FINAL REPORT

Natural Communities and Rare Vascular Plants of West Mountain Wildlife Management Area and Nulhegan Basin Division of the Silvio O. Conte National Fish and Wildlife Refuge, Essex County, Vermont

Mapping, Description, and Ecological Management Recommendations

A Report to the United States Fish and Wildlife Service, Vermont Agency of Natural Resources, The Nature Conservancy, Vermont Housing and Conservation Board, and Vermont Land Trust

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Acknowledgements

We thank all the partners who have collaborated on the conservation of the former Champion lands. Their hard work and steadfast commitment to the landscape scale conservation of these lands has laid a strong foundation for the project. The effort to acquire extensive ecological information prior to the development of management plans is a model that deserves to be followed elsewhere.

Many people provided assistance in the completion of our work. John DeLeo, GIS Specialist at Lyndon State College, worked with us to develop the cartographic process and solve many technical difficulties in the GIS/GPS aspect of the work; his tireless efforts to make the natural community maps the best they could possibly be were indispensable. Michelle Babione, USFWS, helped us through GIS glitches in year two revisions. Eric Sorenson, Vermont Nongame and Natural Heritage Program ecologist, spent several days mapping parts of the Refuge and WMA and helped us think through some of the ecological nuances of the land. Everett Marshall, Vermont Nongame and Natural Heritage Program database manager, provided spatial data from the Heritage database. Dan Farrell, a pure volunteer, and Lou Bushey, Vermont Department of Forests, Parks and Recreation, assisted with plot sampling. Joe Homer, Natural Resource Conservation Service soil scientist, lent us a day of his time to sort out some of the soils complexity in the Nulhegan Basin. Thanks to Bill Hegman and Bob Churchill at the Middlebury College Geography/GIS lab for some GIS pointers and allowing us to occasionally download some large shape files. Craig Goulet hosted us with humor and cheer and provided housing in downtown Island Pond. The US Fish and Wildlife Service was kind enough to supply us with top-notch GPS receivers and a high-quality stereoscope, which were indispensable to the inventory and mapping work.

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Executive Summary

In order to provide ecological information for management planning in the 8,903-ha West Mountain Wildlife Management Area (WMA) and the 10,522-ha Nulhegan Basin Division of the Silvio O. Conte National Fish and Wildlife Refuge (Refuge), natural community inventory and mapping, and rare and exotic plant inventory were conducted between April 2000 and October 2001. A natural community map for the WMA and Refuge was developed based on aerial photograph interpretation and extensive field observation. The map was transferred from hand-drawn acetate overlays to digital spatial data using the ArcView/ArcInfo Geographic Information System (GIS). The natural community polygon shape files are stored at the Vermont Agency of Natural Resources, Waterbury, Vermont, Silvio O. Conte National Fish and Wildlife Refuge, Turner Falls, Massachusetts, and the office of Marc Lapin.

Landforms of the study area include mountain lands of both granite and quartzite-phyllite-schist bedrock, a granitic pluton basin, and a mid-elevation stagnant ice valley and flats. Except for the bottom of the plutonic Nulhegan Basin, the landscape is dominated by northern hardwood and red spruce-hardwood forests. The Nulhegan Basin bottom is dominated by lowland spruce-fir forest, with lesser amounts of red spruce-hardwood forest. Within this matrix of upland deciduous, coniferous and mixed forests, are many smaller spaces of forested and open wetlands, montane forests, cliffs and woodlands, and aquatic stream and pond natural communities.

Although three major forest natural communities dominate the landscape, natural community diversity is substantial. In the stagnant-ice landscape of the WMA, natural community diversity is high and is primarily related to a small-patch mosaic of lowland spruce-fir forest and many wetland natural community types in the numerous pond and stream basins. Spruce-fir-tamarack and northern white cedar swamps are common as are alder swamps, open peatlands, and beaver meadows. The high elevations of West Mountain itself support very limited areas of montane natural communities. Areas of exceptionally high ecological value in the WMA are Dennis Pond (and associated Mud Pond) and Ferdinand Bog.

Within the Refuge, the Nulhegan Basin is an area where hydrology and glacial deposits create a complex, fine-scale mosaic of upland and wetland natural communities—lowland spruce-fir forest, both well drained and wet–mesic variants, are intermingled with spruce-fir-tamarack swamp, black spruce swamp, northern white cedar swamp, a variety of open or shrubby peatlands, and riparian and beaver wetlands. Cloaking the slopes of the basin rim are extensive northern hardwood forests and its variants, plus restricted montane natural communities. Although much of the lowland conifer-dominated area, known as Yellow Bogs, has been heavily logged, it remains unparalleled in Vermont as an example of a northern lowland ecosystem. Of equal ecological significance in the Refuge and adjacent ownerships are the high-quality alluvial shrublands and associated floodplain natural communities along the Nulhegan River and its branches.

Twenty-eight terrestrial and palustrine natural community types were observed in the WMA. A number of these include several variants, for a total of 56 natural community types and variants mapped. Twenty-six terrestrial and palustrine natural community types were mapped on the Refuge. A number of these also include several variants, for a total of 46 natural community types and their variants mapped.

Six natural community types considered rare (S2) in Vermont occur in West Mountain WMA. Two newly described natural community types thought to be rare also are located in the WMA. An additional seven natural community types are ranked uncommon (S3). Thirty-two natural community types and variants in West Mountain WMA have state-significant examples.

The Refuge also has six natural community types considered rare (S2) in Vermont, plus one newly described type that is thought to be rare. An additional 10 natural community types are ranked uncommon (S3). Twenty-five natural community types and variants have state-significant examples in the Refuge.

This and other work in Vermont indicates that some variants of natural community types are rare or uncommon, whereas the type and perhaps most of its variants are more common. Variants that are provisionally considered to be rare number four. Variants that are provisionally considered to be uncommon number six. These are not included in the counts enumerated in the preceding two paragraphs.

Three new natural community types and 22 new variants are described and proposed as additions to the Vermont natural community classification. Dynamics and disturbance regimes are described for closely related groups of natural community types.

Twenty-two natural community complexes featuring inter-related, state-significant natural communities are described in a higher-level ecosystem framework of the four major landforms.

Ecological management recommendations are made in reference to each of the natural community complexes described. Ecological management recommendations suggest management actions or strategies that aim to increase ecological integrity of the natural communities and conserve populations of rare and uncommon plants.

Rare and uncommon vascular plants were inventoried simultaneously with natural community mapping. A total of 46 plant species listed by the NNHP as rare and uncommon in Vermont are now known to occur on both West Mountain WMA and the Conte Refuge. An additional two rare species were found on the Nulhegan floodplain in Wenlock WMA, immediately adjacent to the Refuge; these species very likely occur within the Refuge also. Over one-half of the 46 species were new for the former Champion lands; most, however, were known from Essex County prior to the inventory. Three species ranked as "state historical" were rediscovered after absences of documented occurrences in the state. These are Pickering's reed bent-grass *(Calamagrostis pickeringii)* (G4/SH), Wiegand's sedge *(Carex wiegandii)* (G3/SH), and shining rose *(Rosa nitida)* (G5/SH). In addition to the historical species, the flora includes 12 very rare (S1) and 13 rare (S2 or S2S3) species. Seventeen of the 46 species are ranked as uncommon (S3), and one species. Six plants found in the project area are protected by Vermont's Endangered Species Law (10 V.S.A. Chap. 123). They are auricled twayblade *(Listera auriculata)* (G3/S1), woodland cudweed *(Gnaphalium sylvaticum)* (G5/S1), pod-grass *(Scheuchzeria palustris* ssp. *americana)* (G5/S1), northern yellow-eyed grass *(Xyris montana)* (G4/S1), sweet coltsfoot *(Petasites* frigidus var. *palmatus)* (G5T5/S1), and northeastern bladderwort *(Utricularia resupinata)* (G4/S1). A seventh state-protected plant observed in the area is contracted sedge *(Carex arcta)* (G5/S1), a state-threatened species growing in the Nulhegan floodplain in Wenlock WMA. No plant species listed as federally endangered or threatened were found.

Invasive and exotic plant species are remarkably few, even in floodplain natural communities. Fifteen small populations of common reed and a single plant of common buckthorn are documented in, or directly adjacent to, the WMA and Refuge.

Chapter 1. Introduction

Introduction and Purpose

The conservation and conservation management of the former Champion International Corporation lands (former Champion lands) in Essex County, Vermont are the result of lengthy and detailed planning processes conducted by numerous parties; the U.S. Fish and Wildlife Service (USFWS 1999), the State of Vermont Agency of Natural Resources and The Nature Conservancy (TNC) were involved in the most in-depth ecological evaluations. The federal planning and management effort is primarily based on a Connecticut-River-watershed context, and the TNC effort was part of ecoregional conservation planning for the Northern Appalachian/Boreal Forest ecoregion (The Nature Conservancy 1997). Such broad-scale approaches to conservation are becoming the norm and are commonly thought to be necessary for "meaningful" conservation of intact, highly functioning, natural ecosystems—that is, conservation of 1) biota and population processes, 2) ecosystem diversity, 3) ecosystem function, and 4) landscape-level ecosystem processes (e.g., ecological, meteorological, biogeochemical).

Conservation efforts have resulted in the purchase and establishment of 8,903-ha West Mountain Wildlife Management Area (hereafter referred to as West Mountain WMA or WMA) and 10,522-ha Nulhegan Basin Division of the Silvio O. Conte National Fish and Wildlife Refuge (hereafter referred to as Conte Refuge, Nulhegan Basin Division Refuge, or Refuge), as well as conservation easements on 34,398 ha purchased by Essex Timber Company, LLC.

In order to apply a landscape-scale approach to management of the lands, natural communities of the WMA and Refuge were inventoried and mapped. Simultaneous with natural community mapping, an inventory of rare, uncommon and invasive vascular plants was conducted. The results of that work are presented in this report.

Other researchers were contracted to gather additional scientific information to assist in planning and land management. Surveys were conducted to document species presence in the following animal groups: breeding birds (including separate owl and waterfowl surveys), amphibians and reptiles, small mammals, butterflies and odonates, and fish and aquatic macroinvertebrates. In addition, historical research regarding forest disturbance dynamics, presettlement forest composition, archaeological sites and human uses of the landscape was conducted. When it was available and applicable, information from those reports is cited in this report, but because of the simultaneity of all of the research projects, that blending of information is by no means thorough.

In order to understand relationships between natural community types and species distribution, representative sampling sites were selected to provide a sampling design stratified by natural community. The representative site framework was employed in inventories of the above groups, with the exception of the aquatic flora and fauna.

The natural community map, along with information from the species surveys, is intended to be used in the development of management protocols and boundaries for management areas, including one or several special treatment areas (STA) or ecological reserves on the conservation lands. In addition to the conventional management areas on the WMA, there will be, according to legally binding easement, STAs in which management standards will aim toward a very high level of ecological integrity.

The natural community and vascular flora work, along with the other research efforts noted above, were funded by a collaborative including the U.S. Fish and Wildlife Service, Vermont Agency of Natural Resources, The Nature Conservancy, the Vermont Land Trust, the Vermont Housing and Conservation Board, and the National Fish and Wildlife Foundation.

Organization of the Report

This document is organized into six chapters and three addenda, plus natural community maps for the Refuge and WMA. The addenda are entirely new material added to the year 2002 revision, and they discuss and analyze the Nulhegan Basin in a regional ecological and conservation context, including analysis of the Refuge with regard to high-level ecological conservation potential.

The six chapters are organized as follows, and they do include some revisions and corrections to the initial report dated May 2001. This, the first chapter is an introduction to the project and the study area. Second we present the results of natural community mapping and inventory, accompanied by a discussions of disturbance dynamics and descriptions of proposed additions to the Vermont natural community classification of types and variants. Chapter 2 is the primary documentation for understanding and interpreting the natural community map. The third chapter discusses the landscape at a scale larger than natural communities. In this 54,000-ha system of conservation lands, there are opportunities for conservation at scales larger than those normally considered in New England, and there seemed to be a need for a larger scale ecological framework in which to view the land. Therefore, we developed a first approximation of a hierarchical landscape mosaic (landform level) ecosystem classification; we describe the different landforms and discuss natural community complexes of exceptional significance within each landform. The fourth chapter presents the natural community representative sampling framework utilized by most of the other biological contractors. The fifth chapter of the report discusses the rare and uncommon vascular plants of the WMA and Refuge. Chapter six reports on invasive and exotic vascular plant species.

The natural community map and attribute data that accompany this report are electronically stored as ArcView shape files with the Vermont Agency of Natural Resources, Waterbury, Vermont; Conte National Fish and Wildlife Refuge, Turner Falls, Massachusetts; and Marc Lapin, Cornwall, Vermont. The full, final natural community polygon themes are wmwma_nc_2002final.* and conte_nc_2002final.*. These have been clipped to various boundaries; the resultant themes clipped from these two are listed in Appendix 5, along with other GIS themes developed by the authors.

Common names are used for vascular plants throughout the report, with the exception of sedges, grasses and rushes, most of which do not have widely known common names. Rare and uncommon species are referred to by both common name (if there is one) and scientific name; in parentheses following the names of rare and uncommon species are their global (G rank) and state (S rank) rarity ranks. Scientific names of plants referred to in the text are included as Appendix 1.

Location of the Project Area

The 19,000+ ha of WMA and Refuge lie north and south of the Nulhegan River in the towns of Bloomfield, Brunswick, Ferdinand, Lewis, and Maidstone, Essex County, Vermont. The area, part of Vermont's "Northeast Kingdom," extends from north latitude 44°37' to 44°55' and from

west longitude 71°50' to 71°37'. A portion of the former Champion lands that is public land on the east side of Maidstone Lake was not included in the natural community and rare plant contract and was not visited during this project.

Landscape Description

The former Champion lands in Vermont—now the WMA, Refuge, and landholdings of Essex Timber Company, LLC—are a large portion of the Northeast Highlands biophysical region (Girton and Capen 1997). The Northeast Highlands biophysical region is part of a larger ecological unit that also includes land in New Hampshire and Maine. According to the hierarchical "Ecological Units of the Eastern United States: First Approximation," the land is within, from smaller landscape unit to larger, the Mahoosuc-Rangely Lakes Subsection [may include some of Connecticut Lakes Subsection], White Mountain Section, New England-Adirondack Province, Warm Continental Division, Humid Temperate Domain (Keys and Carpenter 1995). The Mahoosuc-Rangely Lakes Subsection is characterized by relatively high mountains (300-1200 m); glacial till and outwash deposits; granite-granodiorite bedrock; moist, cold climate; spodosol soils; mixed forests of northern hardwood and conifer species; and an abundance of lakes, ponds, rivers, and streams.

Physiography

The physiographic makeup of the lands is scattered mountain summits and slopes, a well-defined range of small mountains, a well-defined mid-elevation basin, and a mid-elevation medium-sized river valley and flats. The Nulhegan Basin is a very discrete, nearly circular, mid-elevation basin circumscribed by mountains; it covers approximately 15,400 ha and measures 14 km in diameter; the elevation range is approximately 365 m to 425 m. The basin is bounded on the east by a line of mountains that includes two named peaks, Potash and Little Potash mountains. The summits on this eastern rim of the basin range from 525 m to 714 m. North of the Nulhegan Basin are taller peaks. The highest peak within the public landholdings reaches 860 m, but the highest point within the Refuge and WMA is on a higher slope slightly north of that, at 884 m near the summit of an unnamed 913 m mountain to the east of Gore Mountain.

To the south of the Nulhegan Basin, a 5,000+ ha valley and mid-elevation flats in the drainages of Paul, Dennis, and Wheeler streams is at a similar elevation (300 m to 460 m); in the middle of this low-relief, mid-elevation terrain sits West Mountain, an 833 m isolated peak.

The lowest elevations in the study area are on the east side of the WMA, on the edge of the Connecticut River Valley near Brunswick Springs (286 m) and the mouth of Paul Stream (274 m). Only a tiny portion of the study area lies within that major river valley.

A name often used for part of the Nulhegan Basin north of the Nulhegan River mainstem is "Yellow Bogs," an area with no formal political or physiographic boundary. Broadly construed, Yellow Bogs is used to refer to the wet-mesic and well drained lowland spruce-fir forest and the associated swamps and bogs that cover much of the bottom of the eastern half of the Nulhegan Basin. The area is primarily drained by the sluggish Yellow Branch of the Nulhegan River.

Hydrology

Surface hydrology consists of numerous brooks, streams, ponds, and the Nulhegan River. The entirety of the area is within the Connecticut River watershed. Surface waters within the project area in the Nulhegan Basin include a short stretch of the Nulhegan River and much of the lengths of the Black, Yellow and Logger branches, plus about one-half the length of the North Branch.

Wenlock WMA, situated between the Refuge and West Mountain WMA, includes a longer stretch of the Nulhegan mainstem. Lewis Pond sits in a large mountain basin, along the course of the Logger Branch, north of the Nulhegan Basin. South of the Nulhegan Basin, Paul Stream is the major river. Both Paul Stream and the Nulhegan flow into the Connecticut River. Several smaller streams between the Nulhegan and Paul Stream join and empty into the Connecticut River as Wheeler Stream. The named streams of that small watershed are Notch Pond Brook, Dennis Pond Brook, Telephone Brook, West Mountain Brook, and Wheeler Stream. Most of the ponds of the former Champion lands are within this watershed; they are Notch Pond, Mud Pond, Dennis Pond, West Mountain Pond, and Wheeler and Little Wheeler ponds. Within the Paul Stream drainage are South America, Unknown, and Paul Stream ponds, as well as the much larger Maidstone Lake, which borders the study area. Tuttle Pond drains directly into the Connecticut River.

Bedrock and Surficial Geology

Most of the area is composed of two types of bedrock—granitic plutonic rocks and Gile Mountain formation phyllite, schist and quartzite, both of Devonian age (Doll 1961). A small area of Ordovician-age Albee formation quartzite, slate and phyllite occurs in the study area. The granitic rocks are divided into three distinct plutons; the Nulhegan and Maidstone plutons comprise the majority of the granite, and a small area of the Averill Pluton extends into the northern extremity of the Refuge. Doll (1961) describes the Gile Mountain formation as:

> Gray quartz-muscovite and phyllite or schist, interbedded and intergradational with gray micaceous quartzite (greywacke northeast of Nulhegan River), calcareous mica schist, and locally, quartzose and micaceous crystalline limestone like that of the Waits River formation.

No areas suspected to have substantially calcareous schist or crystalline limestone were observed during the project.

The Albee formation is (Doll 1961):

> Massive, gray, white-weathered quartzite and feldspathic quartzite interbedded with greenish gray slate, phyllite, feldspathic phyllite and quartzose argillaceous phyllite. [And] Micaceous quartzite, quartz-mica schist, mica schist, and hornfels...

Surficial deposits are of glacial, peri-glacial, and post-glacial alluvial origin. Coarse-loamy tills that are probably best described as washed tills are extensive in the Nulhegan basin and the flats east of West Mountain. Both areas were "stagnant-ice" landscapes during late Wisconsinan glacial ablation. Glacio-fluvial and glacio-lacustrine deposits comprise a significant portion of the surficial deposits; these are predominantly either sandy or cobbly and sandy, and limited areas are extremely bouldery. West Mountain WMA contains a variety of well-developed glacial landforms, including numerous eskers, kames, and kettles. The Refuge for the most part lacks those features, but does include kame moraine (Stewart and MacClintock 1970). Part of what is mapped as kame moraine along the Nulhegan River appears to be a narrow outwash plain deposit; more detailed geologic investigation would be needed to accurately interpret and map those features. The Yellow Bogs portion of the Nulhegan Basin is dominated by a cobbly-sandy deposit, the origin of which has not been sufficiently investigated. It appears to be a very coarse-loamy washed till with a cobble-boulder veneer, which occasionally is seen in situations where till meets glacial outwash (Joe Homer, pers. com.). Similarly, the cobbly-sandy deposit between West Mountain, Dennis and Wheeler ponds has been insufficiently interpreted and mapped. Finer tills more typical of the surficial deposits found throughout Vermont's mountainous regions cover the mountain slopes.

Soils

Except for lands along the Connecticut River, most soils of Essex County, Vermont, have not been mapped by the Natural Resources Conservation Service (NRCS) or their predecessor the Soil Conservation Service. Based on our fieldwork and some preliminary information provided by local NRCS staff we provide the following summary. The temperature regime in the area is frigid, and the soils are mostly spodosols, with smaller areas of inceptisols, entisols and histosols. On mountain slopes and most hills, the northern hardwood, red spruce-hardwood, and montane forest natural communities have typical loamy till spodosols and inceptisols. Glacio-fluvial and glacio-lacustrine landforms have sand to sandy loam spodosols. In the lowland spruce-fir forests of the Nulhegan Basin, however, spodosols and inceptisols occur in a very complex patchwork. Additionally, a substantial area of land is covered with shallow-peat, and to a much lesser extent deep-peat, organic soils. Soil drainage throughout the landscape covers the full range from excessively drained (i.e., on eskers and extremely shallow soils) to very poorly drained peat-filled basins (i.e., many forested wetlands and open peatlands). Engstrom and Lapin, and the soils scientists from northern Vermont and New Hampshire, Roger Dekett and Joe Homer, agree that some of the soils found in the Nulhegan Basin, particularly those in many of the wet-mesic lowland spruce-fir natural communities, are very unusual for the region. Heavy staining of a dark mineral, perhaps manganese, is common in the upper B-horizon, and although the soils are very wet, a substantial organic horizon has not developed (or perhaps it has been burnt off during post-logging fires (see Cogbill 2001)). To summarize, there is a great deal of variability in the soil profiles and soil drainage classes in the study area, but all soils are frigid, and the mineral soils range in texture from sandy to fine-loamy, with coarse-loamy soils predominant. Further information about soils in relation to natural communities can be found in natural community and significant site descriptions in this report, and in *Wetland, Woodland, Wildland* (Thompson and Sorenson 2000).

Chapter 2. Natural Communities

Natural Community Determination and Mapping Methodology

During the period April 2000 to December 2001, natural community maps for West Mountain WMA and Nulhegan Basin Division, Conte NFWR were developed based on the Vermont natural community classification (Thompson and Sorenson 2000). A natural community is an interacting system of biota, climate, bedrock, soils, physiography, hydrology, and natural ecosystem processes (such as nutrient cycling, disturbance regimes, predation, pollination and seed dispersal) (Thompson and Sorenson 2000, Poiani *et al.* 2000). Determination of natural communities on the ground is largely based on vegetation and soils.

Most natural communities in the study area are described by Thompson and Sorenson (2000). They present general, statewide natural community characteristics of 40 upland and 40 wetland types; many of these types are further refined into natural community variants. Biotic community composition (flora, fauna, microorganisms) of natural community types may differ from one biophysical region to another, due to biogeographic patterns of various organisms as well as species habitat requirements that may differ from one region to another. Hence, some new natural communities and variants were needed to describe the landscape of the former Champion lands.

Mapping methods can be divided into several phases, some of which occurred simultaneously: 1) landscape reconnaissance, 2) aerial photograph interpretation and natural community mapping on acetate overlays, 3) digital rectification of aerial photographs with their acetate overlays, 4) digitization and attribution of natural community polygons, and 5) second-season revisions.

7.5' USGS topographic quadrangles, surficial and bedrock geology maps (Doll 1961, Stewart and MacClintock 1970) and various sets of aerial photographs (inherited from Champion International, Inc.) were used to gain an initial familiarity with the land. Some prior information about the natural communities and plant and animal species of interest was available from the Vermont Nongame and Natural Heritage Program (NNHP) (especially Sorenson and Thompson 1989, Thompson 1989, Sorenson *et al.* 1998) and the Lakes and Ponds Division of the Vermont Department of Environmental Conservation.

Existing information and aerial photograph interpretation were used to delineate provisional natural community boundaries prior to fieldwork. Because of the project timeline and the need to define "representative sampling areas" for species inventory work, it was necessary to do the initial photo interpretation and mapping without the benefit of field reconnaissance. Many of the provisional boundaries, especially for upland natural communities, were later erased and redrawn during and after the field season.

Initial mapping of natural communities was done on acetate overlays on 1:15,840-scale aerial photographs. Due to incomplete coverage of the study area, it was necessary to interpret and map on two sets of photographs. Most of the Refuge was mapped on June 1996 false-color infrared photography; nearly the entirety of the WMA was mapped on September 1992 true-color photography. The balance of the public lands units not covered by the primary photo set was mapped on the other set.

The basic method of natural community determination and mapping was an iterative approach based on observation of vegetation and soils in conjunction with aerial photograph interpretation.

On-the-ground transects were selected initially to gain general familiarity with broad natural community (soils and vegetation) patterns and variations. Transects and aerial photograph interpretation were used together to refine understanding of aerial photograph signatures (color and texture patterns). Further into the fieldwork, transects were selected to provide for both field observation in all major parts of the landscape and specific information about places that were not readily interpreted on the photographs.

Field data-collection consisted of observations regarding physiography (landscape position, slope, aspect), soils, and vegetation. Observations of natural community characteristics that were "peculiar," anomalous, confusing, or otherwise did not coincide with natural community descriptions from the state classification were frequently noted. If a site was determined to be outside of the characteristic range of variability of a documented natural community type or variation, it was mapped as a "new" type or variant. These "new" types are provisional, as they are not yet "officially" recognized in the Vermont natural community classification. The majority of proposed "new" types are either variants of the matrix natural communities (northern hardwood forest, red spruce-hardwood forest, lowland spruce-fir forest) or are parts of floodplain ecosystems.

