Oxalis acetosella	Common Wood-Sorrel	Oxaace
Oxalis stricta	Common Yellow Wood Sorrel	Oxastr
Parnassia glauca	Grass of Parnassus	Pargla
Phalaris arundinacea	Reed Canary Grass	Phaaru
Phegopteris connectilis	Narrow Beech Fern	Phecon
Pilea pumila	Clearweed	Pilpum
Plantago lanceolata	English Plantain	Plalan
Plantago psyllium	Leafy-stemmed Plantain	Plapsy
Poa palustris	Marsh Bluegrass	Poapal
Poa pratensis	Common Bluegrass	Poapra
Polygonatum pubescens	Small Solomon's-seal	Polpub
Polygonum arifolium	Halberd-leaved Tearthumb	Polari
Polygonum sagittatum	Arrow-leaved Tearthumb	Polsag
Polypodium virginianum	Virginia Polypody	Polvir
Polystichum acrostichoides	Christmas Fern	Polacr
Prenanthes alba	Southern White Lettuce	Prealb
Prenanthes altissima	Common Rattlesnake Root	Prealt
Prunella vulgaris	Self-heal	Pruvul
Pteridium aquilinum	Bracken	Pteaqu
Pyrola elliptica	Common Shinleaf	Pyrell
Pyrola secunda	One-sided Shinleaf	Pyrsec
Ranunculus abortivus	Dwarf Buttercup	Ranabo
Ranunculus acris	Common Buttercup	Ranacr
Ranunculus hispidus	Hispid Buttercup	Ranhis
Ranunculus recurvatus	Hooked Buttercup	Ranrec
Rumex crispus	Curly Dock	Rumcri
Sanicula marilandica	Maryland Sanicle	Sanmar
Sarracenia purpurea	Pitcher Plant	Sarpur
Saxifraga pensylvanica	Sawmp Saxifrage	Saxpen
Scirpus atrovirens sens. lat.	Black-green Bulrush	Sciatr
Scirpus cyperinus	Wool-grass	Scicyp
Scutellaria galericulata	Common Skullcap	Scugal
Scutellaria lateriflora	Mad-dog Skullcap	Sculat
Scutellaria parvula	Small Skullcap	Scupar
Senecio aureus	Golden Ragwort	Senaur
Senecio schweinitzianus	Robbin's Ragwort	Sensch
Sium suave	Water Parsnip	Siusua
Smilacina racemosa	Common False Solomon's-seal	Smirac
Smilacina stellata	Starry False Solomon's Seal	Smiste
Smilacina trifolia	Three-leaved False Solomon's Seal	Smitri
Smilax herbacea	Carrion Flower	Smiher
Solanum dulcamara	Common Nightshade	Soldul
Solidago canadensis	Canada Goldenrod	Solcan
Solidago flexicaulis	Zig-zag Goldenrod	Solfle
Solidago gigantea	Giant Goldenrod	Solgig
Solidago patula	Spreading Goldenrod	Solpat
Solidago puberula	Downy Goldenrod	Solpub
Solidago rugosa	Rough-stemmed Goldenrod	Solrug
Solidago uliginosa	Bog Goldenrod	Soluli
Sphenopholis obtusata var. major	Common Wedgegrass	Sphobt
Stellaria graminea	Grass-leaved Chickweed	Stegra
Streptopus amplexifolius	White Mandarin	Stramp
Streptopus roseus	Rose Twisted-stalk	Strros
Symplocarpus foetidus	Skunk Cabbage	Symfoe
Taraxacum officinale	Common Dandelion	Taroff
Thalictrum pubescens	Tall Meadow-rue	Thapub
Thelypteris noveboracensis	New York Fern	Thenov
Thelypteris palustris	Marsh Fern	Thepal
Thelypteris simulata	Massachusetts Fern	Thesim
Tiarella cordifolia	Foam Flower	Tiacor
Triadenum fraseri	Marsh St. John's-Wort	Trifra
Trientalis borealis	Starflower	Tribor
Trillium cernuum	Nodding Trillium	Tricer
Trillium erectum	Red Trillium	Triere
Trillium undulatum	Painted Trillium	Triund
Typha latifolia	Broad-leaved Cattail	Typlat
Uvularia sessilifolia	Common Bellwort	Uvuses
Vaccinium macrocarpon	Large Cranberry	Vacmac
Veratrum viride	White Hellebore	Vervir
Veronica officinalis	Common Speedwell	Veroff
Veronica scutellata	Marsh Speedwell	Verscu
Viola blanda	Sweet White Violet	Viobla
Viola cucullata	Marsh Blue Violet	Viocuc
Viola renifolia	Kidney-leaved Violet	Vioren
Zizia aurea	Golden Alexanders	Zizaur