Global positioning system (GPS) location data were captured and used in several ways. GPS receivers utilized during the project were Trimble GeoExplorer 2 and GeoExplorer 3 models and a Rockwell PLGR. Point location data were collected for the following purposes: 1) to document natural community boundary locations, 2) to document having been within a natural community polygon, 3) to document presence of rare or invasive exotic plants, and 4) to document locations of permanent sampling plots.

Field notes were recorded in all-weather notebooks and observation points were numbered and cross-referenced to topographic maps. Aerial photographs were carried in the field, but little actual mapping was done while in the field. The usual mapping method entailed 1) determination of natural community photo signatures and general boundary locations in the field, followed by 2) aerial photo interpretation under 1.5x and 3x magnification (Sokkia mirror stereoscope model MS27), and 3) drawing natural community boundaries on 0.003" clear-acetate overlays. Natural community types were coded for each polygon on a separate clear-acetate overlay.

Aerial photographs with their acetate overlays were scanned and rectified by John DeLeo, Lyndon State College. Lapin and Engstrom then digitized natural community boundaries as line features on ArcView GIS Version 3.2 by "tracing" over the scanned boundary lines and hand-digitizing points along the line. Where GPS location fixes were available, these were used to verify or adjust boundaries as needed.

The map was structured by tiles based on the Vermont Digital Orthophotography Quadrangle tile structure. In this way, natural community coverage of each tile was built as an individual ArcView theme, and editing was done on a tile-by-tile basis, rather than having to alter, and risk corruption of, the entire map.

Rectification of the aerial photographs generally yielded highly accurate results; in those portions of photographs where rectification was inadequate, it was possible to more accurately position natural community boundaries by interpolating among the aerial photographs, digital elevation model contour lines, and Vermont digital orthophotographs, which became available for Essex County toward the end of the first year of mapping.

John DeLeo converted line feature themes into polygon themes using ArcInfo and an extension named EditTools. Finally, the tile structure was dissolved and adjacent polygons of the same type were "unioned" to create natural community maps for West Mountain WMA and the Nulhegan Basin Division, Conte NFWR.

Attributes for the natural communities were entered initially as a point theme, by digitizing a point within each natural community and entering the appropriate information. Attribute information was then merged with the natural community polygon theme. Attribute fields included codes for natural community type, natural community variant, state rank, element occurrence rank, state significance, public land management unit, area, perimeter, and location information.

Second-year map revisions were made by converting the polygon theme into a line theme and revising lines based on new information. Fairly extensive map revisions were made in the Lower Yellow Branch and Lower Black Branch areas. For these revisions, new acetate overlays were drawn and the photos and overlays were scanned and rectified by Michelle Babione, Conte Refuge, Turner Falls, Massachusetts. Lines were adjusted by digitizing on-screen from the rescanned photos. For areas where revisions were minor, line changes were made directly on-screen while visually comparing new lines and old lines drawn onto the first-year acetates. Michelle Babione then converted the line themes back into polygons and used corrected point features to re-apply attributes to the polygons.

Detailed documentation of the GIS methods is available in metadata files prepared by John DeLeo and others and housed at VANR.

Ground-truthing

Field visitation of natural community polygons is documented in GIS point themes entitled "gps1_ml_be" and gps2_ml_be" which were constructed from both GPS location data collected during field work and *ex post facto* digitization of points transcribed from topographic maps used in the field. It was necessary to transcribe points to fill in gaps when GPS receivers were either not carried in the field or were not able to receive enough satellites to enter location data.

Information for over several thousand observation points recorded in field notebooks formed the basis for natural community mapping and ranking. The 1,000+ points in the two GPS-derived shape files provide an approximate indication of which parts of the landscape were mapped based on field observation, and thus were ground-truthed during mapping, and which parts were mapped solely by aerial photo interpretation.

Natural Community Inventory and Mapping Results

With mountain slopes and summits and complex glacial geomorphology, many different natural community types exist on the WMA and Refuge. These public lands each contain both mountain and glacio-fluvial landforms, which are the geophysical foundation for the natural community diversity found on the land.

The predominant natural community types are northern hardwood forest, red spruce-hardwood forest, and lowland spruce-fir forest (Figures 1 and 2). Within the matrix of these forests are many smaller natural communities, including both montane upland types and mineral- and peat-soil wetland types. In total, 32 natural community types, 12 upland and 20 wetland, were observed in the Refuge and WMA (Table 1). Some of the types are further refined into different

natural community variants; a count of all the types and variants totals 63 unique classes identified and mapped.

The natural community map ArcView shape files are stored with the Silvio O. Conte National Fish and Wildlife Refuge, Turner Falls, Massachusetts; Vermont Agency of Natural Resources, Waterbury, Vermont; and Marc Lapin, Cornwall, Vermont. The following natural community polygon themes are the 2002 result of natural community mapping for this project: wmwma_nc_2002final.* and conte_nc_2002final.*. A variety of clipped themes were derived from these master themes and are listed in Appendix 5.

The following sections present brief summaries of the types of natural communities mapped on the public lands. First we present a tabulation of types and variants, with a discussion of rarity and state-significance. Then follow overviews of dynamic processes important to the various natural communities. Descriptions of natural community types or variants that have not been previously described in Vermont but were observed on the former Champion lands are presented following the dynamics overview. Most of the proposed variants are variations of the widespread forest types—northern hardwood forest, red spruce-hardwood forest, and lowland spruce-fir forest. Since these types cover large areas and persist in a wide range of physical conditions, it is not surprising that there is much variation due to the particularities of microsite conditions.

The criteria of what constitutes a natural community type versus a natural community variant are not well defined, and in some cases others may judge what we call a "newly described type" to be a variant of a previously described type. Whether a given natural entity is called a type or a variant is less important than just recognizing and documenting its existence and considering it as part of the diversity on earth. This is much like the flux in species taxonomy, in which different taxa are at some times and by some authors considered to be distinct species, whereas at other times and by other authors the same group of organisms is considered to be distinct at a sub-specific level such as subspecies or variety. Whether classified at one taxonomic level or another, the species diversity and natural community diversity exist and differences between and among entities are observable.

With regard to naming of natural communities, we have followed the names published in *Wetland, Woodland, Wildland* (Thompson and Sorenson 2000) with two exceptions, red spruce-hardwood forest and alluvial shrubland. Thompson and Sorenson call the former natural community type red spruce-northern hardwood forest. The major trees of northern hardwood forests are sugar maple, beech and yellow birch. Because sugar maple is absent from this type in all but a very few cases in the project area, we prefer to call it red spruce-hardwood forest, thus indicating that it is a mixed conifer-hardwood forest without implying that it is a type of northern hardwood forest. In this Northeast Highlands landscape, it has similarities with both northern hardwood forest types and spruce-fir forest types, and may in fact be more similar to the latter. In one location on the properties, a non-montane northern hardwood forest (sugar maple-yellow birch-beech) with a substantial component of red spruce was observed; that area is typed as a northern hardwood-red spruce variant of northern hardwood forest.

Alluvial shrub swamp is the name Thompson and Sorenson (2000) use for what we call alluvial shrubland. Observations of the natural community reveal that it is better characterized as a floodplain community than as a swamp community. Backswamp portions on the floodplains tend to be swamp and often have an organic-over-mineral soil. The main alluvial terraces, however, feature a moderately well drained to somewhat poorly drained mineral soil, with smaller pockets

Table 1.
Natural Community Types and Variants Mapped on West Mountain WMA and Nulhegan Basin Division of the Conte National Fish and Wildlife Refuge

UPLANDS	State Rank
2[1]. Montane Spruce-Fir Forest[2]	S3
2b. Montane Spruce Forest	
2c. Spruce-Fir Ledge	
3. Lowland Spruce-Fir Forest	S3
3a. Well-drained Lowland S-F Forest	
3b. Wet-mesic Lowland S-F Forest	
3c. Lowland S-F-Red Maple-(Aspen)	
3d. Somewhat excessively to excessively drained Lowland S-F, glaciofluvial deposits	(S2)[3]
3l. Lowland S-F, steep pond-shore slopes	
4. Montane Yellow Birch-Red Spruce Forest	S3
4a. Montane YB-Sugar Maple-RS Forest	
4b. Montane YB-Paper Birch Forest	
5. Red Spruce-Hardwood Forest	S4
5a. RS-Hardwood Forest, shallow to bedrock or hardpan	
5b. RS-Hardwood Forest, well drained sands	(S3)
5c. RS-Hardwood Forest, boulder slopes	
5s. RS-Hardwood Seepage Forest	(S3)
6. Boreal Talus Woodland	S3
8. Northern Hardwood Forest	S5
8a. Classic NH Forest	
8c. Sugar Maple-White Ash-Jack-in-the-pulpit NH Forest	(S4)
8d. Yellow Birch-NH Forest	
8e. White Pine-NH Forest	(S3)
8f. Mid-elevation NH Forest, ledges/boulders	(S4)
8g. NH Forest, Beech dominant	
8h. High-elevation Nothern Hardwood Forest	
8j. High-elevation NH Seepage Forest	(S3)
8p. NH Forest, species depauperate	
8s. NH Seepage Forest	(S3)
8t. NH-Hemlock Forest (Hemlock abundant)	
8w. NH Forest, wet mesic	(S4)
11. Hemlock Forest	S4
11a. Hemlock-Red Spruce Forest	
12. Hemlock-Northern Hardwood Forest	S4
13. Northern Hardwood Talus Woodland	S3
27. Erosional River Bluff	S2
34. Temperate Acidic Outcrop	S4
36. Boreal Acidic Cliff	S4

WETLANDS	State Rank
45. Red Maple-Black Ash Swamp	S4
51. Northern White-Cedar Swamp	S3
51a. NWC Sloping Seepage Forest	
51b. Boreal Acidic NWC Swamp	
52. Spruce-Fir-Tamarack Swamp	S3
52a. Red Spruce-Hardwood Swamp	
53. Black Spruce Swamp	S2
55. Seep	S4
56. Vernal Pool	S3
57. Dwarf Shrub Bog	S2
58. Black Spruce Woodland Bog	S2
61. Poor Fen	S2
79a. Sweet Gale-Cedar Poor Fen	(S1)
62. Intermediate Fen	S2
64. Shallow Emergent Marsh	S4
64a. Beaver Meadow	
64c. Beaver Pond	
64d. Beaver wetland, undifferentiated	
85. Oxbow Marsh	(S3)
65. Sedge Meadow	S4
72. River Sand or Gravel Shore	S3
73. River Cobble Shore	S2
77. Alluvial Shrubland	S4
82. Alluvial Meadow/Grassland	(S2)
77a. Alder-Cedar Floodplain Woodland	(S2)
78. Alder Swamp	S5
78a. Alder Swamp, deep peat	(S3)
79. Sweet Gale Shoreline Swamp	S3
81. Mixed Northern Seepage Swamp Forest	(S2)
83. Mixed Northern Floodplain Forest	(S2)
86. Peaty Sand Pondshore	S1

[1] Numbers and alphanumerics refer to codes used on the natural community map.
[2] Types are underlined; variants are indented.
[3] Ranks in ( ) are provisional recommendations. Variants with no rank are assumed to carry the rank of the major type.

that are poorly and very poorly drained. It is not what is commonly considered "swampy" land, and we call it shrubland to indicate that.

Ranking and State-Significance

Natural communities are ranked in two ways. First, each natural community type has been assigned a state rank (S-rank) by the Vermont Nongame and Natural Heritage Program (Refer to Appendix C in Thompson and Sorenson 2000). The system has five categories, from S1, extremely rare, to S5, common and widespread. Second, each natural community occurrence—that is, each polygon on a natural community map, or group of polygons of the same natural community type in close proximity to each other—is given an element occurrence rank (EO rank) based on its "quality." EO-rank specifications take into account 1) vegetation condition, 2) type, degree and "permanence" of human perturbations, 3) landscape setting and "defensibility" (of the ecological integrity) and 4) natural community size (Thompson 1995). EO ranks range from A, very high quality/one of the best examples in the state, to D, heavily impacted and highly disturbed by human perturbations.

State-significance of a natural community is based on a combination of rarity (S-rank) and quality (EO rank). (See Appendix 2 "Guidelines for State Significance.")

The Nongame and Natural Heritage Program has assigned S-ranks to natural community types, but not to variants. Because some variants are less common than others, we have made an attempt to point out which variants appear to be rare or uncommon on a statewide basis. These variant ranks are presented as provisional suggestions and are displayed in parentheses in Table 1.

Uplands and Wetlands: a dichotomy in significance?

It is strikingly apparent from the results summary below that wetland natural communities are much more often highly ranked and state-significant than upland natural communities. This pattern is a direct result of timber productivity and logging history on the former Champion lands. Obviously, open wetlands are not productive for timber and were therefore not logged. Additionally, Champion decided to not log conifer swamps; this was especially true for cedar swamps but also applies to many black spruce swamps and some spruce-fir-tamarack swamps. There had been, however, historic logging in most, if not all, of these swamps.

As present land-management opportunities and alternatives for various levels of conservation protection of large portions of the landscape are evaluated, decision-makers should keep in mind that the integrity of wetland and upland natural communities and flora and fauna are truly intertwined. Ecological interactions, such as nutrient and energy transfers between uplands and wetlands, can regain a more natural state as both upland and wetland systems are given high levels of conservation protection and low levels of human manipulation. Most amphibian and reptile species and many small mammals rely to a large degree upon areas on the land that have a tightly interwoven tapestry of upland, wetland and aquatic natural communities (see species inventory reports by Andrews (2001) and Kilpatrick (2001)). To such organisms, their perception of the environment may not be as simplistic as our traditional upland-wetland dichotomy. This difference in upland and wetland significance ratings demonstrates some of the reasons why larger scale ecological perception of a landscape and landscape-scale conservation planning are becoming more frequently applied.

Natural Community Overview

Proportions of the two management units covered by different general vegetation types show that 86-91% of the land is upland, 7-12% is wetland and 2% is non-aquatic riverine natural community types (Table 2). A caveat is in order, for the wet-mesic variant of lowland spruce-fir forest, which was considered as upland in this calculation, might also be interpreted as wetland; that natural community variant covers 17% of the Conte Refuge. As for the waters in the landscape, ponds (not including beaver ponds) in the WMA cover 2.75% of the landscape and in the Refuge only 0.025%.

Our detailed mapping indicates that 4-5% of the landscape is naturally open. Wetlands, including beaver impoundments and riverine natural communities, account for nearly all of the naturally open areas. Ecological research in northern forests from Northern New England to the Upper Midwest, including the site specific work of Cogbill (2001) for this project, indicate that the natural disturbance regime of forest communities is likely to create openings in roughly 1% of the forested land (Marks and Gardescu 1992, Seischab and Orwig 1991, Canham and Loucks 1984, Lorimer 1977). Thus, if this landscape were left to natural dynamics, it is estimated that upland and wetland natural openings would cover 5-6% of the land, with approximately four-fifths of that comprised of open wetland natural communities and about one-fifth comprised of openings created by forest disturbance.

Table 2. Percentages of Conte Refuge and West Mountain WMA Terrestrial Acreage Comprised of Uplands, Wetlands, Dominant Forest Natural Communities, and Naturally Open Communities.

Land Type	Conte Refuge	WMWMA
Upland	86%	91%
Wetland	12%	7%
Riverine (non-aquatic)	2%	2%
Vegetation Type		
Lowland Spruce-Fir	31%	15%
Red Spruce-Hardwood	27%	21%
Northern Hardwood	25%	51%
Montane Communities	3%	3%
"Beaver Wetlands"	1%	1%
Other Open Wetlands	2%	2%
Open Riverine Communities	1%	2%
Forested Riverine Communities	<1%	<1%

The natural community pattern clearly indicates that, except for the bottom of the Nulhegan Basin, the landscape is dominated by northern hardwood and red spruce-hardwood forests (Figures 1 and 2). In contrast, the bottom of the Nulhegan Basin is dominated by lowland spruce-fir forest, with lesser amounts of red spruce-hardwood and northern hardwood forest. Within this matrix of upland deciduous, coniferous and mixed forests are many smaller spaces of forested and open wetlands, montane forests, cliffs and woodlands, and aquatic stream and pond natural communities.

Although the three major forest natural community types dominate the landscape, natural community diversity is substantial. Within the Nulhegan Basin, the lowland spruce-fir forest is a

closely intermingled mosaic of the well drained and wet-mesic variants, along with spruce-fir-tamarack, black spruce and northern white cedar swamps.

Natural community diversity in the mid-elevation flat of the WMA is primarily related to the mosaic of uplands and wetlands, a legacy of the ice-contact geomorphology. In all of the mountain land, natural community diversity and patterns are largely related to elevation, the shape of the land, and hydrology.

West Mountain WMA Natural Communities

Twenty-eight natural community types were observed in West Mountain WMA (Figure 1). In a number of these there were several variants present, contributing to a total of 56 natural community types and variants mapped. *(Undifferentiated beaver wetland (64d) is not counted as a unique variant, nor is beaver pond (64c) which is an aquatic natural community, albeit impermanently or cyclically so.)*

West Mountain WMA includes six natural community types considered rare (S2) in Vermont, plus two newly described types that are thought to be rare also. An additional seven natural community types are ranked uncommon (S3). (Variants thought to be uncommon have not been tallied in the above counts, because NNHP does not currently rank variants, but that process is suggested as a topic for future discussion.) Thirty-two natural community types and variants in West Mountain WMA have state-significant examples (Table 3).

One newly described natural community variant, sweet gale-cedar poor fen, may be a unique type with only a single occurrence in the state. Its regional extent is unknown, but there is a similar type described in Maine, northern white cedar woodland fen.

Very rare (S1) natural community types in West Mountain WMA are:

- Peaty sand pondshore

Rare (S2) natural community types in West Mountain WMA are:

- Black spruce swamp
- Dwarf shrub bog
- Black spruce woodland bog
- Poor fen
- Intermediate fen
- River cobble shore
- Mixed northern seepage swamp forest (provisionally S2)
- Mixed northern floodplain forest (provisionally S2)

Uncommon (S3) natural community types in West Mountain WMA are:

- Montane spruce-fir forest
- Lowland spruce-fir forest
- Montane yellow birch-red spruce forest
- Boreal talus woodland
- Northern white cedar swamp
- Spruce-fir-tamarack swamp
- Vernal pool
- Sweet gale shoreline swamp

Nulhegan Basin Division – Silvio O. Conte NFWR Natural Communities

Twenty-six natural community types were mapped on the Refuge (Figure 2). In a number of these there were several variants present, contributing to a total of 46 natural community types and their variants mapped. *(Undifferentiated beaver wetland (64d) is not counted as a unique variant, nor is beaver pond (64c) which is an aquatic natural community, albeit impermanently or cyclically so.)*

The Refuge includes six natural community types considered rare (S2) in Vermont, plus one newly described type that is thought to be rare also. An additional 10 natural community types are ranked uncommon (S3). (Newly described variants thought to be uncommon have not been tallied in the counts above, because NNHP does not currently rank variants, but that process is suggested as a topic for future discussion.)

Twenty-five natural community types and variants have state-significant examples in the Refuge (Table 3).

Rare (S2) natural community types in Nulhegan Basin Division—Conte NFWR are:

- Black spruce swamp
- Dwarf shrub bog
- Black spruce woodland bog
- Poor fen
- River cobble shore
- Mixed northern seepage swamp forest/woodland (provisionally S2)
- Mixed northern floodplain forest (provisionally S2)

Uncommon (S3) natural community types in the Refuge are:

- Montane spruce-fir forest
- Lowland spruce-fir forest
- Montane yellow birch-red spruce forest
- Boreal talus woodland
- Northern hardwood talus woodland
- Northern white cedar swamp
- Spruce-fir-tamarack swamp
- Vernal pool
- River sand or gravel shore
- Sweet gale shoreline swamp

Lowland Spruce-Fir Forest Significance

We have ranked lowland spruce-fir forest in the Nulhegan Basin according to the published ranking specifications (Thompson 1995). The basin contains the largest lowland spruce-fir landscape in Vermont. Due to current condition of the vegetation, however, the lowland forest, which is predominantly young regeneration from clearcuts, fits the criteria for an EO rank of C. The S rank of the natural community type is S3, uncommon. C-ranked S3 natural communities are not, according to the 1996 "Guidelines for State Significance," considered to be state-significant. Nevertheless, few would disagree that the lowland spruce-fir forests of the Nulhegan Basin are a natural feature of state-significance. This is an instance in which the ranking specifications and the guidelines for state significance do not adequately measure the significance

Table 3.
State-Significant Natural Communities of West Mtn. WMA and Nulhegan Basin Division-Conte NFWR

Natural Community Type or Variant	Conte Refuge	West Mtn. WMA	State Rank
Lowland Spruce-Fir Forest, well drained	x	x	S3
Lowland Spruce-Fir Forest, wet-mesic	x	x	S3
Lowland Spruce-Fir Forest, somewhat excessively to excessively drained, glaciofluvial deposits		x	S2?
Lowland Spruce-Fir Forest, steep pond-shore slope		x	S3
Montane Yellow Birch-Red Spruce Forest		x	S3
Montane Yellow Birch-Sugar Maple-Red Spruce Forest		x	S3
Red Spruce-Hardwood Forest, shallow to bedrock or hardpan		x	S4
Red Spruce-Hardwood Forest, boulder slope		x	S4
Red Spruce-Hardwood Seepage Forest	x		S3?
High-elevation Northern Hardwood Seepage Forest		x	S3?
Northern Hardwood Seepage Forest	x		S3?
Mixed Northern Floodplain Forest	x	x	S2?
Mixed Northern Seepage Swamp Forest	x	x	S2?
Northern White Cedar Swamp (minerotrophic)	x	x	S3
Northern White Cedar Sloping Seepage Forest	x	x	S3
Boreal Acidic Northern White Cedar Swamp	x	x	S3
Spruce-Fir-Tamarack Swamp	x	x	S3
Red Spruce-Hardwood Swamp	x		S3
Black Spruce Swamp	x	x	S2
Dwarf Shrub Bog	x	x	S2
Black Spruce Woodland Bog	x	x	S2
Poor Fen	x	x	S2
Sweet Gale-Northern White Cedar Poor Fen		x	S1?
Intermediate Fen		x	S2
Beaver Meadow and Pond		x	S4
Oxbow Marsh	x		S3?
Sedge Meadow		x	S4
River Sand or Gravel Shore	x		S3
River Cobble Shore	x	x	S2
Erosional River Bluff	x		S2
Alluvial Shrubland	x	x	S4
Alluvial Meadow/Grassland	x	x	S2?
Alder-Cedar Floodplain Woodland		x	S2?
Alder Swamp	x	x	S5
Alder Swamp, deep peat	x	x	S3?
Sweet Gale Shoreline Swamp	x	x	S3
Peaty Sand Pondshore		x	S1

of what is on the land. Clearly, as the forest in the basin matures, the lowland spruce-fir natural communities will "grow into" state-significance, as defined by the guidelines. We thus contend that it is appropriate and necessary to consider the lowland spruce-fir forest natural community of the Nulhegan Basin to currently be state-significant also. The small fragments of lowland spruce-fir forest that are A- and B-ranked in West Mountain WMA are mostly pieces of the more intact forest that is within Wenlock WMA, or lakeshore or esker forests that are quite mature.

Natural Community Dynamics--Disturbance Regimes

Natural community disturbance dynamics are a combination of continual ecological processes, such as herbivory, single-tree death, and decomposition, and periodic disturbance events, such as small patch blowdowns, mortality due to eruptive insect infestations, and hurricanes. Cogbill (2001) has summarized the historical disturbance patterns of the former Champion lands.

The disturbance patterns Cogbill documented are landscape-scale dynamics. In addition to these broad patterns, individual natural community types are subject to different disturbances, which are often related to particular site factors such as very shallow soils or seasonal inundation.

In this section we discuss disturbance regimes of particular natural community types and groups of types that are seen as having, in the WMA and Refuge study area, specific disturbance agents above and beyond those that apply to the landscape as a whole. Natural community types are generally ordered as arranged in Thompson and Sorenson (2000).

Montane Natural Communities

Montane spruce-fir forests and lower elevation spruce-fir ledges have severe climates and often have soils that are shallow to bedrock. Wind is a nearly constant stress to trees, as is evidenced by small tree stature and the common occurrence of wind sheer and flagged branching. Blowdown occurs at a higher rate in exposed places, especially where tree rooting is shallow. The montane forests in the WMA and Refuge are not particularly high or otherwise exposed to the elements, but they do encounter the general wind, ice and shallow-soil stresses at a greater intensity than the lower elevation forests. Also, because of drying summer winds and shallow soils, these forests may have burned more frequently and hotter than the hardwood forests on the slopes below. Often, a burnt area will regenerate to paper birch. Paper birch is common on the west side of West Mountain, in both montane spruce-fir and montane yellow birch-red spruce natural communities.

Montane yellow birch-red spruce natural communities experience some of the severe stresses of wind, ice, fire and shallow soils described for the montane conifer forests, although typically to a lesser extent. The severity of wind and fire, however, is often a factor of aspect. On West Mountain, a large amount of the west-facing montane birch-spruce forest is currently dominated by paper birch. Greater drying of soil and litter from the prevailing westerly winds and warmer microclimate of the west slopes likely account for the spread of hot, post-logging fires through these natural communities. The present result is a paper birch-dominated forest. Slope aspect is similarly related to disturbance by agents such as ice and hurricanes. The January 1998 ice storm had much more severe effects on east-facing slopes on Vermont's mountains.

Smaller montane natural communities that occur in the study area are boreal acidic cliff and boreal talus woodland. Agents of dynamic change in those natural communities include the climate-soil inter-relationship discussed above, as well as geologic processes such as fracture of new boulders from cliffs and downslope movement of boulders.

The major dynamic forces of montane natural communities in Vermont generally have not been severely disrupted by on-site human activities (although global-scale disturbances related to anthropogenic climate change and acid rain will continue to influence natural community changes). Logging and post-logging fires have temporarily impacted disturbance regimes, but a return to a fire regime less influenced by human-caused fires is expected under state and federal land management. The major forces are related to climate and physiography (slope degree and aspect), and those factors will continue to operate and drive natural community dynamics. Lesser factors, such as amount of moose herbivory, are likely to oscillate over time and drive only minor changes to vegetation of the montane natural communities. Hence, management of natural community dynamics in montane areas is principally a *laissez-faire* proposition. Allowing wind, ice, lightning and hurricanes to effect their changes on the vegetation will lead to "natural" function of the montane communities. Not altering the fire regime, such as with accidental or purposeful burns of logging slash, which were frequent in the first half of the 20th century, should be the primary technique for allowing the natural dynamics to function. Small, lightning-caused fires may occasionally occur and should be allowed to burn. Salvage logging of blowdown would be an interruption in the natural dynamic of woody debris accumulation on the forest floor.

Lowland Spruce-Fir Forest

Across boreal NA fire is a major ecological force in the dynamics of conifer forest ecosystems (Heinselman 1981). The Nulhegan Basin spruce-fir lowlands, however, lie just south of the true boreal forest. In his forest history research Cogbill (2001) found little evidence of presettlement fires in the Nulhegan Basin. Twentieth century anthropogenic fires, however, are well documented. Likewise, Cogbill's search of records revealed no evidence of catastrophic wind events (i.e. hurricanes). The natural disturbance regime, rather than having fire or major windstorms as a principle agent, appears to be one of small-group blowdown, and to a lesser extent spruce-budworm infestation cycles. The Nulhegan Basin, however, is at the southern edge of spruce budworm susceptibility. Historically, budworm infestations are not likely to have been as intense as farther north (Cogbill, pers. com.).

Among the reasons for the lack of a natural fire regime in the Nulhegan Basin is that natural ignition sources and the fine fuels necessary to get a fire going do not frequently coincide in the basin. The fine fuels sufficiently decompose within three years of tree death to a point at which they no longer pose a fire threat.

The "natural" forest is likely composed of multiple patches of same-age tree cohorts. Cohort establishment would appear to be related to small blowdown events. The likelihood of an area blowing down is related to tree composition and soil drainage, which interacts with depth of rooting. Presettlement forest composition in the Nulhegan Basin was apparently a mélange of conifer species, with a lot of red spruce, tamarack and fir, and lesser amounts of black spruce (Cogbill 2001). One might question, however, the original surveyors' identification of red versus black spruce in the basin, as hybridization currently appears to be common; the hybrid abundance may be a recent phenomenon or may have deep historic precedents.

As a result of heavy logging, the current forest is structured very differently from the forest prior to industrial logging. The lowland is now a basically even-age forest across the landscape. The mosaic of different age cohorts no longer exists, and that dramatically changes the forest dynamics (Cogbill, pers. com.). One may guess that a return to the structure of different-age cohort patches will take several centuries. That time estimate is based on tree life limits of 100 to

200 years for the various dominant species and supposition of how long it would take for natural blowdown and tree death, or restoration logging, to diversify cohort ages across the landscape.

Today's forest also features a different species composition than in the presettlement forest (Cogbill 2001). Perhaps the major difference is the paucity of white pine in the well-drained, sandy, glacio-fluvial soils along the Nulhegan River. These soils are found on outwash and ice-contact landforms close to Route 105, particularly from the mouth of the Yellow Branch to west of the mouth of the North Branch, and on eskers. The lowland spruce-fir natural communities on glacio-fluvial soils in the vicinity of the Nulhegan River mainstem are quite different, with respect to species composition and soils, from those northward in the basin. Ecosystem function, including forest dynamics, would also differ between the two types of lowland conifer natural communities. Unfortunately, we do not have enough information to knowledgeably discuss the differences in forest dynamics.

The salient information with regard to natural dynamics is that the Nulhegan Basin is not particularly prone to wildfires, and management by prescribed burning would not be warranted based on what is known about the natural disturbance patterns in the lowland spruce-fir forests. It should be said, however, that given a drought and an ignition, almost any forest system will burn.

To understand forest dynamics, one must understand physical site conditions (including meteorological factors), tree species composition, past disturbance history, disturbance agents and the exceedingly complex interactions among these factors. The tale of the Nulhegan Basin lowlands has not been sufficiently worked out; the information that is presently available suggests that the Nulhegan spruce-fir forest does not function in the same way as the extensive forests of boreal North America (Cogbill 2001).

Red Spruce-Hardwood Forest

The dynamic forces in these low and mid-elevation mixed forests are generally the same as for the landscape as a whole. Single-tree death and small-group blowdown are the dominant agents of forest dynamics. Areas that have particularly shallow (to bedrock or to hardpan) or wet soils may be prone to higher levels of blowdown, but, in general, the spruce-hardwood natural communities are not located in excessively windy sites, so blowdowns are likely to remain small and scattered. Infrequent hurricanes are likely to affect the spruce-hardwood forests in a patchy way, felling small and large patches of trees and skipping over many areas. The degree of exposure to severe wind events will vary according to the prevailing wind direction and how winds interact with orographic features.

Small areas may become inundated if they are adjacent to beaver-dammed waters, or, more likely, beaver may harvest birch, red maple, aspen or other trees from areas close to water. Forests in which red spruce and/or balsam fir are abundant may undergo substantial spruce and fir mortality during spruce budworm infestations. Although that could lead to many canopy gaps, the levels of tree mortality and regeneration are unlikely to approach those in lowland spruce-fir forests.

Moose over-browsing is evident in some red spruce-hardwood forests in the study area. The long-term alterations to forest succession and plant composition and abundance are unknown.

One would suppose that the red spruce-hardwood forest on well-drained sands of glacio-fluvial and glacio-lacustrine origin are more prone to drought, and perhaps fire. Fire, however, requires a source of ignition and natural ignition appears to be infrequent in the Nulhegan-West Mountain landscape. Furthermore, hardwood litter is less predisposed to fire because of the way it layers. Drought, therefore, is more likely to lead to elevated levels of individual tree death.

To promote a regime of natural dynamics, management should incorporate these guidelines: 1) allow standing and down dead trees to decompose *in situ,* 2) permit natural fires to burn and suppress anthropogenic fires, and 3) allow beaver populations and native insect pests to work the forest as they would.

Northern Hardwood Forest

Northern hardwood forest has often been called the "asbestos forest." Natural fires are infrequent and those that do ignite burn very small areas. Hence, the major dynamic forces of forest change are individual-tree death and small-group blowdown (Marks and Gardescu 1992, Seischab and Orwig 1991, Canham and Loucks 1984). As in the mixed forests, infrequent hurricanes are likely to affect the northern hardwood forests in a patchy way, felling small and large patches of trees and skipping over many areas. Clearly some sites, for instance those with steeper slopes or bouldery soils, may be more prone to wind and hurricane damage, but the natural community classification and map are not designed to postulate or demarcate such areas. As mentioned previously, small areas of forest may become inundated if adjacent to beaver-dammed waters, but, in the landscape of the study area, beaver disturbance of northern hardwood forests is more likely to be related to felling of trees close to water. Inundation is more frequent in the mixed and spruce-fir forest bottoms.

In other parts of the northern hardwood and maple-beech forest region, white-tailed deer have substantially altered the composition and abundance of woody and herbaceous species in the forest. One frequent result is near total removal of sugar maple and hemlock regeneration, with obvious ramifications for the future vegetative development of the natural community (Alverson and Waller 1997). A similar, less apparent outcome has been reduction of populations of certain herb species, such as large-flowered trillium, bluebead lily and sweet cicely, and the shrub hobblebush (Anderson 1994, Balgooyen and Waller 1995, Augustine and Frelich 1998). Whether deer survival through the severe winters of the Northeast Highlands could lead to population densities that might significantly alter vegetation is unknown, but deer over-browsing is a dynamic that should be monitored. Moose over-browsing appears to be a current problem in some parts of the study area. Tree regeneration in northern hardwood and red spruce-hardwood clearcuts is being suppressed in these areas; it is particularly evident in the southern part of the WMA, north of the large curve of Paul Stream. The long-term impact to the successional trajectories and plant composition and abundance in these areas is a topic worthy of investigation.

Another dynamic, and one over which managers may have little control, is the apparent decrease in sugar maple regeneration that may be related to soil acidification resulting from acid precipitation, as has been observed in the Adirondacks (Jenkins 1997). The northern hardwood forests on granitic bedrock, which has a lower buffering capacity than the quartzite-phyllite-schist bedrock, would be more prone to this phenomenon. Scientific research addressing sugar maple regeneration in this part of Vermont would be interesting, but it is not recommended that managers attempt to intervene in this dynamic. It must be pointed out that sugar maple comprises a much larger proportion of the current northern hardwood forests than it did in presettlement times, when beech was the dominant hardwood throughout Vermont, northern New England and

New York (Siccama 1971, Cogbill 2000). Hence, an increased abundance of beech is not out of the historic range of variation of northern hardwood forests.

To promote a regime of natural dynamics, management should incorporate these guidelines: 1) allow standing and down dead trees to decompose *in situ,* 2) permit natural fires to burn and suppress anthropogenic fires, and 3) allow beaver populations and native insect pests to work the forest as they would.

Northern White Cedar Swamp

Northern white cedar swamps are often flooded by beaver. This dynamic and subsequent succession of flooded cedar swamps has not been studied in great detail, but it can be observed in the swamp complex around West Mountain Pond. When a dam is breached and the water level decreases, the potential pathways of vegetative succession are unknown. One may presume that this cycle has been ongoing for thousands of years and that cedar swamp eventually re-grows on a flooded site. The authors know of at least one instance in which intermediate fen developed in a still-flooded cedar swamp in Vermont, and there is circumstantial evidence (cedar logs buried in peat) that a variety of open peatland types may develop when cedar swamps are flooded. The wetland complex adjacent to West Mountain Pond is an excellent area for the study of this dynamic.

Aside from inundation by beaver, the natural dynamics of cedar swamps are dominated by single-tree death and small-group blowdown. Northern white cedar is a species able to reproduce "new" trees from the branches of downed live trees. Thus, blowdown in some cases can lead to a very dense stand of cedar. In boreal acidic cedar swamps, spruce budworm infestations may cause widespread spruce and fir mortality, which would open the canopy with the probable result of recruiting a new cohort of spruce and fir and cedar into the overstory. Fast-growing balsam fir may temporarily dominate large canopy gaps.

Northern white cedar is a favored browse of white-tailed deer, and, therefore, high concentrations of deer have the potential to decimate cedar seedlings and saplings. Tree regeneration in very old cedar swamps has not, to our knowledge, been studied. Excessive browsing by deer may have a significant impact on the vegetative development of mature cedar swamps. Since there are several old cedar swamps in the WMA and Refuge, it is a good area to study vegetation dynamics in mature cedar swamps.

Cedar swamps in Vermont are often the sites of rare plants. When there are both rare plants and the threat of beaver inundation, it is necessary to consider management alternatives with regard to beaver populations and dams, and threats, or the lack of, to the rare plant population. If rare plants are found in cedar swamps that may be prone to flooding, it may be prudent to consider plans for protection of the rare plant population. The only site in the study area to which this may apply, given our current knowledge of the rare plants, is in a cedar swamp in the Ferdinand Bog complex, where sweet coltsfoot *(Petasites frigidus* var. *palmatus)* was discovered.

Spruce-Fir-Tamarack Swamp, Black Spruce Swamp, and Black Spruce Woodland Bog

These three wooded peatland natural communities are considered together as they persist under very similar conditions and often exist in different parts of a single wetland. Hydrologic processes and spruce budworm infestations are important dynamic factors. Small-group blowdown and death of an even-aged cohort of one of the tree species are also agents of change. With the addition of hydrologic processes, the dynamic forces in these wetland, coniferous natural

communities are similar to those that operate in the more widespread lowland spruce-fir forests discussed above.

Tree mortality from budworm epidemics can be a major vegetation regenerating force, especially in swamps with a large component of balsam fir. Since black spruce and tamarack are not preferred host species of the budworm, infestations will have less of an impact on areas dominated by those species. Thus, in the Nulhegan Basin one finds widespread budworm mortality in balsam fir-dominated stands (in both lowland and wetland forests) and almost no mortality in black spruce swamps and woodland bogs. Therefore, tree mortality (related to physiological life spans of the short-lived tamarack and balsam fir and moderately short-lived black spruce) and small-group blowdown are likely the more important dynamic forces in the swamps, especially when balsam fir is not dominant.

Hydrologic changes have the potential to disrupt these wetland natural communities. The natural hydrologic cycle in these systems produces a fairly constant water table throughout the year. Prolonged inundation, and likewise prolonged drying, will alter the physical foundation of the natural communities and will transform them. Black spruce swamps and woodland bogs in the study area occur either in trapped drainages or on broad flats, such as Mollie Beattie Bog and Big Swamp, respectively. Hence, they are unlikely to be impacted by beaver inundations. Spruce-fir-tamarack swamps, however, do occur adjacent to surface waters that can be elevated by beaver damming. Cyclical flooding may be a part of some spruce-fir-tamarack swamp natural communities. As with northern white cedar swamps, neither the inundation cycle nor the vegetation dynamics related to it have been documented to our knowledge. Maintaining natural hydrology by careful placement and management of road culverts is important for natural functioning of all natural communities. In areas where beaver can naturally flood a spruce-fir-tamarack swamp, the natural dynamics can best be maintained by allowing the inundation and dam-breaching cycle to occur.

Paludification, a process in which a landscape becomes wetter when a peatland raises its own water table and expands into adjacent uplands, may be occurring in Yellow Bogs (Thompson 1989). No research into the occurrence of this boreal ecological process has been initiated in the Nulhegan Basin, but paludification would certainly be interesting to document.

Poor Fen, Intermediate Fen, Dwarf Shrub Bog and Sweet Gale Shoreline Swamp

Natural community dynamics in small peatlands are driven primarily by hydrologic processes. Changes in hydrologic regimes are the major threat to the natural communities. Hydrologic changes can come from several sources, but the end result is usually either a lowered water table or raised water table in the peatland. Land clearing and subsequent alterations in surface runoff and evapotranspiration can lead to elevated water tables, especially in larger catchments. Historical ecological research would be necessary to determine the effects that heavy logging has had on the hydrologic regime in the peatlands. The other primary agent of hydrologic change is a natural one—beaver. Dams near peatlands frequently elevate water levels and flood the peatland natural community for varying lengths of time. Short inundations (e.g., one to two months) are unlikely to alter the natural community drastically, but longer inundations can kill significant areas of vegetation.

Some sites do not have a large enough inflow to allow for inundation. Mollie Beattie Bog, for example, is on a height of land and there is no water source for flooding the peatland. Little Pond Bog, northwest of Mollie Beattie Bog, is in a similar landscape position, but surficial hydrology is such that there may be potential to further dam the outlet stream and raise the water level enough

to inundate portions of the peatland. The bog and fen at Unknown Pond may also be susceptible to some flooding.

On the other end of the spectrum is Dennis Pond, which is located along the mid-reach of a stream. There is sufficient water flowing through the peatland that, if dammed, the poor fen could be fully inundated. Although that would be a natural hydrologic change caused by beaver, managers need to consider the negative impacts that flooding would have on rare plant populations, and would need to choose between interrupting a natural beaver dynamic and potential extirpation of numerous rare species populations. A similar situation is possible at Little Wheeler Pond, where raised water levels could flood an intermediate fen with rare plants.

Ferdinand Bog is a large peatland with Paul Stream flowing through it. There is much beaver activity upstream of the open peatland, yet damming downstream would certainly flood portions of that peatland, which is a unique natural community.

The pattern of historic beaver and/or human damming and inundation of portions of Dennis Pond Brook and Paul Stream at Ferdinand Bog are unknown to us. There may have been past episodes of inundation and these systems may have (re-)established afterwards. Information about the interactions of beaver and peatlands over ecological time, and the effect of such interactions on the flora of peatlands would be useful for understanding the systems and evaluating management alternatives.

Some of the sweet gale shoreline swamps beside the ponds presently show impacts from inundation. Wheeler Pond demonstrates how elevated water levels (there apparently a result of beaver interacting with road construction) can flood shoreline swamps and alter the natural community. Parts of the peaty swamp are under water, and other parts are raised above or float in the water. Lowering water levels to the pre-flood level would likely lead to redevelopment of the peaty shoreline swamp, but the time period for the mat to redevelop is unknown. Sweet gale shoreline swamp at Upper Yellow Branch Riparian Wetlands offers another opportunity to study this dynamic.

Shallow Emergent Marsh, Sedge Meadow and Alder Swamp

Hydrologic regimes and beaver are the dominant dynamic forces in shallow emergent marshes, sedge meadows and alder swamps. These broadly defined natural communities can persist under regimes of both seasonal and permanent shallow inundation. In the WMA and Refuge, beaver are in most cases involved in controlling the pattern of inundation, but seasonal flood cycles are also involved. The marshes, meadows and shrub swamps are often adjacent to each other and should in such cases be seen as parts of a single dynamic system in which slight to moderate hydrologic changes can shift the natural community from one type to another. Beaver impoundments are also part of the dynamic system, and will, of course, develop under conditions of permanent inundation. For this reason, we have mapped beaver ponds as a variant of shallow emergent marsh.

Some types of marsh and meadow natural communities do not owe their existence to beaver. In the study area, these are most common on the floodplain of the Nulhegan River and are herbaceous, alluvial backswamp systems. This type is represented by the oxbow variant of shallow emergent marsh. In the oxbow marsh natural communities, the hydrologic regime involves annual flooding followed by a slow drying of the soil throughout the growing season.

Maintenance of natural hydrologic regimes and conservation of beaver populations are necessary for the natural functioning of these open wetland systems. The Nulhegan floodplain marshes owe their persistence to the fact that the Nulhegan is a free-flowing river and the fluvial hydrologic processes of inundation, scouring by water and ice, erosion, and deposition are in place.

River Sand or Gravel Shore, River Cobble Shore, Alluvial Shrubland, Alluvial Meadow/Grassland and Mixed Northern Floodplain Forest

Rivershore and alluvial natural communities depend upon stream hydrologic processes. Two of the main reasons that there are numerous high-quality examples of these natural communities in the WMA and Refuge are the natural function of hydrologic regimes and the lack of invasive exotic plants.

River sand, gravel and cobble shores are in the active river channels. They are seasonally inundated, and, although they are depositional features, they also are ice-scoured. The combinations of substrate movement, scouring of vegetation, and inundation make for very dynamic natural communities. Without these dynamic forces operating, the natural communities would not be what they are. Additionally, rivers actively move within their channels and form new channels. These stream geomorphologic processes lead to the creation of new sand, gravel and cobble shores, and the destruction or succession of others. The creation, destruction (i.e., actual movement of the substrate by water or burial of the substrate with a different substrate), and succession of the natural communities are an integral characteristic of river systems.

Alluvial natural communities occur above active river channels in the river floodplain. These are typically depositional environments where floodwaters slow and sediments fall out of suspension, yet erosional banks are also part of the alluvial system, for erosion and sedimentation are inseparable companions. Ice-scouring may also play a role in these natural communities, especially alluvial shrubland and alluvial meadow/grassland. In fact, ice-scour may be a characteristic feature of alluvial shrubland and alluvial meadow, and may preclude their succession to floodplain forest.

For all of the river shore and alluvial natural communities, maintaining natural, free-flowing streams and rivers that have sediment loads in the natural range of variation is necessary for the systems to function without artificial perturbations.

Descriptions of Proposed Natural Community Types and Variants

Proposed Montane Spruce-Fir Forest Spruce-Fir Ledge Variant

The spruce-fir ledge variant of montane spruce-fir forest occurs in small patches (less than 2 ha) of spruce-fir forest that do not readily fit into the classification as either montane spruce-fir forest or lowland spruce-fir forest. Unlike montane spruce-fir forest, they are strictly associated with ledge brows of mountains and hills, generally from 460 m to 850 m. Likewise because of their perched, mountain-slope position in the landscape they do not fit into the lowland spruce-fir type.

From a distance these small stands of red spruce and balsam fir on mountainsides contrast with the extensive surrounding matrix northern hardwood or red spruce-hardwood forest. The presence of the spruce-fir stands is probably a function of the conifers' competitive advantage over hardwoods in the shallow, droughty soils associated with ledge. The natural community variant occurs on both acidic and circumneutral bedrock types. In the study area examples can be found *widely* scattered on low and mid-elevation mountain slopes.

Vegetation of the spruce-fir ledge is very similar to that of montane spruce-fir forest. Red spruce and balsam fir are the principal canopy species, along with paper birch, depending on site history. Likewise the same northern herbs can be found, although frequently the vegetative groundcover is sparse to nonexistent, or has large patches of the same mosses as occur in montane spruce-fir forest.

With its shallow soils and exposed positions, spruce-fir ledge is subject to the same stresses and disturbances as montane spruce-fir forest. Wind events (blowdown), fire, and spruce budworm infestations are all likely disturbance factors, although none are frequent events. The size of ledge stands likely expands and contracts over time, with burning and drought conducive to expansion.

In general, spruce-fir ledge stands are in better condition than the lowland spruce-fir forest. Because the trees growing in these areas tend to be smaller due to stressful site conditions, they were less desirable for harvest, and the sites are generally less accessible.

No rare, threatened, or endangered plants or animals are known to be associated with this natural community variant.

Proposed Lowland Spruce-Fir Forest Variants

Lowland spruce-fir forests in the Nulhegan Basin and West Mountain WMA occur on several distinct glacial deposits—cobbly, coarse-loamy (washed) till; sandy outwash plain; sandy, broad-kamic features; sandy eskers; sandy glacio-lacustrine deposits; and steep cobbly-bouldery pond-shore slopes. Both the moister phase and the drier phase may occur on till deposits, largely a function of the depth to water table. Variations of the well drained phase differ depending on the landform and soil drainage of the natural community. Many of the best existing examples of lowland spruce-fir forest occur on specialized landforms (pond-shore slopes, eskers); it is important to differentiate these types because their structure, composition and ecosystem processes should not by default be considered as representative of the more extensive, more widespread types of lowland spruce-fir forest. Some of the differences among these better-drained types may be subtle, but subtle ecological relations may have greater importance for biological diversity—such as at the genetic, species and population, and interspecific interaction levels—than is commonly realized.

Lowland Spruce-Fir Forest: Wet-Mesic Variant—3b

While not a newly proposed variant, we elaborate here upon the description provided by Thompson and Sorenson (2000) since this is a dominant type in the Nulhegan Basin and we have gained some insights into its characteristics.

Straddling the boundary between upland and wetland, the wet-mesic variant of lowland spruce-fir forest is found in small to large patches primarily in the bottom of the Nulhegan Basin. The largest patches are found in the vicinity of Yellow Bogs, including Big Swamp. Most frequently it is found in complexes with well drained lowland spruce-fir forest, black spruce swamp, and spruce-fir-tamarack swamp.

Wet-mesic lowland spruce-fir forest occurs on flat to very gently sloping terrain of a variety of glacial deposits, including glacio-fluvial deposits (outwash and/or kame), till, and washed till. While the glacio-fluvial deposits tend to be composed of sands and gravels, the till sediments containing significant amounts of silt, gravel and boulders mixed in and are thus loamier in texture. Deposits with a stone (cobble and small boulder) lag on the soil surface are thought to be washed till. A cobbly surface layer appears to be common over large areas of the Nulhegan Basin

and was revealed on numerous occasions in the shallow pits created when canopy spruce or fir tipped over.

The hydrology and soil structure of the wet-mesic variant are likely its most distinguishing characteristics. While the typical spruce-fir forest has a well drained to moderately well drained spodosol, with very bright (reddish to orange) subsoil (B) horizons, the variant's soils are somewhat poorly to poorly drained and lack bright subsoil horizons. Sometimes mottling was found essentially at the soil surface, indicating a water table that fluctuates near the surface during the growing season. During the 2000 field season, the ground water level in this community was frequently at about 30 cm below the surface. The depth to a layer that impedes drainage, which may or may not be bedrock, was sometimes as little as 50 cm. The surface organic layer was generally 10 cm more or less, and typical of upland soils, although a very shallow peaty layer was evident in places. In the parlance of soil scientists, the wet spodosol found in the Nulhegan likely fits into the classification as an "epiaquod." More soil work needs to be done in this community to fully understand the relationships between the soil and the vegetation. The distinctive soil profile characteristics may be strongly related to seasonal and annual groundwater fluctuations and subsurface horizontal flow.

The vegetation of wet-mesic lowland spruce-fir forest is very similar to that of the well drained type. In the Nulhegan Basin at least, black spruce is the more common spruce in the wet-mesic variant, but red spruce occurs as well. Perhaps the most distinctive difference is the regular presence of bog mosses (Sphagnum sp.) in the hollows of the wet-mesic variant. Also, typical wetland species, such as speckled alder, a sedge *(Carex trisperma),* and even bluejoint grass in openings, appear sporadically in the wet-mesic forest.