Shrub and Vine Species

Scientific Name	Common Name	Code
Acer pensylvanicum	Striped Maple	Acepen
Acer spicatum	Mountain Maple	Acespi
Alnus incana	Speckled Alder	Alninc
Amelanchier arborea	Wooly Shadbush	Amearb
Amelanchier laevis	Smooth Shadbush	Amelae
Berberis thunbergii	Japanese Barberry	Berthu
Berberis vulgaris	Common barberry	Bervul
Carpinus caroliniana	Musclewood	Carcar
Cephalanthus occidentalis	Buttonbush	Cepocc
Chamaedaphne calyculata	Leatherleaf	Chacal
Clematis virginiana	Virgin's Bower	Clevir
Cornus amomum	Silky Dogwood	Coramo
Cornus foemina	Gray Dogwood	Corfoe
Cornus rugosa	Round-leaved Dogwood	Corrug
Cornus sericea	Silky Dogwood	Corser
Corylus cornuta	Beaked Hazelnut	Corcor
Gaylussacia baccata	Black Huckleberry	Gaybac
Hamamelis virginiana	Witch Hazel	Hamvir
Ilex verticillata	Winterberry Holly	Ilever
Juniperus communis	Common Juniper	Juncom
Kalmia angustifolia	Sheep Laurel	Kalang
Kalmia latifolia	Mountain Laurel	Kallat
Ledum groenlandicum	Labrador Tea	Ledgro
Lindera benzoin	Spicebush	Linben
Lonicera canadensis	Canada Honeysuckle	Loncan
Lonicera morrowii	Morrow's Honeysuckle	Lonmor
Lonicera tatarica	Tartarian Honeysuckle	Lontat
Lonicera villosa	Northern Fly Honeysuckle	Lonvil
Lyonia ligustrina	Maleberry	Lyolig
Nemopanthus mucronata	Mountain Holly	Nemmuc
Parthenocissus quinquefolia	Common Woodbine	Parqui
Photinia(Aronia) melanocarpa	Black Chokeberry	phomel
Potentilla fruticosa	Shrubby Cinquefoil	Potfru
Potentilla norvegica	Strawberry Weed	Potnor
Prunus virginiana	Choke Cherry	Pruvir
Rhamnus alnifolia	Alder-leaved Buckthorn	Rhaaln
Rhamnus cathartica	Common Buckthorn	Rhacat
Rhamnus frangula	Glossy Buckthorn	Rhafra
Rhododendron canadense	Rhodora	Rhocan
Rhododendron prionophyllum	Common Pinkster Flower	Rhopri
Ribes americanum	American Black Currant	Ribame
Ribes cynosbati	Prickly Gooseberry	Ribcyn
Ribes glandulosum	Skunk Currant	Ribgla
Ribes hirtellum	Northern Gooseberry	Ribhir
Ribes lacustre	Black Swamp Currant	Riblac
Ribes rubrum	Garden Red Currant	Ribrub
Ribes triste	Wild Red Currant	Ribtri
Rosa palustris	Swamp Rose	Rospal
Rubus allegheniensis	Common Blackberry	Ruball
Rubus flagellaris	Prickly Dewberry	Rubfla
Rubus hispidus	Bristly Dewberry	Rubhis
Rubus idaeus	Red Raspberry	Rubida
Rubus occidentalis	Black Raspberry	Rubocc
Rubus odoratus	Purple-flowering Raspberry	Rubodo
Rubus pubescens	Dwarf Blackberry	Rubpub
Salix alba	White Willow	Salalb
Salix candida	Hoary Willow	Salcan
Salix discolor	Common Pussy Willow	Saldis
Salix humilis	Low Willow	Salhum
Salix lucida	Shining Willow	Salluc
Sambucus canadensis	White Elderberry	Samcan
Sambucus racemosa	Red Elderberry	Samrac
Sorbus americana	American Mountain Ash	Sorame
Spiraea alba	Meadow-sweet	Spialb
Spiraea tomentosa	Steeplebush	Spitom
Taxus canadensis	Canada Yew	Taxcan
Toxicodendron radicans	Poison Ivy	Toxrad
Toxicodendron vernix	Poison Sumac	Toxver
Vaccinium angustifolium	Low Sweet Blueberry	Vacang
Vaccinium corymbosum	Highbush Blueberry	Vaccor
Vaccinium myrtilloides	Velvet-leaf Blueberry	Vacmyr
Viburnum cassinoides	Norther Wild Raisin	Vibcas
Viburnum dentatum	Arrowwood	Vibden
Viburnum lantana	Wayfaring Tree	Viblan
Viburnum lantanoides	Hobblebush	Viblat
Viburnum lentago	Nannyberry	Viblen
Viburnum opulus	Highbush Cranberry	Vibopu
Viburnum rafinesquianum	Downy Arrowwood	Vibraf
Vitis aestivalis	Summer Grape	Vitaes
Vitis riparia	River-bank Grape	Vitrip