The wet-mesic variant is subject to the same major disturbance types as is found in the well drained type. Wind events (blowdown), fire, and spruce budworm infestations all can cause major disruptions to the vegetation and other biota. Given the wetter soils, it is likely that wind events have an even greater likelihood of blowing down trees in this variant than in drier ground. One might suppose that the moister soil conditions might lead to less likelihood of fire in this forest. Charcoal was found on the surface in the wet-mesic forest, however, just as in drier areas. The fact that there is a mineral soil and not an organic soil suggests that the soil dries out each year; during a drought, the wet-mesic forest soil probably dries out nearly as much as the adjacent drier forest soil. With a relatively cold climate and generally wet soil, conventional wisdom might presume that the soil in this forest variant would develop a thick organic surface layer. Perhaps intense post-settlement forest fires have consumed significant amounts of the surface organic soil.

Like most conifer forests in the region, it has suffered heavily from timber harvest. Therefore, good examples of the variant are just as scarce as the well drained lowland spruce-fir forest. Spruce, fir, and tamarack, as well as quaking aspen and gray birch readily regenerate in clearcuts,. The great extent of wet-mesic lowland spruce-fir forest in the Nulhegan Basin gives the natural community particularly high significance; this is especially true when considered in the landscape context of the mesic lowland spruce-fir forest and conifer swamps.

The rare and uncommon species, both plant and animal, are the same as those described in *Wetland, Woodland, Wildland.* The lingonberry, or mountain cranberry, *(Vaccinium vitis-idaea)* is apparently more frequently, if not entirely, associated with the wet-mesic variant and the black spruce swamps than it is to the drier spruce-fir forest.

Lowland Spruce-Fir Forest: somewhat excessively to excessively drained esker forest variant—3d

West Mountain WMA includes a small portion of the Nulhegan Basin, but is mostly sloping mountain terrain with smaller areas of mid- and high-elevation flats. It is on these flats where small units of lowland spruce-fir forest are found. Eskers are a common glacio-fluvial deposit on the mid-elevation flats, and almost all the eskers support a type of lowland spruce-fir natural community. In mapping, we have decided, for several reasons, to map the esker spruce-fir forests as a variant different from the more general well drained phase described by Thompson and Sorenson (2000). The esker spruce-fir natural community is easily distinguished by glacial landform and the shape and parent material of the eskers confer different ecosystem characteristics on this variant. Additionally, because of the economic value of the well-sorted sands and gravels from which they are built, eskers are a "threatened" landform.

Among the principal differences of the variant is soil drainage. Eskers, because they are a water-laid deposit, are composed of well-sorted material, most often predominantly medium sand. They are also narrow landforms with very steeply sloping sides. This combination of soil parent material and landform shape makes for excessively to somewhat excessively drained, strongly acidic soils. This lowland spruce-fir variant often has the deepest and brightest spodosol soil profiles. Red spruce appears to be the dominant late successional tree; associates species include balsam fir, hemlock, white pine and northern white cedar. This seems to contrast with the Nulhegan Basin's broader, well-drained glacio-fluvial and glacio-lacustrine features and moderately well drained and moister till features, on which black spruce is the dominant spruce. Another difference in tree composition is the common occurrence of hemlock on these esker deposits and the near total absence of hemlock from most of the other types of lowland spruce-fir forest. Differences in shrub and herbaceous vegetation have not been determined and will need more detailed vegetation sampling to be elucidated. Sampling and comparative analyses of spruce-fir forests on eskers, outwash plains, kamic deposits and well-drained till deposits will shed light upon the similarities and differences.

Lowland Spruce-Fir Forest: Steep pond-shore slope variant—3l

Many of the ponds in West Mountain WMA likely occupy kettle depressions formed in a stagnant-ice landscape of *in situ* glacial ablation. In a typical stagnant-ice situation, isolated ice-blocks are surrounded by kamic deposits, and, after the ice-blocks melt, a depression in the landscape results. Often such depressions become the site of open water and/or peatland ecosystems. Depending upon the shape of the deposits that were laid adjacent to the ice-blocks, short, steep "ice-contact" slopes may or may not form. Short, steep slopes are evident adjacent to parts of Wheeler, Little Wheeler, South America, Dennis and Unknown ponds. It is such slopes that are mapped as a distinct variant of lowland spruce-fir forest.

The steep pond-shore variant tends to be well drained due to both slope and texture of the parent material. It is common for the contact zone between ice and kamic deposits to be cobbly or bouldery, for as the ice disintegrates, meltwater washes away the finer particles. In this respect the pond-shore conifer forests are very different from the closely related esker forests. Exposure to wind and lightning is perhaps highest in this lowland natural community, due to the adjacency of open water. These places are also more prone to burn from anthropogenic fires, for humans often choose to make encampments on shorelines.

As in the esker forest, red spruce is usually the late-succession dominant tree and associates include balsam fir, white pine, hemlock and northern white cedar. Among the shrubs and herbs that are less commonly seen throughout the landscape are pipsissewa, trailing arbutus and black huckleberry.

Lowland Spruce-Fir Forest: Mixed Red Maple-Aspen Variant—3c
This variant of lowland spruce-fir forest is described because it did not fit easily into the classification, but was readily mappable. It is a mixed forest of balsam fir, red spruce, red maple, quaking aspen and occasionally white spruce found on low hills or rolling terrain in the Nulhegan Basin. In the Refuge, most examples of the variant occur along the lower North Branch and the mainstem; they range in size from one to 32 ha. Although located in mesic to wet-mesic settings, the variant lacks the moss groundcover so typical of lowland spruce-fir forest.

The groundcover flora is typical of most acidic woods in northern New England. Canada mayflower, bluebead lily, bunchberry and goldthread are the dominant species. Shrub layers are variable. High shrubs, especially beaked hazelnut and wild raisin, can be prominent; velvetleaf blueberry is in places a common low shrub.

The sandy loam to fine sandy loam soils tend to be somewhat poorly drained and moderately rocky. In one case, the soil was a well drained loamy sand. Two uncommon to rare plants were found in that well drained example of this variant—a bluegrass (*Poa saltuensis)* (G5?/S2) and northern bedstraw (*Galium boreale)* (G5/S3).

These are youthful, even-aged forests, that have come back after clearcutting, and, in some cases, after fires as well. Where the overstory remains intact, balsam fir regeneration is prominent. In areas with recent cutting, red maple and quaking aspen regeneration can be thick. Very large (roughly 1 m in diameter) cut stumps are likely white pine.

This is likely a type of successional vegetation of lowland spruce-fir forest. The lack of moss groundcover might be the result of hardwood litter smothering the moss, or, it is possible that it is really a successional variant of red spruce-hardwood forest. Early in the field season this forest was labeled the enigmatic "kamic mixed forest." It remains a mystery, but most of it is not found on kame deposits.

Proposed Red Spruce-Hardwood Forest Variants

Red Spruce-Hardwood Forest, shallow to bedrock or hardpan—5a
Mixed conifer and hardwood forest is characteristic of the moderately to gently sloping, lower elevation terrain of West Mountain WMA. The deposits are an as yet undetermined type of coarse-loamy glacial deposits, in places cobbly or even bouldery. The deposits may include basal till, coarse glacio-fluvial deposits, ablation till and washed till. Drainage is imperfect and impeding hardpans are often present in the Bs horizon. Moderately well drained spodosols are the best general characterization of the soils.

Because of the logging history of the landscape (throughout Vermont, not just within the project area), the late successional vegetative composition of red spruce-hardwood forest is not well understood. Young regeneration includes red spruce, yellow birch and red maple, as well as paper birch and pin cherry. Typically, in lowland spruce-fir forest young regeneration features a dense thicket of spruce and fir, although there are areas where saplings and poles of paper birch, red maple and aspen are common to dominant. Therefore, the absence of a dense, coniferous regeneration thicket and the presence of a substantial component of yellow birch were often used to distinguish this natural community from lowland spruce-fir forest, a type in which yellow birch is not generally thought to be a major, widespread species. Another factor that was used to differentiate this type was a leaf-litter forest floor as opposed to a moss carpet. Low spots and depressions in a landscape dominated by red spruce-hardwood forest often display a striking transition to a ground surface carpeted by moss and a dense spruce-fir sapling or tree strata—the

low spots are "good" coniferous forest communities, whereas the general terrain, at least at this point in time, apparently features a truly mixed forest.

The herbaceous flora of this type more closely resembles that of well drained lowland spruce-fir forest than that of northern hardwood forest, although elements characteristic of each are present. Canada mayflower, bluebead lily, wild sarsaparilla, bunchberry, mountain wood-sorrel, painted trillium, goldthread, whorled aster, hay-scented fern, shining clubmoss and pink lady's-slipper are common. The only common shrub is hobblebush. In the West Mountain WMA, hemlock is a fairly constant member of the natural community. Throughout the lowland between Dennis and West Mountain ponds, one regularly finds hemlock.

Red spruce-hardwood forest is one of the "most problematic" natural community types in the study area. It often occurs in fairly narrow bands between lowland spruce-fir forest and northern hardwood forest, and in such situations one might be inclined to call it "transitional." It does, however, occur in broader areas, the largest of which on the public lands is between West Mountain and Dennis ponds. In this area, the natural community type varies from closely resembling lowland spruce-fir forest, to resembling northern hardwood forest that lacks sugar maple. Cold-pocket climatic conditions, excessive soil moisture and low concentrations of nutrients in the soil can be factors, alone or in combination, that "drive" vegetative composition from one end of this mixed forest spectrum to the other. On top of these physical ecosystem variables, one must overlay the history of human uses of the forest. The system defies easy answers and over-generalization, yet, the natural community type may cover large portions of the lower elevations in the Northeast Kingdom. The historical preference of softwoods over hardwoods in the industrial logging of these woods in the last century suggests that the present abundance of spruce and fir in the mixed forest is less than it had been in presettlement times.

Red Spruce-Hardwood Forest, well drained sands—5b
Mixed forest on well-drained sandy soil differs substantially from mixed forest on soils with impeded drainage. Well-sorted sandy deposits result from fluvial or lacustrine processes. In the project area, the well drained, sandy, glacial and peri-glacial features are typically either mixed forest or lowland spruce-fir forest. Landscape position and soil texture and chemistry are, perhaps, the principal factors related to the presence of either coniferous or mixed forest types.

The mixed forest type, red spruce-hardwood forest on well-drained sands, is most commonly located adjacent to Paul Stream. The Vermont surficial geologic map has these sands mapped as kame-terrace deposits and glacio-lacustrine sands that were deposited in and around an ice-dammed lake that filled a portion of the Paul Stream valley. The soils are deep, very well developed spodosols of very fine sand with very fine sandy loam and very fine loamy sand in the B horizons. In some places, exceedingly deep E horizons (e.g. >30cm) were observed, as were cemented (hardpan/incipient hardpan) horizons in the upper B.

Red maple, yellow birch and red spruce are the dominant trees. Associate species include beech, sugar maple, balsam fir and hemlock. Striped maple is a very common small tree; shrub cover is generally sparse and includes smaller striped maples, spruce seedlings, hobblebush and beaked hazel. Dominant ground cover species include Canada mayflower, intermediate wood-fern, mountain wood-sorrel, bluebead lily and bunchberry. Moss cover is sparse.

Red Spruce-Hardwood Forest, boulder slope—5c
Forests on steep slopes and rocky slopes are subject to different ecosystem processes and dynamic forces. Downslope flow of moisture and nutrients, distribution of various types of germination microsites, and differential susceptibility to wind gusts and ice-loading are some

examples. For this reason, it is important to differentiate among natural communities on steep and/or rocky slopes and similar ones on moderately sloping to level terrain. Even historic human use patterns can demonstrate the ecosystem differences of such places; for instance, steep, bouldery slopes in many cases have been less frequently and less heavily logged than adjacent ecosystems.

Red spruce-hardwood forest on boulder slopes is a very restricted type of mixed forest natural community. Such slopes are not extensive, but they display clear ecosystem differences from adjacent slopes that are less steep and/or less rocky. Red spruce and yellow birch are the later-succession dominant trees. Hemlock may occur in lesser abundance. Additional tree species include red maple, paper birch, and balsam fir. Tree species composition and abundance depends largely on both size and coverage of boulders, which are directly related to availability of different types of microsites for germination and establishment, and elevation and landscape position, which can largely determine seed source availability.

A species that has strong affinities to very steep and very bouldery slopes is mountain maple, and the presence of that tall shrub is very characteristic of the natural community type. Other small trees and shrubs are generalists; these include striped maple and hobblebush. A moss carpet and low coverage of herbs are also characteristic of steep bouldery slopes; Schreber's moss and the liverwort *Bazzania trilobata* are usually most abundant, and stair-step moss is also quite common. Although not abundant, a variety of herbs are present; these include many of the more common boreal/northern hardwood herbs—Canada mayflower, bunchberry, goldthread, bluebead lily, mountain wood-sorrel, intermediate wood-fern, shining clubmoss, painted trillium and the fern most characteristic of acidic rocky sites in the northeastern forests, rock polypody.

Soils are typically strongly colored, coarse-loamy spodosols, with a minimum of approximately 35% boulder coverage. Slopes have an approximate minimum inclination of 30%.

Montane yellow birch-red spruce forest is a similar natural community type, but that type is restricted to higher elevations and occurs with a variety of slope and boulder conditions. Among the factors that distinguish the two types are more severe climate and different composition and abundance of plant species in the montane forest.

Red Spruce-Yellow Birch-Red Maple Seepage Forest—5s
Seepage forests are not uncommon in Vermont. They are continuously moist throughout growing seasons of normal rainfall and can occur on slopes and in valley bottoms. Groundwater seepage is the hydrologic process that differentiates such forests from related types. As a result of the moisture regime, the soils and vegetation of the natural community differ from those of similar communities.

The soils are mineral soils, but they often have a thicker humus layer (Oe and/or Oa) than in non-seepage forests. Unlike in swamps, however, spodosols are characteristic, except in the scattered, low, permanently wet depressions.

The tree species are those typical of the mixed forests throughout the region—red maple, red spruce, yellow birch, balsam fir, hemlock and white pine. Not present in this type of seepage forest are sugar maple, beech and white ash; those species are more characteristic of northern hardwood seepage forests. Striped maple is a common small tree/tall shrub; additional shrubs include wild raisin, bush-honeysuckle and mountain-holly. Common herbs include bunchberry, bluebead lily, goldthread, Canada mayflower, wild sarsaparilla, Indian cucumber-root, and, in the wet depressions, cinnamon fern, water-avens, sedges *(Carex spp.),* spotted touch-me-not and field

horsetail. Open seeps, a natural community in itself, can be common, and integral, to seepage forests.

Proposed Northern Hardwood Forest Variants

Mid-elevation Northern Hardwood Forest, ledges and boulders—8f

Steep mountain slopes offer a great deal of physical variation. Below large ledges and cliffs one often finds an accumulation of boulders and cobbles. Often open talus or talus woodland natural communities are present, but equally often, or perhaps even more so, a closed forest has developed over much of the talus. These bouldery forests have much in common with classic northern hardwood forest, but because of the bouldery substrate and the landscape position beneath a steep slope, one can define some differences also. Even if the vegetation does not appear to differ substantially from the surrounding forest, the cobble-boulder substrate may relate to significant habitat differences for soil-dwelling vertebrates and invertebrates, as well as to differences in disturbance regimes and nutrient cycles.

This natural community variant is described from one location on the western slope of West Mountain, beneath a montane spruce-fir forest sub-summit that includes a small area of boreal acidic cliff and boreal talus woodland.

Paper birch is a fire-succession dominant in the natural community. Its presence is a good example of how fire and/or forest succession patterns can be influenced by physical factors such as a cobbly-bouldery, lower-talus deposit. Associate overstory trees are the major northern hardwood species—yellow birch, sugar maple, and beech. Striped maple is an abundant small tree in a stratum with sugar maple saplings. The low diversity herb flora includes wild sarsaparilla, intermediate wood-fern, painted trillium, Canada mayflower and tree clubmoss.

If yellow birch becomes predominant as forest succession proceeds, this variant may fit the criteria of the yellow birch-northern hardwood forest variant.

Northern Hardwood Forest, beech dominant—8g

Northern hardwood forest, when "mature," is most often dominated by some combination of sugar maple, beech, and yellow birch. It is known that the presettlement northern hardwood forest had a much greater abundance of beech than the current forest, and research into successional patterns and/or site conditions that may favor sugar maple over beech or vice versa has been in vogue at times in the history of North American vegetation ecology.

Several small areas that are currently dominated by beech have been mapped as the "beech dominant" variant of northern hardwood forest. Although beech tends to be favored over sugar maple in less fertile, more acidic conditions, such as on convex slopes and shoulders, there are other conditions, both physical and historic, that may be related to the dominance of beech in any particular place on the land. Mapped units of this variant may include areas that have shallower, more acidic soils on convex slopes and ridges, as well as areas that are beech dominated as a result of historic vegetative processes or human activities. All that is implied in distinguishing this type is the current dominance of beech. An abundance of beech is often of importance to black bear and other hard-mast feeders.

High-elevation Northern Hardwood Forest—8h

High-elevation, or montane, forests in the Northeast Highlands typically extend to lower elevations of approximately 600 m. Red spruce is normally thought to be a dominant or co-dominant species in high-elevation forests, but occasionally that is not so. The natural community variant called "high-elevation northern hardwood forest" is one in which certain aspects of

montane forests are present, but red spruce is only a minor component of the overstory or is not present at all.

One example of this type was observed on a sub-summit of West Mountain and the following description is based on that single observation. The elevation ranges from about 640 to 700 m, and the site is a moderately sloping mountain shoulder with comparatively deep soils. The relatively short trees and the prominence of mountain wood-fern patches are vegetation elements that are characteristic of montane forest. The area is dominated or co-dominated by paper birch, as is much of the surrounding steep, ledgy terrain on the western slope. The abundance of paper birch is almost certainly related to fire. Co-dominant overstory species are yellow birch and sugar maple. The understory includes also beech and striped maple, but not the light-demanding paper birch. The herbaceous vegetation is dominated by wild sarsaparilla, Canada mayflower, mountain wood-sorrel, intermediate and mountain wood-ferns, bluebead lily and whorled aster; several sedges and painted trillium also occur. Red spruce, although present nearby in the natural communities at the top of the sub-summit and on the steep, ledgy western slopes, is not present in the high-elevation northern hardwood forest.

Soil in the natural community is coarse-loamy spodosol. Characteristic of northern hardwood forests, but not mixed or coniferous forests, the E horizon is not well developed and shows either a "salt and pepper" or a purplish-gray color. The Bhs and Bs horizons are well developed, but are not as brightly colored as one expects to see in mixed or coniferous forests. The less developed soils may be inceptisols.

High-elevation Northern Hardwood Seepage Forest—8j
Forests that grow at the upper elevation limits of the northern hardwood tree species typically feature a canopy dominated by yellow birch and red spruce. Particular conditions of enriched soil moisture, nutrient enrichment, or protected landscape positions, however, are often associated with more specialized types of northern hardwood forests, and this holds true for high-elevation forests as well.

Seepage forest is characterized, as the name implies, by groundwater seepage. High-elevation northern hardwood seepage forest occurs where conditions of moisture, nutrients and protection from the extremes of wind and shallow soils are present; typically these conditions occur in concavities on the mountain slopes or ridgeline saddles. In such places, sugar maple is able to survive and even dominate or co-dominate the canopy at elevations where sugar maple-dominated forests do not often occur.

This natural community variant is described from one location on West Mountain and is not a type that we have widely encountered in New England. Other high-elevation northern hardwood seepage forests are likely to resemble this one, but, of course, will also exhibit their own unique variations.

High-elevation hardwood and mixed forests, in general, have a dense growth of hobblebush and a high coverage of mountain wood-fern. The seepage forest variant has these typical "high-elevation" vegetative elements, and it also has structure and species related to seepage conditions. The canopy is widely spaced; a possible explanation for this is the wide-spacing of appropriate germination and establishment microsites for trees, due to both competition from the dense shrub growth and excessive soil moisture in the zone of active seepage. How logging history may be related to this canopy structure is unknown. The canopy in the West Mountain natural community is composed entirely of sugar maple; on the sides of the concavity other species (yellow birch, red spruce, beech) are present, but in the heart of the seepage zone the only trees are sugar maple.

Beneath the dense hobblebush layer is a ground cover with different and more species than characteristically occur in non-seepage forests. Herbs include mountain wood-fern, silvery spleenwort, drooping woodreed, a sedge characteristic of seeps *(Carex scabrata),* wood-nettle, spotted touch-me-not, lady fern, dwarf enchanter's-nightshade, rosy twisted-stalk, whorled mountain aster, and, rarely, red baneberry. On the sides of the seepage zone, up the slopes of the concavity, the more typical high-elevation northern hardwood forest herbs grow—bluebead lily, intermediate and mountain wood-ferns, Canada mayflower, false Solomon's-seal and hay-scented fern.

The soil, as one would expect in a seepage forest, has a deep organic horizon (15cm Oa); the soil profile is that of a well-developed spodosol, with a hefty Bhs horizon (>10cm). In the site on which this variant description is based, the soil is shallow to a layer of cobbles. Texture ranges from fine sandy loam to loam. The natural community is small, for it is spatially restricted to places on the landscape that have a rather specific range of hydrologic and physiographic characteristics.

Northern Hardwood Forest, depauperate in species—8p
Northern hardwood forests occur over a wide variety of conditions in Vermont, and thus they exhibit a relatively wide variance in species composition. Those places that are known to have few herbaceous species have been mapped as a "depauperate" variant.

The variant may be thought of as the most "basic" of northern hardwood forest types. It has the species that are nearly ubiquitous in the northern hardwood forest and few additional ones. It also tends to have more bluebead lily and painted trillium than is generally characteristic of northern hardwood types. The "ubiquitous" species are Canada mayflower, shining clubmoss, and intermediate wood-fern. There are lesser amounts of mountain wood-sorrel and starflower. Vernal flora, such as trout lily and Dutchman's breeches, either do not occur in this type or occur only in very close association with local pockets of enrichment. Hobblebush is the most prevalent, and often the only, shrub. The canopy and subcanopy trees in the natural community are beech, sugar maple, yellow birch and red maple; the small tree, striped maple, is present also. Red spruce, balsam fir and mountain maple may or may not co-occur with the other species. A moderate to high abundance of spruce and fir would likely place such a natural community in the red spruce-hardwood mixed forest type, in which sugar maple is rare to very uncommon.

Soils in the depauperate northern hardwood forest in West Mountain WMA are loamy sand to sandy loam, with strong spodic horizons. It appears that even at a very local scale, the coarser the sands, the fewer the herb species. Although no research from either the study area or northern New England as a whole has been consulted, it seems likely that the depauperate variant is associated with a soil chemistry that is lower in pH and plant nutrients than more species-rich northern hardwood types. Landscape position, soil parent material and soil drainage are amenable to persistence of sugar maple in the natural community and do not tend to support more than a low abundance of spruce and/or fir. Thus, the natural community is a northern hardwood type.

Northern Hardwood Seepage Forest—8s
Seepage forests occur in small areas of active groundwater seepage. They differ from the natural community named "seeps" in that they are a forested natural community; perhaps the volume of water seepage is not enough to preclude the establishment of forest cover. Open seeps, however, may or may not be found within or above areas of seepage forest.

Northern hardwood seepage forest is found on those parts of the landscape where elevation, microclimate and soil chemistry make for a northern hardwood species composition. Mixed conifer-hardwood seepage forests are closely related natural community types that have been classified as northern white cedar sloping seepage forest and as red spruce-hardwood seepage forest.

Due to both moisture and nutrient enrichment, northern hardwood seepage forests tend to have a number of species that are not widespread across the landscape. A tree that is characteristic of the natural community is black ash. Among the nutrient- and moisture-demanding herbs that occur are silvery glade fern, red baneberry, wild millet, swamp saxifrage, wood-nettle, foamflower, sweet-scented bedstraw, jack-in-the-pulpit, the sedge *Carex plantaginea* and the grass *Brachyeletrum erectum.* Sugar maple and yellow birch are the dominant overstory trees, and shrub cover tends to be light.

Northern Hardwood-Hemlock Forest, hemlock abundant—8t
Hemlock is not a widespread species in the northern hardwood forests of either the WMA or the Refuge. There are, however, several areas where hemlock is a prominent component in the northern hardwood forest. (Hemlock is also present in some of the red spruce-hardwood forest types and some of the lowland spruce-fir forest types in West Mountain WMA.) These few places are not necessarily similar in landscape position and soils, but only in the presence of substantial amounts of hemlock in the tree strata. One area is a "footslope flat," while another is a steep, concave mountain slope.

Soils of the variant are well to moderately well drained and seeps may be common. Overstory trees in addition to hemlock are sugar maple, yellow birch, beech, red spruce and balsam fir. Striped maple is a common small tree.

The areas mapped as this variant have not been investigated in more than a cursory fashion. Because of the anomalous abundance of hemlock, the areas were differentiated from the general northern hardwood forest matrix. Further study is necessary to elaborate upon the ecosystem characteristics of those northern hardwood areas that have an abundance of hemlock.

Northern Hardwood Forest, wet-mesic—8w
Species composition in northern hardwood forest types is closely related with both soil chemistry and soil moisture. The wet-mesic variant is a moisture-enriched type; in general the soils are moderately well drained, but there may be pockets of both somewhat poorly drained and well drained soils. Intermittent streamlets and "low-volume" seepage areas are occasional to frequent.

Yellow birch grows very well in wet-mesic hardwood forests and is often more abundant in this variant than in some of the other variants. White ash also tends to be present, and is often more abundant in closer proximity to intermittent streams and seeps. Sugar maple and beech are typically co-dominant with yellow birch; red spruce and balsam fir saplings may be scattered throughout the understory. In the moistest areas, one may find black ash in wet depressions.