Tree Species

Scientific Name	Common Name	Code
Abies balsamea	Balsam Fir	Abibal
Acer rubrum	Red Maple	Acerub
Acer saccharinum	Silver Maple	Acesai
Acer saccharum	Sugar Maple	Acesac
Betula alleghaniensis	Yellow Birch	Betall
Betula lenta	Black Birch	Betlen
Betula papyrifera	Paper Birch	Betpap
Betula populifolia	Gray Birch	Betpop
Carya cordiformis	Bitternut Hickory	Carcor
Carya ovata	Shagbark Hickory	Carova
Fagus grandifolia	American Beech	Faggra
Fraxinus americana	American Ash	Fraame
Fraxinus nigra	Black Ash	Franig
Fraxinus pennsylvanica	Green Ash	Frapen
Juglans cinerea	Butternut	Jugcin
Larix laricina	Tamarack	Larlar
Nyssa sylvatica	Black Gum	Nyssyl
Picea glauca	White Spruce	Picgla
Picea mariana	Black Spruce	Picmar
Picea rubens	Red Spruce	Picrub
Pinus rigida	Pitch Pine	Pinrig
Pinus strobus	White Pine	Pinstr
Populus grandidentata	Big-toothed Aspen	Popgra
Populus tremuloides	Quaking Aspen	Poptre
Prunus pensylvanica	Pin Cherry	Prupen
Prunus serotina	Black Cherry	Pruser
Quercus alba	White Oak	Quealb
Quercus bicolor	Swamp White oak	Quebic
Quercus macrocarpa	Mossycup Oak	Quemac
Quercus rubra	Northern Red Oak	Querub
Quercus velutina	Black Oak	Quevel
Salix nigra	Black Willow	Salnig
Thuja occidentalis	Northern White Cedar	Thuocc
Tilia americana	Basswood	Tilame
Tsuga canadensis	Hemlock	Tsucan
Ulmus americana	American Elm	Ulmame
Ulmus rubra	Slippery Elm	Ulmrub



APPENDIX B

TWINSPAN Table, Hardwood Swamps, 100 Plots, 349 Species, All species with only one occurrence were deleted from this analysis