The herb flora includes a number of species not generally common in northern hardwood forests that are better drained. Among these are New York fern, interrupted fern, foamflower, tall meadow-rue, the grasses *Glyceria striata* and *Cinna latifolia,* a sedge *(Carex tribuloides),* spotted touch-me-not, lady fern, and the creeping shrub dwarf raspberry. Jack-in-the-pulpit is rare. One wet-mesic area features an abundance of sessile-leaved bellwort, rare dwarf ginseng, and a moderate amount of red trillium.

Soils tend to have a deeper organic (Oa) or A horizon and range from well-developed spodosols to entisols; the soil profiles have been observed to change dramatically within a distance of several meters. Textures range from coarse-loamy to fine-loamy. The range in soil profile development and texture may be an indication that this "variant" includes natural communities that are in fact quite different. Some may consider the "entisol type," and perhaps the "spodosol type" as well, to be a northern version of sugar maple-white ash-jack-in-the-pulpit northern hardwood forest.

Mixed Northern Floodplain Forest—Proposed New Natural Community Type

The following description is based primarily on observations from upper Paul Stream, Ferdinand, Vermont.

Mixed northern floodplain forest is a seasonally inundated natural community with a moderately closed to closed canopy. The type is restricted to narrow floodplain zones in the northeastern-most rivers of Vermont, such as Paul Stream and the Clyde River. Physiography and hydrology are the principle factors that determine the presence of this natural community. More specifically, the frequency and duration of flooding and the sediment load are largely determined by the landscape position of a particular floodplain (that is the position of any portion of a floodplain in relation to the surrounding land and the upstream watershed).

Annual floodwaters deposit silt, sand, and organic matter on the floodplain, and this alluvium—rich in nutrients and with a high capacity to hold moisture (relative to evapotranspiration rates)—is the parent material for the floodplain forest soil. Mixed northern floodplain forests are levee forests. A levee is raised above the surrounding terrain by the deposition of sand or silt alluvium. Alluvial shrubland and alluvial grassland/meadow occur in close association with the levee forests. The physical and hydrologic factors that account for the presence of levee meadow versus levee forest have not been investigated to our knowledge. In the lower, wetter land behind a levee, any combination of alluvial shrubland/woodland, alder backswamp and conifer swamp (often northern white cedar-swamp) occurs.

Trees can attain large diameters and tall stature, and herbaceous plant coverage is often very high in mixed northern floodplain forest. Black ash trees, for example, grow to larger diameters in floodplain forest than in the other natural communities where they occur. Also, white spruce growing on the floodplain tend to be very tall. Trees may form a closed canopy, or may grow in patches among denser herb growth. Where tree growth is patchy, the differentiation between alluvial shrubland and floodplain forest becomes indistinct. Where the water table is very near or above the surface, the differentiation between floodplain forest and alder swamp becomes indistinct.

Trees of the mixed northern floodplain forest are white spruce, balsam fir, paper and yellow birches, northern white cedar and black ash. Common shrubs include speckled alder, beaked hazel, mountain maple, black elderberry, highbush-cranberry, pussy-willow, spiny swamp-currant, and, on the river banks, red-osier dogwood. American elm and choke cherry are also part of the tall shrub flora.

Herbaceous species of the forest cannot easily be separated into those which are dominant and those that are associates. There is a patchy character to the herb layer, with striking differences in species abundance between more shaded and more open parts. Species include numerous sedges and grasses (e.g., *Carex vesicaria, Calamagrostis canadensis, Brachyeletrum erectum, Glyceria melicaria),* rough goldenrod, tall meadow-rue, sensitive fern, intermediate and toothed wood-

ferns, lady fern, false hellebore, rough bedstraw, foamflower, Canada mayflower, shining clubmoss, mountain wood-sorrel, virgin's-bower, and dwarf raspberry, a creeping shrub. Wiegand's wild-rye *(Elymus wiegandii)* (G?/S3), a plant uncommon in Vermont and restricted to floodplains, is known from the more open areas on floodplain levees.

Northern floodplain forest soil is most often silt loam to fine sand. Soil profile development is normally truncated by the continual addition of alluvium, and perhaps especially by larger flood events that deposit thicker layers of alluvium. Texture is also strongly related to the type of flooding event; large, powerful storms or rapid snowmelt create greater volume and faster flows over a floodplain and, therefore, lead to deposition of coarser materials, such as fine and medium sands as opposed to the very fine sand and silt that are transported and deposited in lesser floods. The more dramatic flood events may be responsible for the creation of higher pieces of levee, where closed-canopy forest may be more likely to form. Such happenings are likely important for creating the heterogeneity of the floodplain mosaic.

Proposed Poor Fen Variant

Sweet Gale-Northern White Cedar Poor Fen

The following description is based on preliminary observations from Ferdinand Bog, Essex County, Vermont.

The natural community is a permanently saturated peatland that occurs on broad basin floors. Peat depth ranges from 50 cm to greater than 120 cm, and the depth can change from one extreme to the other in a small space. The top 10-20 cm are fibric peat, which is underlain by well-decomposed, sapric peat. pH readings of 5.2-6.4 were measured with a Cornell Soil Test Kit; although probably in the ballpark, pH measurement of saturated peat may not be as accurate with this system as are measurements of non-hydric soils.

The overall appearance of the natural community is best described as a shrub-and-sedge dominated open wetland punctuated by patches of dense taller shrubs and scattered northern white cedar. Closer observation reveals that four to six vegetation strata are present. The short-shrub layer and moss carpet have the densest cover, with 30-60% and 60-90%, respectively. The short-shrub sweet gale, as the natural community name suggests, is the most abundant vascular plant species, and sphagnum mosses dominate the moss layer. A variety of sedges, ferns and forbs are common in the herb stratum. The tall-shrub stratum is composed of speckled alder and/or northern white cedar.

Along with sweet gale in the short-shrub layer are numerous species, including leatherleaf, meadowsweet, speckled alder, shining and pussy willows, black chokeberry, alder-leaved buckthorn, the rare species shining rose *(Rosa nitida)* (G5/SH) and uncommon mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3).

Northern white cedar is the only common tree in the natural community. Other species, which occur less abundantly, include balsam fir, tamarack, white spruce, and paper birch. At Ferdinand Bog, coarse woody debris is present in the peat, an indication that trees have long been a part of the ecosystem.

Herb cover ranges from 5% to approximately 30%. Species present include numerous sedges—*Carex vesicaria, C. utriculata, C. echinata, C. trisperma, C. paupercula, C. leptalea, C. stricta.* Marsh St. John's-wort is common, as are low rough aster, water-horsetail, and Robbin's ragwort.

With gratitude to Mark Rahill for determinations, we can report that the sphagnum dominants appear to be *Sphagnum centrale, S. girgensohnii* and *S. palustre.*

Proposed Shallow Emergent Marsh Variants

Shallow Emergent Marsh: Beaver Meadow Variant—64a

Beaver meadows are a natural community variant of shallow emergent marsh easily recognized, but difficult to describe. Their variability over time and space make them chimerical. Their intimate connection with beaver populations and activities, and the aftermath of beaver activities, make them almost inherently short-lived. The meadows may last for months, several years, or decades.

A beaver meadow typically occurs when beaver abandon an area—often because the food resource is temporarily low—are trapped out, or die. The dam that holds back the stream waters which form their pond slowly, or sometimes instantly, is breached thereby allowing the pond's water level to drop dramatically. The exposed pond bottom sediments, often a muddy mixture of sand, silt and organic material in various stages of decay, foment a flush of wetland herb, grass, sedge and rush growth that forms a meadow. If not impounded again by beaver, the meadow may succeed over time into a shrub swamp, and, depending on the local hydrology, perhaps into a forested swamp. The "typical" chronosequence is perhaps more theoretical than real. Multiple pathways can lead to a wide array of outcomes, only some of which follow a classical pattern of succession.

The other confounded aspect to beaver meadows is their vegetative-hydrologic variation. Often they occur in beaver flowages, where a series of impoundments are constructed and water-level gradients lead to vegetation gradients. Going upstream from a dam, typically the vegetation ranges from an aquatic environment where water stands at some depth, to a shallow water/freshly exposed mud environment where scant herb growth occurs, to saturated (and likely seasonally inundated) soil with dense herb and graminoid growth, to an alder swamp adjacent to the downstream side of the next beaver dam. If impoundments are small (less than 0.5 ha), the different vegetation types are not mappable. If they are large, they are mappable, but still can change over a short period of time.

Although detailed descriptions of beaver meadows were not made during the 2000 season, we have made observations of these meadows in numerous other locations throughout Vermont. A more detailed description of this variant must come at a later date. The species listed in *Wetland, Woodland, Wildland* catches many of the major ones. To that list can be added a variety of St. John's-wort species *(Hypericum* spp.), and narrow-leaved gentian, which occurred in several beaver meadows in the Conte Refuge.

Beaver meadows, and their counterparts beaver ponds, are the most common wetland type in the study area, and in the state as a whole. Ranking beaver meadows is problematic since they are ubiquitous, are prone to frequent natural disturbances, and most often occur in very closely interrelated complexes of pond, meadow, shrub swamp and sometimes forested swamp. Placement of culverts during road construction has been a boon to beaver and consequently beaver ponds and meadows. Because beaver can plug culverts very easily, road construction has had a secondary consequence of increased beaver impoundments.

Shallow Emergent Marsh: Beaver Pond Variant—64c

Beaver ponds are the small bodies of standing water created when beaver dam streams. Like beaver meadows, beaver ponds vary in time and area. They may last a single year or endure

scores of years, depending upon beaver populations, dam strength, and stream flow over the years. When drained, the ponds become beaver meadows and, with time, other natural communities. Because of this, mapping beaver ponds and beaver meadows is time dependent. A reading of the preceding description of the beaver meadow variant gives a picture of the general nature of beaver impoundments.

Detailed descriptions of beaver ponds were not made during the 2000 season, but a few generalizations can be made. They are typically small—generally less than half a hectare—but may be as large as 5 ha. They are generally shallow and have bottoms composed of a mix of organic and mineral sediments. Water depths can fluctuate seasonally due to both water flow and dam conditions. Vegetation is variable, with aquatic plants establishing over time if water levels do not fluctuate too radically. If they are formed in a basin that formerly was forested swamp, the ponds will have snags that can be important sites for a variety of cavity and non-cavity nesting birds. The large canopy openings created by impoundments provide aerial space often utilized by fly-catching birds, swallows in particular. Beaver ponds can be very important breeding sites for amphibians, especially new ponds that are free of egg and larvae predators. Although beaver ponds do not often contain rare species, they are important, dynamic natural openings integral to the life histories of many animals and plants.

Shallow Emergent Marsh: Oxbow Variant—85

Oxbow marshes are small open wetlands found in river oxbows. These "U"-shaped segments of abandoned river channels retain such a distinctive character because they lie in the deepest portion of the old channels. In the Conte Refuge, West Mountain WMA, and adjacent Wenlock WMA they are restricted to the wide floodplain of the Nulhegan River mainstem and the adjacent lowest reach of the North Branch. Oxbow marshes in Wenlock WMA were mapped at this time because they are located between two river sections in the Conte Refuge and it is all one exemplary floodplain system. The oxbow marshes are in a low-gradient reach, where the river lazily, but consistently, winds its way to the lowest lip of the Nulhegan Basin at the Stone Dam.

While the broadly defined natural community type shallow emergent marsh describes the general character of oxbow marshes, the variant was mapped separately because of its very distinctive physiographic setting, consistent vegetative composition, which might include a couple of species distinctly associated with it, and its distinctive dynamic regime driven by fluvial geomorphology.

The 34 oxbow marshes mapped along the Nulhegan, from the Stone Dam Road bridge upstream to just above the Wenlock bridge, are very small, ranging in size from 0.025 to 1.2 ha. Their diminutive size is directly related to the small size of the river, which cuts a channel generally less than 10 m wide.

Oxbow marshes are slight to moderate depressions in the floodplain. They have saturated soils that are flooded most springs, with a shallow mud layer, 10-30 cm deep, over silt or sand. In mid-summer, most of the oxbows had some standing water, 10-30 cm deep. In the deepest parts of the marsh depressions grow aquatic plants, such as yellow waterlily, pondweeds *(Potamogeton* spp.), and a semi-aquatic grass *(Glyceria borealis).* Growing in exposed mud just above the pool zone are wetland species including spike-rush (*Eleocharis acicularis*), creeping spearwort, and common arrowhead. A sedge (*Carex vesicaria*) is often the dominant species in the highest ground of the oxbows, with a rush (*Juncus filiformis),* swamp candles, and a variety of wetland herbs and sedges mixed in. The rare sedge *Carex lenticularis* (G5/S2S3) was found in one oxbow marsh; the species is typically found on shores of lakes, ponds and rivers.

Because they hold water for significant lengths of time, it is likely that oxbow marshes are good amphibian breeding habitat, but because they are filled annually with river water, amphibian predators may be present. Also, a host of invertebrates may utilize these marshes for breeding.

The longevity of oxbow marshes is a function of how long it takes the river to meander back to a particular point on the floodplain. It is a dynamic process, where the destruction of an oxbow by the active channel, has the reciprocal effect of creating a new abandoned oxbow elsewhere on the floodplain. Sedimentation may also fill in some of the oxbow marshes over many years.

Proposed Alluvial Shrubland Variants

Alder-Northern White Cedar Floodplain Woodland—77a

The following description is based on observations from the upper Paul Stream floodplain, Ferdinand, Essex County, Vermont.

Alder-northern white cedar floodplain woodland is a natural community that occurs along frequently flooded portions of the riparian zone of Paul Stream. It is not known whether it occurs elsewhere in Vermont. Alluvial soils, rich in nutrients and with a high water-retention capacity, and annual floods of relatively long duration are characteristic of the natural community.

The trees of the woodland are northern white cedar, balsam fir, black ash, and white spruce. As in mixed northern floodplain forest, the trees of the floodplain woodland may grow to larger sizes than in many of the other natural communities in which they occur; of particular note are heights of white spruce and black ash, and diameters of black ash and balsam fir. Tree cover is sparse, typically less than 25% cover.

A dense growth of tall and medium shrubs is characteristic. Speckled alder is the dominant shrub; co-dominant or associate species include beaked hazel, black elderberry, wild raisin, and red-osier dogwood. Most of the shrub species do not strongly exhibit microsite preference, but red-osier is much more common in wetter depressions and on stream banks than elsewhere within a site.

The herb flora of floodplain woodland is very similar to the alluvial grassland/meadow herb composition. Many species co-exist and strong dominance is not necessarily displayed. Among the species are sedge *Carex intumescens,* sensitive fern, rough goldenrod, rough bedstraw, purple-stemmed aster, spotted touch-me-not, turtleheads, tall meadow-rue, the grasses *Glyceria striata* and *G. melicaria,* nodding beggar-ticks, American and northern water-horehound, spotted joe-pye-weed and the creeping shrub, dwarf raspberry. The vining plants virgin's-bower, arrow-leaved tearthumb and fringed bindweed frequently twine over and among the robust herbs.

Where shrub cover is less complete, herb coverage is very dense, and *vice versa.* Overall plant growth accounts for complete coverage of the floodplain; very little bare ground shows through the shrub and herb strata.

Alder-cedar floodplain woodland occurs in a complex mosaic with alluvial grassland/meadow, northern mixed floodplain forest and alder swamp. These natural communities are likely to occur as a shifting mosaic in which flood frequency and intensity, raising of floodplain areas by sediment deposition, floodwater pathways during major flood events, groundwater fluctuations, and beaver activity influence the current vegetation on any given piece of the floodplain. As such, the floodplain ecosystem should be seen to include a variety of natural community types that may relatively frequently be rearranged by hydro-geomorphic processes.

Alluvial Meadow/Grassland—82

The following description is based on observations from northern river floodplains (Nulhegan River and Paul Stream watersheds). The natural community is likely to occur in other biophysical regions and may exhibit floristic differences among the regions. Alluvial meadows commonly grow in close association with alluvial shrubland, levee forests (mixed northern floodplain forest), and alder backswamp; they are seen as so much a part of the alluvial system that they are classified as a variant of alluvial shrubland. The striking aspect of this natural community is that it appears to be a naturally maintained "meadow" in a vast region of northeastern North America defined by its forests.

Alluvial meadows are the epitome of luxuriant vegetation. They are places of tall, dense, tangled growth of numerous species of herbs, grasses and vines. They tend to occur in relatively small patches on floodplains, where the appropriate combination of hydrology and physiography exists. Often these places are near the junctions of tributary branches, and they are always alongside relatively low-gradient reaches.

As in floodplain forest and alluvial shrubland, the soils of alluvial meadows are comprised of flood deposits. Since new alluvium is frequently deposited atop the soil, profile development does not typically proceed much. The upper horizons tend to be organic rich, brown, fine sandy loam to silt loam, with little differentiation in color or pH. Layers of different textures may frequently be juxtaposed as a result of deposits from different flood intensities. The soil is often mottled above 50 cm; typical soil is moderately well drained.

Species that are common in alluvial meadows are typically robust forbs and grasses; shrubs are also common in some types of meadows. Height of the vegetation is generally one to two meters.

Common dominant to co-dominant species include virgin's-bower, bluejoint grass, cow-parsnip, black elderberry, great angelica, spotted touch-me-not, rough goldenrod, and false hellebore. Associate species include fringed bindweed, tall meadow-rue, rough bedstraw, wood-nettles, nettles, ostrich fern, spotted joe-pye-weed, Robbin's ragwort, Canada lily, and meadowsweet. Notably absent in the alluvial meadows in the project area are exotic species, including those that are invasive throughout much of New England.

Proposed Alder Swamp Variant

Alder Swamp: Deep Peat Variant—78a

As is reflected in the name, this variant of alder swamp occurs where peat soils are relatively deep, generally greater than one-half meter. Stunted speckled alder, often about 2-3 m in height, plus sedges, mosses and other plants more typical of boggy situations are characteristic vegetation. Deep peat alder swamps are found along sluggish small streams, and in backwater zones of low-gradient reaches of larger streams.

The soil is generally well-decomposed, saturated peat. The peat consistency typically becomes firmer with depth. While speckled alder is almost always the dominant shrub, wild raisin and mountain-holly can be common. Altogether they form about 75% cover. The groundcover vegetation is often a mix of peat mosses (*Sphagnum* spp.), sedges typical of acidic peatlands (e.g. *Carex trisperma* and *Carex canescens*), boreal herbs, and other more generalist wetland plants, such as purple-stemmed and flat-topped asters, wild calla, marsh fern, turtlehead, and bluejoint grass. No rare plants were associated with this alder swamp variant.

In the Conte Refuge deep peat alder swamps are most frequently associated with black spruce swamp, lowland spruce-fir forest, and beaver flowages. They likely represent some transition from an acidic swamp or bog, to a more minerotrophic alder swamp. Slight impounding of an acidic peatland might be the origin of some of these swamps. Others may be the result of their position in the backwater fringes of a stream—just far enough from enriching water near the stream channel, but not remote enough or perhaps too wet and aerated to produce "good" bog conditions. Whether they are successional is unknown. Because many of these swamps appear in very natural condition, they were assigned high element occurrence ranks.

Mixed Northern Seepage Swamp Forest/Woodland—81—Proposed New Natural Community Type

Mixed northern seepage swamp forest generally occurs in narrow seepage zones at the base of mountain slopes or in narrow, nearly level valleys. As the name indicates, seepage of groundwater is a dominant physical process that occurs in the natural community. A constant supply of mineral-rich seepage waters maintains a fertile, hydric soil.

The vegetation is characteristically diverse. A wide array of plants thrives in the moist, fertile conditions. Trees often grow in clusters, with shrubs and herbs dominant in between, but trees also may grow as scattered individuals. The natural community, therefore, can range from forest to woodland. The trees of mixed northern seepage swamp include white spruce, black cherry, black ash, balsam fir, northern white cedar, red spruce, tamarack, quaking aspen, and balsam poplar. Speckled alder is the dominant shrub; additional shrubs include red raspberry, spiny swamp-currant, wild raisin, meadowsweet, steeplebush, and mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3). The herb cover can be quite grassy, with bluejoint grass dominant, or more frequently, bluejoint grass occurs in a diverse mix with other grasses *(Glyceria striata, Bromus ciliatus),* rough goldenrod, crested wood-fern, purple-stemmed aster, golden and Robbin's ragworts, giant goldenrod, cinnamon and marsh ferns, water-avens, large-leaved avens *(Geum macrophyllum)* (G5/S3), and sedges *(Carex leptalea, C. stipata, C. disperma, C. canescens).*

Soil in the seepage swamp generally has a 3-10 cm mucky or peaty organic horizon over mineral soil. The water table is often at the soil surface, yet it can clearly fluctuate seasonally and from year to year and thus can allow distinct horizons to develop.

Similar to mixed northern floodplain forests and woodlands, seepage swamps can grow some very large trees. Large diameter balsam fir and exceptionally tall white spruce are not unusual to see in these natural communities.

Peaty Sand Pondshore—86—Proposed New Natural Community Type

In a few instances, ponds in the Northeast Highlands biophysical region have shorelines that have a mix of peat and sand. These open shorelines are most visible later in the summer when water levels tend to drop. It appears as though this shoreline natural community can occur when there is a sand source in proximity to shoreline peatland or peat deposits, and movement of water from wave action and/or water currents. Also, pronounced water level fluctuations may play an important role. The peaty sand pondshore natural community features a high diversity of low sedges, rushes, grasses, and some unique herbaceous plants. Two examples of the community type are known from WMWMA, and one occurs on the shore of Nulhegan Pond on private land.

The three peaty sand pond shores that are presently known are very small. The largest is perhaps 50-75 meters long by less than 10 meters wide. The others occupy less than 25 meters of shoreline. The shores at these sites are very gently sloping and have substrates that vary from pure sand, generally higher on the shore, to pure organic material, but most often peat and sand are mixed together.

The vegetation on these shores is zonal, ranging from plants growing in the pond shallows to those growing in the moist or dry sands highest on the shore. The moisture regimes for the different zones vary seasonally, and from year to year as annual precipitation in the area determines water levels. Plants typical of the shallows include water lobelia, swamp candles, pipewort, floating mannagrass, hairy-fruited sedge, threeway sedge, and water bulrush. In the next higher zone, the exposed wet peaty sands support a wide variety of plants, with sedges and rushes predominating in both species and abundance. This middle zone includes such common species as beaked sedge, tussock sedge, few-fruited sedge, beakrushes *(Rhynchospora alba* and *R. fusca)*, rushes *(Juncus pelocarpus, J. canadensis)*, horned and intermediate bladderworts, small cranberry, and intermediate sundew; uncommon species like Michaux' sedge *(Carex michauxiana)* (G5/S3), northeastern sedge *(Carex cryptolepis)* (G4/S3), shore sedge *(Carex lenticularis)* (G5/S2S3), and bog-rush *(Cladium mariscoides)* (G5/S2S3) also occur. Hidden among these sedges and rushes, especially where the vegetation is thin, the diminutive yellow-eyed-grass *(Xyris montana)* (G4/S1), a state-threatened species, infrequently occurs. Yellow-eyed-grass might be uniquely associated with this natural community type in Vermont. The highest vegetation zone of the community can be quite sandy, sometimes with an abundance of small cranberry and wooly panic-grass, as well as a rare grass known as fall dropseed muhly *(Muhlenbergia uniflora)* (G5/S2?). The high shore can also be quite shrubby.

More investigation is needed in this natural community, both in terms of ecology and biota. An inventory of various invertebrate groups might be especially rewarding, given the natural community's very restricted and unusual physical conditions, as well as its unique plant composition.

Chapter 3. Landscape Scales

The landscape of the Nulhegan Basin, West Mountain, Paul Stream and environs is a large and physically complex area. In order to best appreciate and describe its natural history and significance, and manage it, it is useful to stand back and look from a perspective that provides a broader landscape context. In this chapter we present a classification of large, landscape-scale ecosystems based on landforms, and provide detailed descriptions of the most intact and otherwise significant natural community complexes within each landform. In addition, we offer ecological management recommendations for these highly significant sites.

State-Significance and the Need for a Higher-Level View

State-significance is evaluated at a natural community (micro) scale. This is sensible when inventorying natural communities to evaluate composition, variation, and general statewide of integrity of natural community types, and for informing landowners when there is a natural treasure on their property.

When evaluating natural communities for land management purposes, however, it becomes clear that, because of complex patterns on the ground and differing ranking specifications for different natural community types, "significant" natural communities lie scattered among closely related "non-significant" natural communities, and furthermore, there may be inclusions of "non-significant" natural communities within a significant one, or a highly significant natural community isolated in a "sea of non-significance." This is particularly true throughout New England because wetland, cliff, or high-montane natural communities that are not productive for timber, agricultural or residential uses tend to have higher ecological integrity than the matrix upland forest natural communities. For management purposes, it therefore becomes necessary to determine how to bound a significant site—that is, how to draw appropriate ecological boundaries that make sense from a management perspective.

In a search for solutions to this problem of scale, and to avoid a need to draw boundaries that are not ecologically sensible, we have classified and mapped higher-level units in a landscape mosaic ecosystem map.

Ecosystem Management and the Question of Scale

To apply ecosystem management to a place on earth, it is first necessary to have a clear concept of what an ecosystem is. A natural community is an ecosystem perceived at a fine scale, but there are higher-level ecosystems in which natural communities are nested. Depending upon the size of the land base of a management-planning effort, it may be necessary to look at the land at various scales (Hunter 1999). Ecologists and geographers have developed objective ways of doing this, and these methods can be very useful in conservation planning.

Ecosystems include physical aspects of the earth (e.g., climate, geology, hydrology, soils), ecological processes (e.g., energy capture, nutrient and carbon cycles, natural disturbances), biota, and biotic processes (e.g., herbivory, pollination, seed dispersal, predation, demographic cycles, competitive exclusion, species evolution, vegetative succession). Rowe (1961) defined an ecosystem as "a volume of land and air plus organic contents extended areally over a particular part of the earth's surface..." and discussed how ecosystems occur at different levels in a nested hierarchy from the earth's entire ecological system to local ecosystems (Barnes *et al.* 1998, Rowe

and Sheard 1981). Barnes et al. (1998) stressed the geographic, spatial nature of these pieces of earth and their interactions with other pieces of earth through numerous abiotic and biotic processes, from the largest scales of macroclimate to the smallest scales of genecology.

Various authors have defined ecosystems at different scales; Bailey's (1996) three broad scales—macro (ecoregion), meso (landscape mosaic), and micro (site)—is a clear, simple schema. Ecosystems at each smaller scale, or level, are nested within a spatial ecosystem at a higher level in the hierarchy. Different names have been used for these levels, but there is general agreement on the hierarchical nature of ecosystems and the need to recognize ecosystems at each of these three major scales. To illustrate, ecoregions and biophysiographic regions are ecosystems at the macroscale (10,000 to 1,000,000 ha (sizes per Barnes *et al.* 1998)). Physiographic systems and landforms are ecosystems at the mesoscale (100 to 10,000 ha). Natural communities are ecosystems at the microscale (0.01 to 100 ha). As will be discussed below, it may be useful to describe sublevels in each of the three major levels. In fact, to understand landscapes and ecological relationships within the biophysiographic region, it is necessary to map, or at least consider, other levels at the mesoscale.

> In summary, the relationships between an ecosystem at one scale and ecosystems at smaller or larger scales must be examined to predict the effects of management. Because management occurs at various levels from national to site-specific, one of the prerequisites for rational ecosystem management is to delineate ecosystems at a level, scale, and intensity appropriate to management levels (Bailey 1996, p. 14).

Bailey (1996) points out that to be useful for scientific research and land management, and others would add conservation planning (see Soulé and Terborgh 1999, Boyce and Haney 1997, Noss *et al.* 1997, Noss and Cooperider 1994), ecosystems at every scale must be mappable. Strong arguments have been made for the wisdom of delineating macroscale ecosystems based primarily upon macroclimate and bedrock geologic formations, and landscape mosaic (mesoscale) ecosystems based primarily on interactions of climate and bedrock and surficial geologic landforms (Bailey 1996). Bailey's (1976) map of ecoregions—macroscale ecosystems—is the foundation for ecosystem mapping and conservation planning and management efforts of the Forest Service and The Nature Conservancy, and probably others.

Mapping ecosystems at the macroscale and the upper levels of the landscape mosaic scale is a top-down exercise (Barnes *et al.* 1998). Mapping ecosystems at the micro- or landscape-scale is an on-the-ground endeavor, or at the very least, must be based on in-depth on-the-ground experience and extrapolations and interpolations made there from. Natural community mapping is ecosystem mapping at the microscale.

The primary feature of mapping landscape mosaic scale (landforms) and microscale ecosystems (or read, if you prefer, natural communities) is multiple-factor integration of physiography, soil, bedrock geology, microclimate, and vegetation (Barnes *et al.* 1982, Barnes *et al.* 1998). Such is the method used to develop the natural community and landscape mosaic ecosystem maps for the lands of the Refuge and WMA.

The former Champion lands, moreover, are an excellent example of a mix of public and private conservation lands of a size large enough to be important in and of themselves at the landscape mosaic scale. Thus, there exists the potential that management planning implications for these lands are real at both the landscape mosaic scale and the natural community (micro/site/local) scale.

Bailey (1996) contends that there is a need to understand landscape genesis to understand ecosystems and ecological processes, for the genesis of landscapes and the processes that occur in dynamic ecosystems are intimately related. In conservation planning, it is important to understand ecological processes at various scales (Poiani *et al.* 2000). Maps at the landform mosaic level of an ecosystem hierarchy are an excellent beginning point for understanding landscape genesis and process at the mesoscale. Therefore, for planning purposes it is useful to look at the study area at the landscape mosaic level. We thus present first approximations of ecological mapping at three scales—natural communities (discussed above) represent the microscale, while two levels of landforms represent two levels at the landscape mosaic scale.

Landscape Mosaic (Mesoscale) Ecosystem Classification

Physical factors, particularly bedrock and surficial geology, physiography, and microclimate, are the primary determinants of higher-level ecosystems (Barnes *et al* 1982, Barnes *et al.* 1998, Bailey 1996). In the Northeast Highlands biophysical region of Vermont, and similarly in the Mahoosuc-Rangely Lakes Subsection, these factors have not been analyzed in great detail, but, based on previous field experience in the region, observations made during one field season in the study area, and existing bedrock and surficial geologic and topographic maps, we have made an attempt at a first approximation of a landscape mosaic ecosystem classification and map for the former Champion lands.

A spatial, hierarchical approach is useful for understanding ecological differences, ecosystem diversity (Lapin and Barnes 1995), and ecological interactions between and among units of land (Spies and Turner 1999). Ecosystems nested in one level are most similar and interact most closely with other ecosystems within that level of the hierarchy; hence, present condition (i.e., ecological integrity, fragmentation, successional status), management regimes and activities, and natural disturbances within an ecosystem most greatly influence ecological processes (e.g., natural disturbances, population processes, etc.) within that ecosystem (at any level in a hierarchy). Such factors to a lesser extent influence other ecosystems within the same hierarchical level, and ecosystems of a similar type that are nearby. This reasoning is intuitive—ecological activities in one space on the earth usually most directly impact that space and also greatly impact spaces nearby that have similar ecosystem characteristics (e.g., biota, geochemistry, hydrology). (There are clearly exceptions to this, particularly when one considers atmospheric phenomena such as chemical and particulate air pollution from industrial sources and particulate air pollution from natural events like volcanic eruptions and earth-meteor collisions.)

An ecological hierarchy provides a framework for planning and evaluating management and research activities. That framework enables us, among other things, to 1) more easily predict where certain direct and indirect impacts of management activities are most likely to occur, 2) understand which "parts" of biological diversity are and are not being conserved or managed for ecological integrity, and 3) replicate scientific study with a higher degree of accuracy.

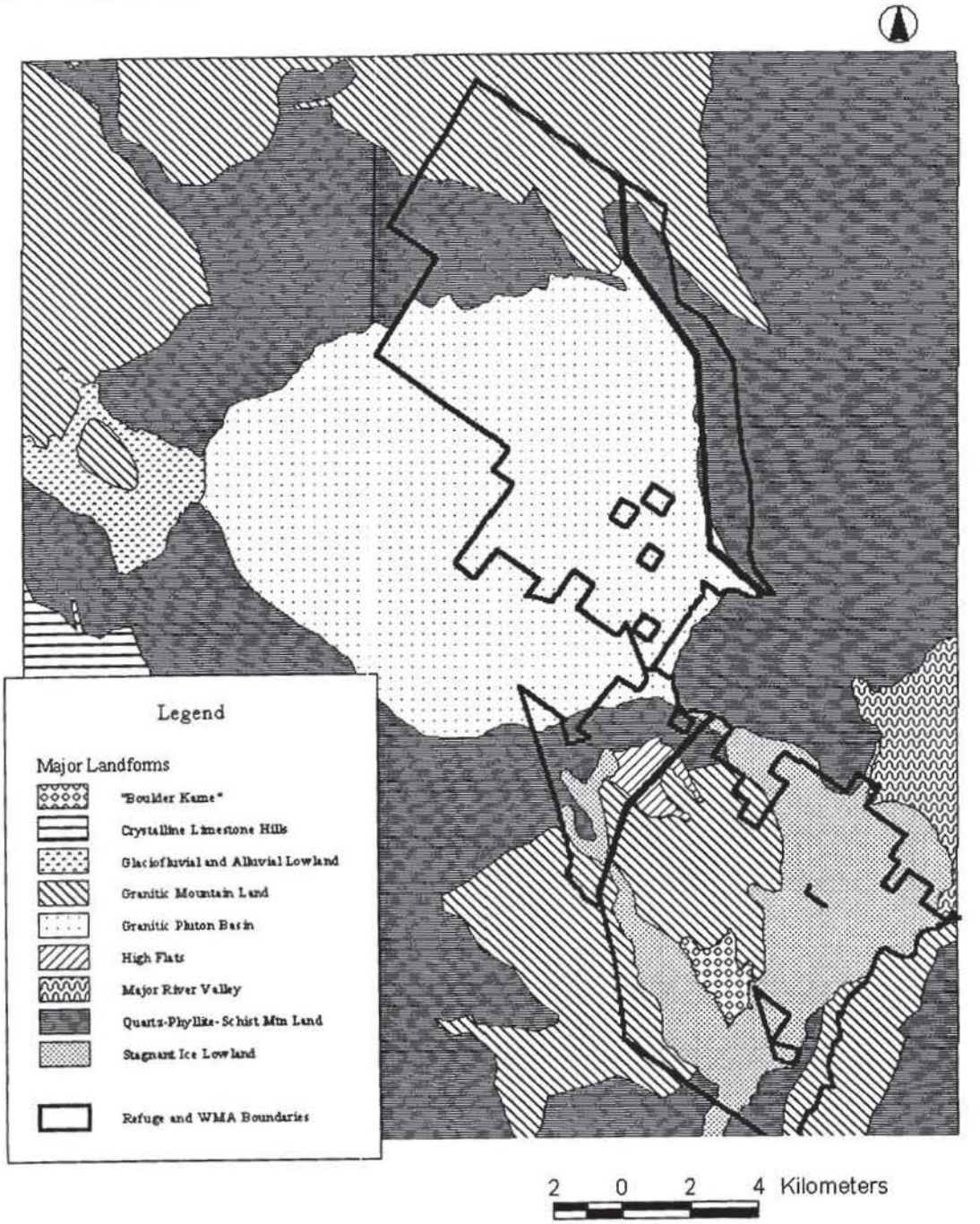
The study area, including lands adjacent to the WMA and Refuge, is a mosaic composed of three major physiographic units, among which climate, soils, geochemistry, and biota differ (Table 4, Figure 3). These units are geologically and/or geomorphologically differentiated—1) land comprised of Waits River formation crystalline limestone, 2) land formed of granite pluton, Gile Mountain formation and Albee formation quartzite-phyllite-schist bedrock, and 3) land within the Connecticut River Valley. The great majority of the WMA and Refuge lands are within the second physiographic unit; a tiny portion on the eastern edge of the WMA is within the third unit. No parts of the WMA or Refuge are within the first unit. Within the granite and

Table 4. Landscape Mosaic-Level (Mesoscale) Ecosystem Classification: West Mountain WMA and Nulhegan Basin Division, Conte NFWR—First Approximation[4]

I. Carbonate-rich bedrock (Waits River formation crystalline limestone)
II. Granite and Quartzite-Phyllite-Schist (Q-P-S) Bedrock
  a. Granitic Pluton Basin
    i. Coarse-loamy, cobbly (washed till?) deposits
      1. Well drained mineral soils
      2. Somewhat poorly drained to poorly drained mineral or shallow-organic-over-mineral soils
      3. Very poorly drained organic soils
        a. more minerotrophic
        b. less minerotrophic
    ii. Finer loamy till low hills
      1. Lower slopes (generally mixed forest or lacking sugar maple at least)
      2. Upper slopes and broadly rounded summits (northern hardwood forest)
    iii. Sandy kame-moraine and outwash deposits
      1. Kamic deposits, well drained sand and loamy sand
      2. Outwash plain, well to somewhat excessively drained medium and fine sand
      3. Very poorly drained organic soils
        a. more minerotrophic
        b. less minerotrophic
  b. Granitic Mountain Land
    i. Mountain summits and high-elevation ridges
    ii. Upper slopes
    iii. Lower slopes and all lower elevations
  c. Quartzite-Phyllite-Schist Mountain Land
    i. Mountain summits and high-elevation ridges
    ii. Upper slopes
    iii. Lower slopes and all lower elevations
  d. Stagnant Ice Valley/Flats, mid-elevation
    i. Bouldery, kamic deposits
      1. Well to moderately well drained soils
      2. Poorly drained shallow-organic-over-mineral soils
      3. Very poorly drained organic soils
    ii. Coarse-loamy glacial deposits (washed till? Glacial geomorphologic process unknown)
      1. Well to moderately well drained mineral soils
      2. Somewhat poorly to poorly drained mineral soils
      3. Very poorly drained organic soils
        a. more minerotrophic
        b. less minerotrophic
    iii. Somewhat excessively to excessively drained eskers and kames
    iv. Moderately well to somewhat excessively drained kamic and glacio-lacustrine deposits
    v. Moderately well to very poorly drained basins and channels
    vi. Very poorly to well drained, mid-high-elevation flat
III. Connecticut River Valley

[4] The ecosystem classification serves as the legend for the ArcView shape file "Lndfrms2.*"

Figure 3. Major Landforms of Nulhegan Basin Division of the Conte National Fish and Wildlife Refuge and West Mountain Wildlife Management Area, Essex County, Vermont



Refuge and WMA boundaries from VT ANR Champion Lands Boundary, modified by Lapin

quartzite-phyllite-schist unit, four landforms have been mapped. They are: a) granitic pluton basin, b) granitic mountain land, c) quartzite-phyllite-schist mountain land, and d) stagnant-ice valley/flats. Like the larger physiographic units, the landforms also differ in climate, soils, geochemistry, and biota.

Descriptions of Landforms and State-Significant Sites

Within each landform, certain complexes of closely related natural communities are described in detail because they are sites where a number of state-significant natural communities occur. Some of these areas, such as Big Swamp, Dennis Pond, Ferdinand Bog, and Mollie Beattie Bog, are well known places of high ecological integrity and natural history interest. Other complexes have not been documented previously as having a high level of significance. Many of the natural community complexes served as representative sampling sites.

Because these sites represent many of the highest quality and rarest natural communities in the WMA and Refuge, ecological management recommendations are included with the discussion of each complex. Some complexes were observed more intensively than others, and the descriptions vary in detail accordingly.

Granitic Pluton Basin

The Nulhegan Basin proper is a mid-elevation basin composed of Nulhegan Pluton quartz monzonite. The basin is geologically and physiographically unique in Vermont; unlike other granitic plutons in the state, the Nulhegan pluton is a nearly circular basin, surrounded by a mountain rim. Surficial glacial deposits are a complex assortment of glacio-fluvial deposits, such as kame, kame moraine and outwash, and till deposits. Much of the eastern half of the basin has an undetermined surficial deposit that may be washed till. There is much room for geomorphologic research, but our first approximation has mapped three types of smaller landform within the large basin landform—a coarse-loamy, cobbly (washed till?) basin floor; finer loamy till, low hills; and a glacio-fluvial unit of sandy kamic deposits and outwash plain.

There are distinct, repeated patterns in the basin bottom. One of the most striking is the strong north-south orientation of both the till hills and the sandy, glacio-fluvial deposits. There are many low ridges of glacio-fluvial origin in the lower Yellow Branch and lower Black Branch area. These are so subtle as to be very difficult to glean on aerial photographs, unless one is looking for very fine-scale features. Walking across the basin, they are very distinctive, and the parent material and soil drainage are notably different from the surrounding landscape. The glacio-fluvial ridges are mesic, well-drained lowland spruce-fir forest, and the surrounding lower landscape is a mix of wet-mesic lowland spruce-fir forest, northern white cedar swamp, mixed northern seepage swamp, black spruce swamp, and riparian and alluvial natural communities. A broader, sandy glacio-fluvial landform is prominent in the lower Yellow Branch area and along the mainstem of the Nulhegan River, and that is where the largest blocks of mesic, well-drained lowland spruce-fir forest occur.

Another pattern that is apparent in the basin needs further investigation to understand the underlying inter-relationships. On low till hills and some of the higher undulations of the basin floor, northern hardwood forest with sugar maple occurs on the east slopes and the tops, but in nearly all cases is not present on the west slopes. The west slopes are red spruce-hardwood forest in which sugar maple is absent. Other vegetative differences are also related to this physiography-

natural community relationship, but the sugar maple and natural community type differences are the simplest way to illustrate the point without extensive plot sampling. Interestingly, this same pattern has also been noted in the Lake Umbagog area (Publicover *et al.* 1997).

The lowest elevations in the Nulhegan Basin are in the lower Black Branch area, near the basin's outlet at Stone Dam. There, the surficial geology clearly indicates that a post-glacial/peri-glacial braided stream system laid down the parent materials. The natural communities and their vegetation in the lower Black Branch area are also somewhat different from other parts of the basin. Much of the lowest land adjacent to the riparian and alluvial zone is mixed northern seepage swamp forest. Upslope of and interfingered with the seepage zone is lowland spruce-fir forest that is somewhat different from that found throughout most of the basin. The abundance of black cherry, white spruce and bearded short-husk *(Brachyeletrum erectum)* are, perhaps, the most obvious floristic differences. Whether the differences are related to human land-use history, hydrology, chemistry of the parent material, or interactions among these and/or other factors is unclear.

A hypothesized historic pattern in the basin is that early 20th century, post-logging fires were more frequent and perhaps more intense in the lower Black Branch and lower Yellow Branch area. One piece of evidence suggesting this is the abundance of bracken on the glacio-fluvial ridges in the area. Another difference there is the occurrence of the red maple-aspen lowland spruce-fir forest variant adjacent to the Nulhegan River system. Since the greatest source of ignition—steam locomotives running the rails—is directly adjacent to this part of the landscape, and since there are more well-drained glacio-fluvial sands in the area, it is logical to think that the lower Yellow Branch and lower Black Branch lands were more often ignited. The total effect of such a human modification to the natural disturbance regime has not been investigated, and it is surely complex. The lower Black Branch-lower Stone Dam Road area exhibits the poorest regeneration of conifers in the lowland forests. That may be related to an unusual fire history in that local area, but examination of the 1940s aerial photographs would be needed to discern if that is a century-long phenomenon or a more recent one. On the other hand, it is also important to note that some of the best remaining well-drained lowland spruce-fir forest patches are in the lower Yellow Branch area.

The northern part of the basin is the upslope and upstream portion. That area is dominated by very cobbly, very coarse-loamy, and perhaps, glacially compacted soils. Sandy glacio-fluvial deposits are rare in that part of the landscape. Despite its upslope and upstream position, it is the wettest part of the basin in the Refuge and likely in the whole basin. In fact, the largest concentration of wetland in the Refuge, including Big Swamp's black spruce swamp forest and woodland bogs, occurs on a height of land in this northern part of the basin. The lowland spruce-fir forest adjacent to the perched wetland complex is also imperfectly drained; much of that land is the wet-mesic variant of lowland spruce-fir forest, whose soils exhibit unusual dark staining.

Additional analysis of the Nulhegan Basin has been submitted to US Fish and Wildlife Service as a supplementary report entitled "Regional Context, Remnant Conifer Forest Patch Analysis, and Conservation Assessment of the Nulhegan Basin, Essex County, Vermont."

Coarse-loamy, cobbly (washed till?) basin floor

The bulk of the Conte Refuge within the Nulhegan Basin itself is on this landform. Lowland spruce-fir forest, both well drained and wet-mesic, dominates the landscape. Within the matrix of lowland spruce-fir are conifer swamps (northern white cedar, spruce-fir-tamarack, and black spruce), woodland bogs, and open wetlands related to streams or zones of heavy groundwater

seepage. The extent of lowland conifer forest that makes the Nulhegan Basin so obviously different from surrounding terrain occurs on both this and the sandy kame moraine and outwash flat landform.

The basin lowland-wetland ecosystem should be seen as an ecological unit, not as separate significant sites. We have discussed natural landscape breaks in the basin-floor lowlands of the Conte Refuge, and have concluded that there really are no ecological boundaries that make sense other than those we present in the landscape mosaic classification. Nevertheless, we have presented complexes within the larger "Yellow Bogs" ecosystem that represent clusters of state-significant natural communities.

State-significant natural communities in this part of the basin are all wetlands, both forested and open. The upland spruce-fir forest has been almost entirely logged in the past 15 or 20 years. The small amount of forest not recently logged is restricted to areas left for deer wintering and a number of black spruce, spruce-fir-tamarack, and cedar swamps.

Big Swamp

Big Swamp is a well-known site of importance for natural community and rare plant conservation. Thompson (1989) calls it one of the best examples of black spruce swamp in Vermont. Our mapping of the Big Swamp natural community complex includes what Thompson called Big Swamp along with the nearby area she dubbed Blowdown Bogs. While not every natural community within the complex is swamp or bog, the site is the largest contiguous area of forested wetland in Yellow Bogs. Although it is somewhat artificial to separate Big Swamp from the rest of Yellow Bogs, both the pattern of clearcuts and the network of gravel roads do set it apart.

Natural communities within the complex are black spruce swamp, black spruce woodland bog, wet lowland spruce-fir forest, well drained lowland spruce-fir forest, spruce-fir-tamarack swamp, northern white cedar swamp, mixed northern seepage swamp, and beaver pond (related to culverts on Eagle's Nest Road). (Although not really part of the wetland and lowland coniferous complex, we also arbitrarily included a piece of red spruce-hardwood forest in the mapped complex to bound two close fingers of black spruce swamp with a simple line.)

One of the rarest plants in Vermont, lingonberry *(Vaccinium vitis-idaea)* (G5/S1) occurs in the Big Swamp complex. The uncommon plant, mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3), also grows in scattered locations. *Splachnum ampullaceum,* a rare moss that grows on moose dung, has been observed in the swamps as well.

Faunal surveys in Big Swamp and other black spruce swamp natural communities reiterated the previously recognized importance of these areas for state and regional conservation-priority northern bird species such as state-endangered spruce grouse *(Dendragapus canadensis)* (G5/S1), special concern species black-backed woodpecker *(Picoides arcticus)* (G5/S2B) and gray jay *(Perisoreus canadensis)* (G5/S1S2B), and blackpoll and northern parula warblers (Lambert 2000). Kilpatrick (2001) found that Big Swamp was one of two high-diversity sites for small mammals and the swamp appears to be one of the highest production sites (based on trap success) for several species of small mammals, especially red-backed vole *(Clethrionomys gapperi).* Peanut Dam Road, on the southeast end of the complex was one of the highest diversity sites for butterflies, and a "special concern" species of tiger beetle, *Cicindela purpurea* (G5/SU) was collected along the road (Miller 2001). Andrews (2001) notes that highly acidic wetlands without open water are not preferred habitats for the herp species of the region; both the black spruce

swamp and black spruce woodland bog sampling sites were practically void of herp species, and the lowland spruce-fir site had very few species.

Black spruce swamp is certainly the most prominent natural community at the site. The largest (northwest) section of swamp sits at the height of land and is surrounded by clearcut lowland spruce-fir forest, mostly the wet-mesic variant. The spindly canopies of the black spruce signal "wetland, unlogged black spruce swamp." It is a natural community with few vascular plant species and a continuous cover of numerous sphagnum species. Balsam fir and tamarack join black spruce to comprise the overstory; the forest is park-like and easy to walk through, until one reaches a patch of blowdown. In general, the black spruce overstory trees measure 10-18 cm dbh and are 70-85 years old. The largest diameter trees in the swamp are tamarack, up to approximately 25 cm. Shrub species grow in two layers—the taller has mountain-holly, wild-raisin and speckled alder, the shorter has Labrador tea, velvetleaf blueberry and sheep and bog laurels. The sparse herb cover is strongly dominated by the sedge *Carex trisperma,* with bunchberry, winterberry, painted trillium, wintergreen, pink lady's-slipper, and Indian pipe as associates. Soil in the swamp is shallow peat (typically 10-20 cm deep) over a very cobbly, bouldery, medium sandy loam. Spruce-fir-tamarack swamp occurs in scattered locations in the complex where there are presumably more soil aeration and/or more nutrients available to the plants.

Nine black spruce woodland bogs are imbedded in the complex. They occur where peat is deeper and fewer plant nutrients are available. The woodland bogs are small, ranging from less than one-quarter to three hectares. No dwarf shrub bog occurs in the complex.

A very small stream flows near the northwest margin of the swamp and the mineral enrichment provided by the moving water allows for the growth of northern white cedar swamp (minerotrophic type). The cedar are relatively large (45 cm dbh) and the uncommon shrub mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3) is present. The herb species composition is related to the presence of the stream and is somewhat different from that typically found in cedar swamps. Bluejoint grass, purple-stemmed aster, Robbin's ragwort, a grass *(Glyceria striata),* tall meadow-rue, rough bedstraw, and dwarf raspberry all occur in the ground cover.

Upstream from the cedar swamp, Eagle's Nest Road crosses the stream. Swamp forest northwest of the road has been flooded by beaver, and the area is now a pond with scattered tree skeletons.

Lowland spruce-fir forest in the Big Swamp complex, as is true for the vast majority of the natural community in the Refuge, has been clearcut and is in various stages of young successional regeneration.

Management Overview

Because Big Swamp sits on a height of land, the hydrology has been little affected by either roads or elevated water tables associated with clearcutting. An exception to this is the ditch draining into the swamp off of Canal Road, approximately 1.5 km north of the junction with Peanut Dam Road. The ditch has raised the water table in the black spruce woodland bog and deep peat alder swamp into which it empties, and has significantly impacted these wetlands. Likewise, beaver working with the alterations wrought by Eagle's Nest Road have been responsible for impounding a portion of the mixed northern seepage swamp north of the road. Roads and clearcuts, however, are the principal fragmenting features that have isolated this important site from the surrounding conifer lowland.