See page 13 of the report for more description

ORDER OF SITES

20	Downer	6	Bennet	18	Cranberr	22	EarlWay	70	SAlburg1
23	Echarlo	52	MtCalv	7	Berksh	15	Cornwal2	39	KirkMead
67	ProdPark	71	SAlburg2	94	UpFishPd	50	MinardPd	4	BearHill
32	Hidden	33	High	41	Koledo	57	NorthRd	68	RattleS
80	Simpson	81	SkitchMt	96	Western	19	Doughty	51	Morristo
87	TBasin	93	TownshNE	40	KnobHill	60	Nyes	26	Fernvill
37	I-91-2	58	NorwThet	72	SAlburg3	10	ColeHlW	48	MidPown
64	PinePond	66	PondWood	74	Sawyers	21	DragonBk	49	MillBk
62	OtterCk	44	MapleGr	65	PondRd	83	SMillBk	47	McGinn
53	MtFuller	54	MtTabor1	55	MtTabor2	95	WCounty	5	BennAirp
28	Guilford	43	LostNat2	77	ShellMt	82	SkunkCab	9	Brandon
30	HapVal11	31	HapVal12	76	SEHill	92	TownHill	1	BaconHo1
2	BaconHo2	3	BaconHo3	36	I-91-1	42	LilyPdS	59	NourseHo
61	OrcuttH1	86	Spicebus	8	BowenRd	17	CottonBk	97	Whiting1
98	Whiting2	11	Conant1	12	Conant2	13	Conant3	90	Towne1
85	SodomPd	29	Halfway	38	JoslinT	84	SNewb	88	Thetford
89	TinkhamH	100	Wormwood	16	Cornwal3	56	MudCk	91	Towne2
14	Cornwal1	24	Farming1	99	Whiting3	27	GrandTr	45	Maquam
25	Farming2	46	MarshHl1	78	Shoreha1	79	Shoreha2	63	Oxbow
75	SBurlAir	34	Hildene	35	HydePnt	69	Rosetti	73	Salisbur

SITE NAMES

1	BaconHo1	2	BaconHo2	3	BaconHo3	4	BearHill	5	BennAirp
6	Bennet	7	Berksh	8	BowenRd	9	Brandon	10	ColeHlW
11	Conant1	12	Conant2	13	Conant3	14	Cornwal1	15	Cornwal2
16	Cornwal3	17	CottonBk	18	Cranberr	19	Doughty	20	Downer
21	DragonBk	22	EarlWay	23	Echarlo	24	Farming1	25	Farming2
26	Fernvill	27	GrandTr	28	Guilford	29	Halfway	30	HapVal11
31	HapVal12	32	Hidden	33	High	34	Hildene	35	HydePnt
36	I-91-1	37	I-91-2	38	JoslinT	39	KirkMead	40	KnobHill
41	Koledo	42	LilyPdS	43	LostNat2	44	MapleGr	45	Maquam
46	MarshHl1	47	McGinn	48	MidPown	49	MillBk	50	MinardPd
51	Morristo	52	MtCalv	53	MtFuller	54	MtTabor1	55	MtTabor2
56	MudCk	57	NorthRd	58	NorwThet	59	NourseHo	60	Nyes
61	OrcuttH1	62	OtterCk	63	Oxbow	64	PinePond	65	PondRd
66	PondWood	67	ProdPark	68	RattleS	69	Rosetti	70	SAlburg1
71	SAlburg2	72	SAlburg3	73	Salisbur	74	Sawyers	75	SBurlAir
76	SEHill	77	ShellMt	78	Shoreha1	79	Shoreha2	80	Simpson
81	SkitchMt	82	SkunkCab	83	SMillBk	84	SNewb	85	SodomPd
86	Spicebus	87	TBasin	88	Thetford	89	TinkhamH	90	Towne1
91	Towne2	92	TownHill	93	TownshNE	94	UpFishPd	95	WCounty
96	Western	97	Whiting1	98	Whiting2	99	Whiting3	100	Wormwood

Cut levels:

0.0000 2.0000 5.0000 10.0000 20.0000

Options:

Minimum group size for division = 5
Maximum number of indicators per division = 5
Maximum number of species in final table = 175
Maximum level of divisions = 6

Length of data array after defining pseudospecies: 8786
Total number of species and pseudospecies: 888
Number of species: 349
(excluding pseudospecies and ones with no occurrences)