Management recommendations:

- Consider the Big Swamp complex to be a focal point for conservation of the lowland conifer forest complex of spruce-fir forest, black spruce swamp, and boreal acidic cedar swamp.
- Close Peanut Dam Road, remove roadbed, and allow natural re-vegetation to occur. The road is a dead-end spur and it divides Big Swamp from the Black Branch to the east. In a landscape context, road removal would allow full connection among Big Swamp, the middle Black Branch, and the Potash slopes.
- Close Canal Road, remove roadbed, and allow natural re-vegetation to occur. Although the road does connect the two main access routes in the Refuge (Lewis Pond and Stone Dam roads) it also fragments the heart of Yellow Bogs. Road removal would allow reconnection of a very large portion of Yellow Bogs' lowland conifer forest ecosystem.
- Allow natural succession to occur in the clearcut lowland spruce-fir forest.
- Allow natural forest dynamics (budworm cycles, blowdown, etc.) to operate in all the natural communities of the complex. Allow naturally ignited fires to burn; suppress anthropogenic fires.
- Control and monitor *Phragmites* population in the swale adjacent to Peanut Dam Road and in other places where it may establish.

Eastern Bog

Part of the greater Yellow Bogs ecosystem, Eastern Bog is an arm of hydrologically related wetlands located at the head of a small, sluggish tributary of the Black Branch. This area, bumping up against the eastern rim of the basin, was named by Thompson (1989), but not described as a significant site on its own, for reasons unknown. Although not as large as some, the predominant natural communities within the complex are in good condition and, therefore, are state-significant.

Eastern Bog is a coniferous wetland complex bordered on three sides by heavily cut lowland spruce-fir forest, and to the east by red spruce-northern hardwood forest of the lower slope Quartzite-phyllite-schist Mountain Land. The natural community type varies according to the degree of influence by surface or seepage waters. The core of the wetland is composed of mature black spruce swamp and spruce-fir-tamarack swamps, the latter positioned largely along the stream courses. In the center of two of the black spruce swamps are two small, circular pockets of black spruce woodland bog. Northern white cedar swamp and mixed northern seepage swamp forest occur in narrow bands that form a transition from the basin-bottom peatlands to upland-slope forests. Alder swamp follows the stream leading south from the heart of the wetland. Natural communities along the stream are variously affected by beaver impoundments.

A small population of lingonberry (*Vaccinium vitis-idaea*) (G5/S1) was found in one of the black spruce woodland bogs and adjacent the black spruce swamp. Although he did not visit this site, Lambert (2000) found the general lowland conifer forest, including all the types of wetland and upland conifer communities found at this complex, to have both high bird diversity and a high percentage of species that are rare or of regional conservation concern. The complex is not far from Miller's (2001) Peanut Dam sampling site and has many of the same natural communities; therefore, one may presume importance of these natural communities for butterfly and odonate diversity also.

Management Overview

For maximum ecological integrity, the Eastern Bog complex should be managed as part of the larger Yellow Bogs ecosystem. While mapped as a discrete unit based primarily upon significant

natural communities, the adjacent heavily impacted lowland spruce-fir forest should not be considered separated from the wetlands; they are all part of one conifer lowland ecosystem.

Management Recommendations:

- Close the old logging road that cuts through the western side of the complex; allow natural re-vegetation and remove culverts and berms when appropriate to allow natural water flow to occur, and
- Allow forest surrounding the wetland complex to naturally regenerate and grow to mature condition through a regime of natural forest dynamics.

Lower Yellow Branch Spruce-Fir Flat

Occupying the low terrain to either side of the Yellow Branch in the town of Brunswick, this complex features the most intact example of lowland spruce-fir forest found in the project area. The site is a mosaic of different natural community types within the matrix lowland spruce-fir forest. Raised areas feature well drained spruce-fir forest, while lower places in the gently undulating landscape are wet-mesic spruce-fir forest. In the lowest parts of the landscape are boreal acidic northern white cedar swamps, spruce-fir-tamarack swamps, alder swamps, and small black spruce and alder swamps. Although it has more well drained spruce-fir forest and fewer wetlands, this complex is clearly a part of the larger Yellow Bogs ecosystem.

The lowland spruce-fir forest is roughly 80 years old with an apparently even-aged structure; the trees range mostly from 15 to 25 cm dbh. Where there are not blowdowns or strip-cuts that create canopy openings, the forest is quite uniform, with similar size upright trunks of black spruce and balsam fir. In some places, the canopy includes red maple, paper birch and quaking aspen. The tall-shrub layer is virtually non-existent, but throughout there is a low-shrub layer comprised of one-meter tall spruce and fir seedlings. Sphagnum mosses carpet the ground, and the sparse herb growth consists of boreal herbs such as mountain wood-sorrel, creeping snowberry, bluebead lily, Canada mayflower, goldthread, and bunchberry. The soils are loamy sand to light sandy loam, and are well developed, brightly colored spodosols.

Including survey work in this complex, Lambert (2000) found that the lowland spruce-fir forest had the greatest number of bird species of any natural community in the project area. Lowland spruce-fir forest also supported the highest proportion of state and regional conservation priority species. Small mammal sampling had very low trap success and low diversity at this site, the only intact lowland spruce-fir forest sampled (Kilpatrick 2001). Andrews (2001) found low amphibian diversity at the site.

Management Overview

Lower Yellow Branch Spruce-Fir Flat was the representative sampling site for lowland spruce-fir forest. It is one of the few areas on the public lands where there remains upland conifer forest that has not been clearcut; one reason that it was not logged was deeryard management agreements. A private inholding along the lower Yellow Branch also features some of the most intact upland conifer forest in north of the Nulhegan River.

The complex should be managed via a natural dynamics regime; since it is the most mature area of upland conifer forest in the Refuge, it should be seen as a focal point for conservation of mature, natural spruce-fir forest. Management of the area should be planned holistically for the entire larger Yellow Bogs ecosystem.

Management Recommendations:

- Exclude Lower Yellow Branch Spruce-Fir Flat from timber management, and allow natural disturbances, such as wind events, flooding, and spruce budworm infestations, to create canopy openings and varied forest structure and composition; if the natural dynamics regime operates at a large enough scale, the varied landscape will contain representative diversity of native plants and animals, and
- Negotiate acquisition of the inholding at the south end of the complex.

Big Dam Swamp

Similar to the Logger-Black Confluence upstream, this one-kilometer stretch of the middle Black Branch features a medium-size alluvial shrubland in the floodplain, plus good examples of deep peat alder swamp, boreal acidic northern white cedar swamp and black spruce swamp. The floodplain area was impounded by the Big Dam shown on the 1929 USGS topographic map. The lasting influence of the impounded waters on the floodplain is unclear. Based on its presence along undammed portions of rivers, the alluvial shrubland does appear to be an expected natural community type along a low-gradient reach of river like this.

Management Overview

Only the southern-most portion of the alluvial shrubland was visited during the 2000 inventory. While it is clear that this is a significant natural community complex, more inventory work needs to be done to delineate community boundaries and types, especially with regard to the conifer swamps west of the river. The complex should be managed, for maximum ecological integrity, as part of the larger Yellow Bogs ecosystem.

Mid Yellow Branch

This rather large complex runs along the mid-section of the Yellow Branch from the south corner of Lewis up the tributary of the Yellow Branch that parallels Canal Road. The Yellow Branch and that tributary join in this area where all the streams wind their way sluggishly through conifer swamps and the matrix lowland spruce-fir forest. It is an important piece of the larger Yellow Bogs ecosystem. It includes Thompson's (1989) Yellow Branch Swamps, and the eastern portion of the Central Wetlands, both significant sites in her natural community inventory of Yellow Bogs.

At the tributary confluence and downstream, the Yellow Branch works through a constricted floodplain of alluvial woodland. Above the confluence the tributary lacks the volume to create floodplain. Instead it flows through a deep peat alder swamp. To either side of these riparian natural communities are sizeable patches of both spruce-fir-tamarack swamp and black spruce swamp. In general, the former tends to have deeper and wetter peat soils, while the latter has very shallow (15 cm or less) and drier peat soils over very stony, presumably washed till. These mature swamp forests greatly contrast with the surrounding heavily harvested upland spruce-fir forests.

Rare in Vermont, lingonberry (*Vaccinium vitis-idaea*) (G5/S1) was found in one of the black spruce swamps in the lower half of this complex by Thompson in her 1989 inventory work. In 2001 fieldwork, several other small populations were located in black spruce swamps in the northern part of the complex. In the 2000 inventory, both spruce grouse *(Dendragapus canadensis)* (G5/S1) and black-backed woodpecker *(Picoides arcticus)* (G5/S2) were observed, also in black spruce swamp at the northern end of the complex. This site is part of the lowland

conifer forest that Lambert (2000) found to have both high bird diversity and a high percentage of rare and regional conservation priority species.

Management Overview
The Mid Yellow Branch complex should be managed for maximum ecological integrity as part of the larger Yellow Bogs ecosystem. The lowland spruce-fir forest of the adjacent uplands, which represents the drier end of the moisture gradient of conifer lowlands, is an important component of that ecosystem.

Management Recommendations:

- Exclude the complex and surrounding lowland spruce-fir forest from timber management, to allow natural disturbances, such as wind events, flooding, and spruce budworm infestations, to create canopy openings and varied vegetation structure and composition.

Logger-Black Confluence

Logger-Black Confluence is where two branches of the Nulhegan River join. Fluvial and alluvial processes largely shape the site; groundwater seepage is also an important process. The largest natural communities are alluvial shrubland, alluvial meadow/grassland and northern white cedar swamp. The stream-floodplain meadow is one of the largest aside from those on the Nulhegan mainstem. Historic topographic maps indicate that the site was dammed to facilitate log drives; the continuing ecological influence of the historic inundation has not been investigated.

Natural communities included in the complex are alluvial shrubland, alluvial meadow/grassland, northern white cedar swamp, boreal acidic northern white cedar swamp, mixed northern seepage swamp, alder and deep peat alder swamps, beaver meadows and ponds, and a strip of wet-mesic lowland spruce-fir forest. The wetland complex lies within a matrix of well-drained lowland spruce-fir forest.

Uncommon plants observed at Logger-Black Confluence were swamp thistle *(Cirsium muticum)* (G5/S3), mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3) and large-leaved avens *(Geum* cf. *macrophyllum)* (G5/S3). The site is also one of two locations in the study area of common hops *(Humulus lupulus),* an herbaceous vine native to riparian thickets in New England, but not often seen in Vermont. Two exotic plants—hemp-nettle *(Galeopsis tetrahit)* and coltsfoot *(Tussilago farfara)*—were also documented in the alluvial shrubland; neither is currently considered to be strongly invasive.

The area was not visited by biologists conducting faunal inventories, but a woodcock, a species of regional conservation concern, was flushed from the alluvial shrubland on August 30.

Management Overview
Logger-Black Confluence is in close proximity to Big Swamp and Middle Black Branch Seepage Woodland. The sites are currently fragmented by Tin Shack and Peanut Dam roads; reconnecting these three important parts of the Nulhegan Basin ecosystem would increase the conservation value of an already very high-value part of the landscape.

Management recommendations:

- Close Tin Shack Road south of the intersection with Eagle's Nest Road and remove the bridge over the Black Branch. Remove roadbed and allow natural re-vegetation.
- Maintain natural hydrologic dynamics.

Upper Yellow Branch Riparian Complex

The Upper Yellow Branch Riparian site is one of several sizeable areas of open wetlands embedded in the spruce-fir lowlands of the Nulhegan Basin. It appears to have the most natural community types of any of the open wetland systems associated with tributaries of the Nulhegan River. The convergence of three principal tributaries of the Yellow Branch along this low-gradient reach of the stream are likely responsible for its creation and maintenance. Lying between the larger Black and North Branches, the Yellow Branch watershed is starved for water. As such it is sluggish and lacks the flooding and depositional capacities that the larger branches have. Its sluggish nature likely leads to the peaty soils found in the wetlands here. Old maps, such as the 1929 USGS 15' topographic quad, do not show evidence of a dam that might have created this open wetland complex.

The natural communities that comprise the Upper Yellow Branch Riparian open wetland are alder swamp, alder swamp deep peat variant, sweet gale shoreline swamp, black spruce swamp, black spruce woodland bog, beaver meadow and lowland spruce-fir forest. The natural community complex was mapped as including only the riparian wetlands east of the intersection of Lewis Pond and Eagle's Nest roads, but it perhaps should be interpreted to include also the open wetlands northwest of the road intersection, along another branchlet of the Yellow Branch. That nearly contiguous riparian area includes many of the same natural community types, plus alluvial meadow/grassland, and one of the rarest plants in the state, Wiegand's sedge *(Carex wiegandii)* (G3/formerly SH, to be re-ranked S1).

The site has numerous signs of former beaver activity (abandoned dams and lodges, tiny remnant ponds), but now has perhaps only a single active dam. As a result, there is much exposed area that had been flooded, including deep peat alder swamps, beaver meadows, alder swamps and sweet gale shoreline swamp. At over a hectare in area, two of the beaver meadows at the upper end of the complex are unusually large. Also, the site has a concentration of deep peat alder swamp that is as great or greater than anywhere else in the project area, and it features a good-sized piece of sweet gale shoreline swamp in a less usual streamside position.

In addition to the discovery of Wiegand's sedge, rare and uncommon plant species that were observed in the wetlands were shining rose *(Rosa nitida)* (G5/SH), shore sedge *(Carex lenticularis)* (G5/S2S3), mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3) and swamp thistle *(Cirsium muticum)* (G5/S3). Mountain fly-honeysuckle is quite common in the deep peat alder swamps and peripheries of the beaver meadows, in this complex as well as other open wetland types throughout the Conte Refuge. This was one of several sites in the study area where these other rare plants were observed.

It is not surprising that this open wetland site with a high level of natural community diversity was found to be important for animal species. Miller (2001) reports that the area was a high diversity site for both butterflies and odonates. Two rare odonate species, *Somatochlora* cf. *minor* and *S. walshii* (both S2), were observed along with three uncommon species, *Lestes congener, S. elongata* and *Sympetrum danae* (all S3). Miller also suspects that rare skippers *(Hesperioidea)* may be present. The Upper Yellow Branch open wetland complex was the highest diversity site for small mammals. Additionally, the only observations of rare pygmy shrew *(Sorex hoyi)* (G5/S2) and uncommon water shrew *(Sorex palustris)* (G5/S3) were from this site (Kilpatrick 2001). Andrews (2001) observed that the Upper Yellow Branch riparian complex, with its "streams, beaver ponds, pools, and nearby upland habitat" was among the more diverse sites for amphibians. Bird species diversity was low in the open wetland, but rusty blackbird *(Euphagus*

carolinus) (G5/S3B), a species of special concern in Vermont did occur there, along with three species of regional conservation concern (Lambert 2000).

Management Overview
Being an open wetland with no valuable timber, the Upper Yellow Branch Riparian Complex has not been directly impacted by logging. Nor has road construction or culvert placement diminished its ecological integrity. The good fortune of geology (a raised bedrock knoll) allowed for the placement of the road system in such a way as to not impact the riparian system of either the eastern or western forks of the Yellow Branch.

Management recommendations:

- Allow natural patterns of vegetative and hydrologic change, including beaver-dam cycles to occur,
- Investigate the *Carex wiegandii* location more thoroughly, and study/research the interaction between beaver flooding and the persistence/occurrence of the rare sedge. If deemed appropriate, protect the Wiegand's sedge population from extirpation by controlling beaver-induced flooding, and
- Allow natural re-vegetation of lowland spruce-fir forest adjacent to the site.

Mollie Beattie Bog

Mollie Beattie Bog, also known as Western Bog, is among the most significant black spruce woodland bogs in Vermont. It is the largest example of the natural community type in the former Champion lands, and is one of the most open as well. The bog is surrounded by high-quality black spruce swamp and cedar swamp; these natural communities have been included in the significant natural community complex. Adjacent to the site are clearcut lowland spruce-fir forest and more elevated areas of red spruce-hardwood forest, which has been heavily logged also.

A large population of the rare sedge *Carex exilis* (G5/S2) occurs in the bog. It is one of the larger populations of the rare plant in the study area, and likely in the state also.

The woodland bog is a textbook example of the natural community type. Stunted black spruce grow in some places as dispersed clumps and in others more regularly spaced. Six to twelve meters is a typical height for the trees. The shrub growth is moderate to dense and is dominated by mountain-holly, sheep and bog laurels, Labrador tea, leatherleaf, rhodora, bog rosemary and velvetleaf blueberry. Small cranberry and creeping snowberry are abundant atop the sphagnum carpet. Herbs include hare's tail cottongrass, and the sedges *Carex trisperma, C. pauciflora, C. oligosperma, C. stricta, and C. exilis.* Peat in the deepest part of the basin is greater than 180 cm deep and is very well decomposed. The western part of the bog is more open, appears to have deeper peat, and has the greatest concentration of *Carex exilis.*

Black spruce swamp blends outward from the most open parts of the bog. Tree heights increase and tamarack becomes more abundant. The largest trees measure 25-32 cm dbh. The shrub species composition is very similar to that of the bog, with the addition of witherod and early low blueberry. The species more closely tied to open peatland conditions, bog laurel, bog rosemary and small cranberry, are rare to absent in the forested swamp. The herb flora differs also. The sedge *Carex trisperma,* wintergreen, bunchberry and three-leaved false Solomon's-seal are dominant; also present are bluebead lily and dewdrop. Trees are commonly draped with old man's beard lichen *(Usnea* sp.). Peat in the swamp is much shallower than in the bog; it commonly ranges from 10 to 80 cm deep.

Northwest of the black spruce bog and swamp flows a streamlet, with which is associated a narrow northern white cedar swamp. The minerotrophic cedar swamp and the nutrient poor black spruce natural communities show a great contrast in species composition. Cedar, black ash, balsam fir, and black spruce comprise a well-structured canopy. Speckled alder and beaked hazel are common in the shrub layers, along with witherod, mountain-holly, velvetleaf blueberry, swamp red currant, and the creeping shrub dwarf raspberry. The herbaceous flora includes foamflower, dewdrop, bunchberry, mountain wood-sorrel, bluebead lily, wild sarsaparilla, interrupted fern, tessellated rattlesnake-plaintain, and the sedges *Carex trisperma, C. intumescens,* and *C. blanda.*

The interior of the site is not of especial importance for amphibians or reptiles, but Andrews (2001) located three amphibian breeding sites along the southwest border of the wetland. Spruce grouse *(Dendragapus canadensis)* (G5/S1) and gray jay *(Perisoreus canadensis)* (G5/S1S2B) were located in Mollie Beattie Bog, as were three other bird species of regional conservation concern (Lambert 2000). Miller found Mollie Beattie Bog to have one of the highest butterfly species counts in the study area, including the lone record of rare Arctic jutta *(Oeneis jutta)* (S2). He also observed the uncommon odonate *Leucorrhinia proxima* (S2) in the bog.

Management Overview
Mollie Beattie Bog has long been recognized as a state-significant site. Management of the bog and adjacent, intact black spruce swamp and cedar swamp natural communities should allow natural vegetation dynamics to occur. The surrounding lowland spruce-fir and mixed forest should be allowed to regenerate naturally, and enhancing the quality of the site with a broad area of forest free of active management is recommended.

Little Pond Bog

Little Pond Bog is a small (5.7 ha) wetland complex situated in a slightly elevated flat that separates the North Branch from the western tributary of the Yellow Branch. Mollie Beattie Bog is located in this terrain of very minor relief a bit to the southeast. Perched as such, both of these peatlands are isolated from surface water inputs. Little Pond Bog was apparently missed, or at least not field surveyed, by Thompson (1989) during her inventory of the natural communities of Yellow Bogs.

The complex is a combination of four small peatland natural communities: poor fen, black spruce woodland bog, black spruce swamp, and boreal acidic northern white cedar swamp, with a pond in the center. The pond of Little Pond Bog is a classic "mud pond." It is very shallow with a deep muck bottom, and its waters are tannic and nutrient poor. Though classified as a "dystrophic lake" in the most recent Vermont classification of aquatic communities (Aquatic Classification Workgroup 1998), it is better described in Maine's natural community classification as a "bog pond community" (Maine Natural Heritage Program 1991). The pond has an abundance of floating aquatic plants, including yellow waterlily, water-shield, and pondweed (*Potamogeton* sp.), plus a sizeable population of the rare floating bur-reed *(Sparganium fluctuans)* (G5/S2).

On two sides of the pond is poor fen. In addition to the typical bog plants, such as bog laurel, pitcher plant, and small cranberry, the very slightly minerotrophic peatland supports a wealth of rare and uncommon species, including state-threatened pod-grass *(Scheuchzeria palustris* ssp. *Americana)* (G5/S1), and white-fringed orchid *(Platanthera blepahriglottis)* (G4G5/S1), bog sedge *(Carex exilis)* (G5/S2), tuberous grass-pink *(Calopogon tuberosus)* (G5/S3) and rose pogonia *(Pogonia ophioglossoides)* (G5/S3). Formed largely by the accumulation of bog mosses (*Sphagnum* sp.), the poorly decomposed peat is over 1.5 m deep. The poor fen grades into a black

spruce woodland bog to the south and black spruce swamp to the west. East and north of the pond is a small but good example of a boreal acidic northern white cedar swamp. This broken canopy swamp is a mix of black spruce and cedar. While not large in girth (generally less than 35 cm dbh), the narrowly cylindrical-crowned cedar looks old, perhaps over 120 years. It has an unusually shrubby understory of stunted speckled alder, mountain-holly, wild-raisin, and winterberry. Amongst this shrubbery is a small population of the rare shining rose *(Rosa nitida)* (G5/SH) and the uncommon mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3).

Because of their small sizes, none of these natural communities rank as state significant on their own. However, when viewed collectively, they are an excellent example of a peatland complex, ranging from the pond to swamp, and containing an unusually high diversity of rare plants. Except for some selective timber harvest in the cedar swamp, all the natural communities are in an undisturbed condition.

The complex was not visited by other biologists during the 2000 inventory. Given the high diversity of butterflies, dragonflies and damselflies found in other open peatlands (Miller 2001), it is recommended that these groups be surveyed at Little Pond Bog. Two mink frogs were heard calling during a site visit by Engstrom on July 20; Andrews (2001) considers mink frogs to be an important, characteristic species of the Nulhegan/West Mountain landscape.

Management Overview
This is a highly scenic spot on the Conte Refuge, especially when the orchids and other bog flowers are in bloom during mid-summer. The bog mat with its rare plants, however, is highly vulnerable to foot traffic. It should be placed off limits to the public, and access by managers and researchers should be kept to a minimum. Visitors wanting to see a bog setting can be directed to the boardwalk at Mollie Beattie Bog.

Management recommendations:

- Drainage from the adjacent Four-mile Road should be directed away from the peatland.
- Lowland spruce-fir and red spruce-hardwood forest adjacent to the site should be permitted to re-grow in accord with a natural dynamics regime.
- The site should be surveyed for insect and additional rare plants, and perhaps small mammals.

Middle Black Branch Seepage Woodland

The Middle Black Branch Seepage Woodland lies between the Black Branch and the slopes of the Potash Mountains. The long, linear seepage area extends approximately 2.5 km and is dominated by mixed northern seepage swamp forest/woodland. Other natural communities in the complex are spruce-fir-tamarack swamp, northern white cedar swamp, black spruce swamp, alluvial shrubland, alder swamp, and well-drained lowland spruce-fir forest on what appear to be glacio-fluvial deposits. It is a relatively large, naturally open part of the landscape, and is a good example of a low-elevation, highly productive, naturally herb- and shrub-dominated ecosystem that occurs in our mostly forested landscape. As with many of the level areas adjacent to larger streams this seems like a likely site for an impoundment to aid in log drives, but the 1929 USGS 15' topographic quadrangle does not indicate that it was dammed.

The mixed northern seepage swamp varies from forest to woodland. It is the largest example of the natural community type seen in the study area. There are many "glades" dominated by a "turf" of bluejoint grass with a variety of associate herbs, such as golden ragwort, cow-parsnip and giant goldenrod. Clumps of speckled alder and trees such as black cherry, white spruce,

northern white cedar, quaking aspen, balsam poplar and tamarack add structural diversity to the woodland.

Judging by a number of moose beds and abundant bear sign, especially concentrated around one large white spruce that may have been a "babysitter tree," the seepage woodland is important wildlife habitat for those species. There are no data regarding faunal species, since those inventories did not cover the Middle Black Branch Seepage Woodland. Lambert (2001), Andrews (2001) and Miller (2001) found that alluvial shrubland had high bird, herp and butterfly diversity, and, because physiognomically and compositionally there are many similarities among the seepage woodland and the alluvial shrubland, it would be interesting to see if species diversities were similarly high.

No roads cross through the site. The bridge over the Black Branch on Stone Dam Road is located at its southerly end, but the gravel road diverges from the site in both directions. No other major haul roads are very close, but there is a grassy "winter road" that courses along the lower slope of the Potash Mountains; that road was apparently a main historic logging access into this part of the Basin.

Management Overview
Except for the clearcut black spruce swamp, the area is in quite good shape. Allowing natural vegetation succession to occur is the recommended management strategy.

Management recommendations:

- Close and allow natural re-vegetation of the "winter road," to allow full connection among the eastern upland, the seepage woodland, and the Black Branch; the powerline upslope would then be the only fragmenting feature between the lowland and the Potash ridge.
- Jim Andrews should survey the site for wood turtle *(Clemmys insculpta).*

Upper North Branch Riparian Area

This is a relatively small, but unusual part of the landscape, along the upper North Branch, in the proximity of the Whiskey Brook confluence. A small, but intact example of a higher-gradient, more upstream type of mixed northern floodplain forest, with several vernal pools, is featured. The North Branch along this stretch is a fairly high-gradient stream. It is big enough to create a gap in the canopy and make sunny, gravel bars, but small enough to have mostly shaded banks. The stream and its small floodplain are set in a mostly intact riparian buffer-strip of red spruce-hardwood forest; the surrounding red spruce-hardwood forest has been recently logged. Along the slopes of the stream banks is a population of rare small-flowered wood-rush *(Luzula parviflora)* (G5/S2); that plant also was found on high-gradient reaches of the Black Branch.

The description of the mixed northern floodplain forest found in the section describing proposed natural community types and variants in Chapter 2 applies, with some differences, to the floodplain forest along the North Branch. This stretch of the North Branch is where the waters tumble off the mountain rim and enter the basin; it is more of a mountain stream—smaller and with a higher gradient—than the stretch of Paul Stream from which the natural community description was written. This site is more-or-less a northern analog to the sugar maple-ostrich fern riverine floodplain forest type, with respect to landscape position, soils and also vegetation; unlike that natural community type, this one is not dominated by ostrich fern, but does include it in small patches. The upper North Branch floodplain has a coarser texture soil than that on downstream portions and larger streams such as Paul Stream and the Nulhegan River, where other mixed northern floodplain forests are mapped; the soil ranges from sandy loam to loamy

sand. It supports many of the same species as in the natural community description, but lacks some species like northern white cedar, white spruce, and common elderberry. Interestingly, at both locations large black ash occurs, suggesting that floodplains are where the species grows best. The North Branch floodplain forest, as well as other mixed northern floodplain forests, has a broken canopy, which leads to a high diversity of both shrubs and herbaceous species. This varied vegetation structure is a product of flooding dynamics. Herb species in the upstream floodplain forest that are not typical of other parts of the project area include wild ginger, blue cohosh, white snakeroot, ostrich fern and red baneberry. With the exception of a smattering of coltsfoot and self-heal, no exotic plant species were observed.

Another unusual natural community variation occurs adjacent to the floodplain, in a flat between the North Branch and Whiskey Brook. Although the area was heavily logged, the soils and vegetation indicate that it is unlike any other forest community observed in the Refuge or WMA. The natural community is truly a northern hardwood-red spruce forest, with the three major northern hardwood tree species and a substantial presence of red spruce. It is neither at a high elevation, nor on a mountain slope, but rather is on a unique little landform in the upper part of the basin. The soil is a stone-free, very fine to fine sandy loam spodosol; the texture suggests that there was a small, post-glacial impoundment on the flat, where fine materials settled out of suspension. The herb flora does not differ much from in the red spruce-hardwood forest natural community, but the landform, soil texture and abundance of sugar maple and beech strongly suggest a system that is subtly different from that type. Adjacent parts of the landscape are more typical of the natural community types and pattern found throughout the basin.

To our knowledge the Upper North Branch area was not surveyed by other biological inventory groups. It is likely a high quality area for moderate-size mountain stream aquatic fauna.

Management Overview
As with other riparian complexes, the best means of conserving the area is to buffer the stream corridor with intact forest, and make sure that stream flow is not artificially altered upstream.

Management recommendations:

- Either repair the bridge over the North Branch or erect stronger barricades to keep trucks from crossing through the stream. Currently the bridge is unsafe to cross and many drivers choose to cross the North Branch upstream of the roadway and bridge. The erosion and associated disturbances to the stream ecosystem should be avoided.

Sandy Kame Moraine and Outwash Flat

During the period of glacial downmelting (ablation), well-sorted sandy deposits were laid down in the vicinity of the present-day Nulhegan River. These deposits appear to be both very gently rolling kame moraine and a more level outwash plain of coarser sands. The well drained soils of these deposits likely supported a pre-settlement forest in which white pine was a major component. Some of the droughtiest areas also likely supported red pine. The best examples of these coarser, better-drained kame deposits are along Route 105 further west in the basin. Even though the soils are coarse throughout much of this landform, the water table is high in many areas; thus there is a mosaic of well drained and wet-mesic lowland spruce-fir forest, along with black spruce and northern white cedar swamps. Recent geomorphic processes in the Nulhegan floodplain have created many alluvial natural communities within the ancient glacio-fluvial channel. This floodplain ecosystem is one of the highest quality floodplains in Vermont. Additionally, some of the lowland and wetland conifer forest natural communities are the most intact of any in the basin; not all of these are within West Mountain WMA and the Refuge.

Buxton Pond Lowland

Buxton Pond Lowland is a piece of West Mountain WMA that reaches into the Nulhegan Basin and contains the most significant example of lowland spruce-fir forest found in the project area. When the extent of the complex, most of which is in the adjacent Wenlock WMA, is considered, this is probably the most intact lowland (but not wetland) spruce-fir forest in the entire Nulhegan Basin, if not the entire state of Vermont.

Sitting on gently rolling to flat kame, and perhaps outwash, deposits, this spruce-fir forest has well-drained and heavily leached, loamy sand soils. It is composed of mature, but not large (less than 30 cm dbh) red and black spruce and balsam fir, plus paper birch and some super-canopy white pine. While these pine are not exceptionally large at present, old pine stumps suggest that these light soils could produce some impressive pines, a meter or more in diameter. Although different species are different sizes, the forest is likely even-aged and relatively young (perhaps 50 years?). The spruce and fir understory is thick in patches, with approximately 25% cover overall. Low- and high-shrub layers are poorly developed, composed primarily of mountain-holly, wild-raisin, and velvetleaf blueberry. As characteristic of the community, the moss layer is forms a nearly complete cover, while typical boreal herbs are relatively sparse.

Within the matrix spruce-fir forest are a variety of wetland communities, including the three variants of northern white cedar swamp (minerotrophic, boreal acidic, and sloping seepage forest), flooded northern white cedar swamp, and spruce-fir-tamarack swamp. Most of these are small, but in good condition. There is a quite large black spruce swamp east of Buxton Pond, and a small one on the southwest side of the pond. Both have classic lollipop-shaped black spruce and an unusually dense high-shrub layer of mountain-holly and wild-raisin.

The area, including Wenlock WMA and the Buxton's property, is well-known spruce grouse *(Dendragapus canadensis)* (G5/S1, state-endangered) habitat. It is also known for its gray jays *(Perisoreus canadensis)* (G5/S1S2B), black-backed woodpeckers *(Picoides arcticus)* (G5/S2B), and a host of warblers associated with lowland spruce-fir forest. Most of the gray jays and black-backs are rare to uncommon year-round residents in Vermont, while the warblers are neotropical migrants. An adult black-backed woodpecker was observed in this forest during the natural community survey. While this particular part of the lowland spruce-fir forest was not surveyed by Lambert (2000) during his breeding bird inventory, results of his work in similar lowland spruce-fir natural communities along the lower Yellow Branch showed this type supported more species than any other single natural community, and featured the highest proportion of state-listed or regional conservation-concern species. The lowland spruce-fir forest, including the Buxton Pond Lowland/Wenlock WMA area, clearly is some of the most significant habitat for breeding birds in the region.

Management Overview

Conservation of this lowland is a very high priority both because intact examples of upland spruce-fir forest are regionally rare and because of its importance for breeding birds. From an ecological perspective, the area should be managed cooperatively with Wenlock WMA and the private inholdings. Since so much of the spruce-fir forest in the Nulhegan Basin is regenerating from recent cutting, this area, which is quite mature, should be excluded from timber harvest in order to allow trees to reach full maturity and the forest to develop natural structure and patch dynamics. If not harvested, over time this will become an exemplary occurrence of lowland spruce-fir forest, even though parts of it will undoubtedly blow down, or perhaps be burned in forest fire or damaged by spruce budworm. Regeneration in the natural openings will develop into excellent spruce grouse habitat.

Because it is one of the most accessible areas of West Mountain WMA, public access needs to be carefully considered. Well-worn trails are already present. A trail and trail-monitoring network may need to be established in order to concentrate foot traffic and hopefully avoid bootleg trails. All planning should be done in concert with Wenlock WMA.

Management recommendations:

- Manage this lowland in concert with Wenlock WMA, but a substantial portion should be permitted to develop under a regime of natural dynamics to attain old-growth forest structure, because it is the part of the landscape nearest to that condition,
- Permanently close and allow re-vegetation of the logging road that cuts through the area (between Notch Pond and Buxton Pond roads).

Nulhegan Floodplain

Without a doubt the Nulhegan River floodplain is one of the most remarkable ecosystems in the project area, and in the whole Nulhegan Basin. This is really the heart of the Nulhegan Basin, where both the Yellow Branch and North Branch—two primary tributaries—join the mainstem. The complex includes land in Wenlock WMA because the middle portion of the floodplain ecosystem is on that property. From an ecological perspective, the natural community map could not be drawn otherwise.

The Nulhegan River is not a huge river like the Connecticut into which it flows, but it is large enough to create a substantial floodplain. In this stretch of the Nulhegan, the floodplain ranges in width from 250-400 m broad. The river in this flat area of the basin bottom cuts through sandy kame and what appears to be a narrow outwash plain. Stewart and MacClintock (1970) mapped all the glacio-fluvial deposits in the basin bottom as kamic, but a section appears to be an outwash flat. In the floodplain ecosystem, the natural hydrogeomorphic process of flooding leads to fresh sediment deposition, while at the same time the river erodes portions of the alluvial sediments as it winds its way across the floodplain. Hence, in relatively short time period—perhaps from several hundred to several thousand years—much of the floodplain's soil is recycled. In contrast, the surrounding land not affected by the river may take tens of thousands of years before it is recycled by the next glaciation.

Alluvial shrubland is the predominant natural community in the complex. Imbedded in the shrubland are two other floodplain natural communities: alluvial grassland/meadow and oxbow marsh. On the periphery are several other small wetland communities not heavily influenced by floodwaters. These include northern white cedar swamp, deep peat alder swamp, and alder swamp. The alluvial shrubland is our name for what Thompson and Sorenson (2000) described as "alluvial shrub swamp." Our reason for giving it a different name rests on the grounds that it is not primarily a swamp ecosystem.

As in most floodplains, the alluvial shrubland along the Nulhegan is a result of well-watered, highly fertile soils. Floodwaters deposit silts and sands to form a deep, rock-free, very fine sandy loam soil. Speckled alder is the principal woody plant, generally ranging from 3-5 m in height, with some exceptionally tall trunks growing to 8 m. Other tall shrubs, such as nannyberry, wild-raisin and common elderberry, commingle with the alder. The high shrub layer ranges anywhere from 50 to 75% cover, and is thickest in the swales. Emerging above the shrub layer are widely scattered black cherry, balsam fir, white spruce, white pine, tamarack and even black spruce. Seeing these conifers in the floodplain is a clear indication that it is a different type of floodplain system—one with a more northern character. Although rare, white pines can be enormous: one measured 166 cm dbh and approximately 25 m tall and another was 128 cm dbh. Black cherry is

clearly the commonest hardwood in the floodplain; in places it forms a canopy of 50% cover at 15 m height. The black cherry are notably small relative to the highly vigorous conifers.

The groundcover, however, really displays the productivity of the floodplain. Herb and graminoid vegetation is very lush, almost always over 100% cover except in the densest alder thickets. Plus, it is exceptionally tall, frequently in the 1-2 m height range. Here, species grow at their maximum capacity: bluejoint grass to 1.7 m, joe-pye weed to 2 m, tall meadow-rue to 2.5 m! These species, along with rough goldenrod, flat-topped aster, bearded shorthusk, and swollen sedge are the most common species to be found. Virgin's bower, an herbaceous vine, frequently climbs over both the alder and the herbs and grasses. Other species not so abundant as the above, but strongly allied with floodplains, include Canada lily, cow-parsnip, and Virginia wild-rye. Rare or uncommon plants found in the alluvial shrubland include state-endangered contracted sedge *(Carex arcta)* (G5/S1), nodding trillium *(Trillium cernuum* (G5/S2), Wiegand's wild-rye *(Elymus wiegandii)* (G?/S3), and swamp thistle *(Cirsium muticum)*(G5/S3).

Adding natural community diversity to the floodplain ecosystem are oxbow marshes and alluvial grassland/meadows. Both of these occur in very small units, but are distinctive on the ground and mappable from aerial photographs. The oxbow marshes are the deepest portions of abandoned channels, and alluvial grassland/meadows are most frequently associated with pointbar deposits. Both are described above in the section on proposed natural community types and variants in Chapter 2.

One outstanding aspect to the Nulhegan Floodplain complex is the lack of exotic plants. Floodplains are notorious for their diversity and abundance of exotic plants, including many invasive species. While a very few exotics were observed on the Nulhegan floodplain, none were invading, or even abundant.

While archaeological research might reveal otherwise, it appears as though there was not a dam that impounded this stretch of the Nulhegan, which suggests that what we see today is probably a natural condition for the floodplain.

The natural community complex of the Nulhegan Floodplain was found to be one of the most species diverse natural community (or complex) types for butterflies and odonates (Miller 2001) and amphibians and reptiles (Andrews 2001). Andrews (2001) observed the special concern species wood turtle *(Clemmys insculpta)* (G4/S3) in the North Branch section of the alluvial shrubland and meadow complex. Results from the bird inventory reveal that the alluvial shrubland, which included four species of regional conservation concern, had the greatest diversity of all the non-forested wetland types (Lambert 2000). The area was in the mid-range for small mammal diversity (Kilpatrick 2001).

Management Overview

Negative impacts to the site include the railroad, Route 105 and Lewis Pond Road, all of which cut across this stretch of floodplain. The major railroad impact has been the creation of impoundments. Recognizing the presence of the railroad is important for management because activities along the tracks are likely impact the surrounding floodplain. Spraying of herbicides to retard woody plant growth along the rails has the potential to affect the adjacent floodplain plant and animal life. The St. Lawrence and Atlantic Railway is currently involved in the process of assessing alternatives to the use of herbicides in the Nulhegan Basin. Alternatives benign to the surrounding floodplain should be promoted.

Exotics are not currently a problem on the floodplain, and it is important to maintain a watchful eye. Any management techniques that can keep the floodplain free of exotics should be promoted.

Management recommendations:

- Any work on the railroad bed should try to minimize direct impact on the floodplain; a derailed boxcar full of paper should be cleaned up; railroad trestles should be expanded, if possible, to decrease the impounding effect of the bed,
- Road work on Route 105 or Lewis Pond Road should make all attempts to minimize any impacts upon the floodplain,
- Eradication of the known location of common buckthorn, and periodic survey for invasives are recommended preventative management,
- More research on the wood turtle population is needed to understand the extent and size of the population and threats to it, and
- This stretch of the Nulhegan should be managed cooperatively by federal and state managers and private landowners.

Finer loamy till low hills

The till-soil low hills in the Nulhegan Basin generally support northern hardwood forest on their broad tops and often on their east slopes. The footslopes and west slopes are typically red spruce-hardwood forest. The hardwood and mixed forests have either been clearcut or heavily selectively cut. Only one small area within these low hill landforms was found to be significant.

Within the basin, sugar maple occurs with few (if any) exceptions only in the northern hardwood forest atop the low hills and on the east slopes. Even when the soil was similar on the lower and west slopes of the hills, sugar maple was not observed. On most of these features, there are very distinct boundaries between the red spruce-hardwood forest (which lacks sugar maple) and the northern hardwood forest natural communities. Reasons for such clear vegetation boundaries in the absence of soil texture or drainage differences are unclear. Microclimate is one possible determinant, but the answer is likely to be a more complex set of inter-related factors.

Stevens Brook Knoll

In the far northwest point of the WMA is a high-quality 16-ha piece of red spruce-hardwood forest. The natural community is larger, but extends outside the boundaries of West Mountain WMA, onto lands of Wenlock WMA and Essex Timber Company. The forest is on a low, till hill on the edge of the Nulhegan Basin. Yellow birch, red maple, hemlock and black spruce comprise the overstory; dominant hemlock measure 60-65 cm dbh, while hardwoods are slightly smaller (55-60 cm). This is perhaps the most mature representation of the red spruce-hardwood natural community in the basin.

Adjacent to the west-southwest is a very nice minerotrophic northern white cedar swamp in a headwater of a Stevens Brook tributary. The swamp slopes 5% and has 50 to 70 cm sapric peat over medium sand; over much of the peat is a 10-cm Oa horizon with a dense mat of roots. The herb flora is typical of nutrient-rich cedar swamps and the moss-liverwort carpet is comprised of *Hylocomium splendens, Trichocolea tomentella,* and *Bazzania trilobata.*

The landscape surrounding these high-quality natural communities is a mixture of cutover forest and quite nice lowland natural communities. Atop the low, till hill, a very young white spruce plantation was initiated in a clearcut northern hardwood forest natural community. Northwest and west of the red spruce-hardwood forest is a nice pole-sized stand of wet lowland spruce-fir forest, on Essex Timber property, with some black spruce and northern white cedar to 35 cm dbh. The

Stevens Brook tributary to the north has a remote beaver pond and meadow complex that is on West Mountain and Wenlock WMA lands as well as Essex lands.

Management Overview
The property and WMA boundaries in this corner of land cut across natural community and physiographic boundaries in a manner that makes management planning very difficult. Coordinated management among the two WMAs and Essex Timber is necessary for appropriate ecosystem management of these Nulhegan Basin natural communities. Protection of both the red spruce-hardwood forest and the cedar swamp should be done on natural community, not ownership boundaries.

Management recommendations:

- Conserve the high-quality red spruce-hardwood forest and cedar swamp natural communities by trading or purchasing land, or by negotiating management agreements among the parties,
- Negotiate a management agreement or land trade/purchase to allow the lowland spruce-fir forest adjacent to the WMA to develop by natural dynamics, thereby enhancing the integrity of a fine piece of lowland landscape, and
- Cut the planted white spruce seedlings (currently 50-100 cm tall) and allow a northern hardwood forest to grow on the knoll.

Granitic Mountain Land

The project area includes two separate granitic mountain landforms. Mountainous terrain of the Maidstone Pluton in West Mountain WMA is dissected by a mid-elevation stagnant-ice valley and flats discussed below. The WMA granitic mountain land is best represented by West Mountain itself. Separated on the west by the Paul Stream valley (including Ferdinand Bog) are the lower slopes of Seneca and Bull mountains. An area of granitic mountain land to the east of West Mountain is also separated by the Paul Stream valley; that area includes hills on the shore of Maidstone Lake and higher terrain east of the lake, outside of the WMA.

Granitic mountainous terrain of the Averill Pluton occurs north of the Nulhegan Basin. A small portion of that landform is within the Refuge, much more of it lies north of the Refuge on lands of Essex Timber and other large landholders. The part in the Refuge includes low-, mid-, and a bit of high-elevation lands including Lewis Mountain and an unnamed higher summit.

The granitic mountain land is predominantly northern hardwood forest, except for the small amounts of montane mixed and conifer forests atop the low mountains that are within the public landholdings. Nearly all of the forest has been selectively logged, in places quite heavily in recent decades. West Mountain is the only upland area on a granite mountain landform with natural communities of state-significance, except for a small natural community of more mature forest along the outlet stream of South America Pond. Moreover, even the better quality natural communities on West Mountain are only marginally of state-significance. With time, however, the vegetation will mature and forest structure will regain the characteristics of natural forest. Also of state-significance is an exceptional mountain stream riparian complex that occurs along the Upper Black Branch in the Conte Refuge.

West Mountain

The 833-m summit of West Mountain is the highest point in the WMA and is the largest montane area on the public landholdings. There are several montane and high-elevation natural community

types represented on the mountain, and they are generally of average quality. Montane spruce-fir forest, with oldest trees 50-70 years old, occurs on the ridgeline and the summit, as well as in scattered patches on the steep, upper west slope; there are less than 90 ha of the natural community and its variants on the mountain. Montane yellow birch-red spruce forest covers a larger area—118 ha on West Mountain and a northern sub-summit. Montane yellow birch-sugar maple-red spruce forest (63 of the 118 ha) on the west slope is the highest quality of the montane types. The relative intactness of the forests on the western slope can be attributed to the steepness of that face. Much of the yellow birch-sugar maple-red spruce forest presently has a canopy dominated by paper birch; the supposed late-successional canopy species are in the understory and sapling layers. It is interesting to note that sugar maple reaches relatively high elevations in the montane forests, even though the slopes are steep.

A small area of boreal acidic cliff and its associated boreal talus woodland is visible on the western slope at 700 m. It is one of the few spots on the public lands where the gradient is great enough to have formed a cliff and talus system. The cliff is less than one hectare and the talus below covers from two to three hectares.

Lower on the steep western slopes, and on a sub-summit ridge, high-elevation northern hardwood forest and yellow birch-northern hardwood forest occur. The most interesting natural community in the West Mountain montane complex is high-elevation northern hardwood seepage forest. This uncommon natural community variant sits in a deep, narrow concavity at 670-700 m. Groundwater seepage begins at the head of the concavity and extends approximately 500 m downslope. The physiography and hydrology combine to create an unusual natural community dominated by widely spaced sugar maple, with a dense low-shrub layer of hobblebush and an assortment of seepage related herbs, plus the typical montane fern, mountain wood-fern. The natural community type is more fully described in the section on proposed natural community and variants.

The lower west slope, from the flat of the Paul Stream Valley to approximately 500 m elevation, is one of the richer northern hardwood natural communities observed in the study area. The site is sugar maple-white ash-jack-in-the-pulpit northern hardwood forest, although, as may be characteristic of the moderately rich hardwood forests in the Northeast Highlands, jack-in-the-pulpit is rare. Because of recent logging, the occurrence is not highly ranked.

One rare and two uncommon plant species were observed on the mountain, all with small populations. These were Kamtschatkan bedstraw *(Galium kamtschaticum)* (G5/S2S3), wild millet *(Milium effusum)* (G5/S3), and large-leaved avens *(Geum macrophyllum)* (G5/S3). The rare bedstraw and uncommon avens are boreal and northern north-temperate species that are near the southern end of their ranges and are much more frequent in far northern Vermont than elsewhere in the state.

Bear use of the mountain is evident in northern hardwood forest on the west slope, where there is common scarring on beech trees. Not much beech was observed in a single transect on the mountain's north slope, and the east slope was not visited. Therefore, there may well be other beechnut-feeding areas.

Faunal surveys in the montane spruce-fir forest were conducted in 2000. On a drizzly morning, Lambert (2000) located only about one-half of the 20 characteristic species of Vermont's montane forest bird community; three of the species, however, are regional conservation priorities. He did not locate suitable Bicknell's thrush *(Catharus bicknelli)* (G3G4/S3B) habitat

on the mountain. Andrews (2001) found only redback salamander at the site; this was an expected result for a high-elevation area that is "dry and distant from breeding sites" of most herp species.

Management Overview

Although West Mountain is not currently an exemplary site for northern hardwood and montane natural communities, it has great importance as the headwaters landform for most of the sites that by legal easement will be managed as ecological core areas (STA). Furthermore, there are (marginally) state-significant natural communities and significant plant occurrences. The mountain is in many ways typical of mountains in the Northeast Highlands—dominated by northern hardwood forests with only a small portion of the upper elevations in the montane forest zone. Logging on the mountain has been extensive, but clearcutting has not been used on the slopes in this century. (Past logging was certainly intensive, but the extent of historical clearcutting has not been researched.) Hence, the forest structure is characteristic of what one sees over much of Vermont's mountainous lands. The paper birch-dominated montane yellow birch-sugar maple-red spruce natural communities on the western slope were likely burned somewhat severely by anthropogenic, not natural, post-logging fires.

The mountain does have an old fire tower and a camp on the summit, with a well-developed trail leading there. No other trails exist on the slopes.

Management recommendations:

- Allow natural forest structure and composition to develop through the function of natural dynamics,
- Allow naturally ignited fires to burn, but suppress anthropogenic fires if weather and fuel conditions indicate that a burn could get large,
- When the camp lease lapses (or by other legal arrangements), remove the camp and clean up all debris from such.

Upper Black Branch Riparian Area

The upper Black Branch Riparian Area is a complex featuring the Black Branch itself, its small riparian zone, and the mature lowland spruce-fir forest lining the valley bottom through which the stream runs. The Black Branch is a high-gradient stream along this stretch dropping 135 meters over roughly four kilometers. This riparian corridor runs from the elevated country forming the north rim of the Nulhegan Basin, down to the basin bottom.

The forest in this area is mapped as lowland spruce-fir. In reality it is more of a mosaic of spruce-fir and red spruce- northern hardwood forest. The moss cover, so characteristic of lowland spruce-fir, comes and goes. The forest is more mature than average, and in places contains large trees.

In the upper half of this stretch the river is swift, clear, about 7 m broad and has a cobble bed. It is not pitched so steeply, however, that it cannot wiggle out of its bed. In most places the stream riparian zone is only two to five meters broad, and the stream is just large enough that the area is not fully shaded. Exposure to sunlight, in combination with the dynamics of stream erosion and deposition, create an attractive habitat for plant growth in a landscape that is dominated by the shady and relatively stable soil conditions of the forests.

Hence, the riparian vegetation features lush herb and graminoid growth, dominated by bluejoint grass, rough goldenrod, joe-pye weed, tall meadow-rue, foamflower, bearded shorthusk, and a host of other species. The sedge *Carex torta* characteristically forms a line along the edge of the

streamwaters. The rare and uncommon drooping bluegrass *(Poa saltuensis)* (G5/S23) and swamp thistle *(Cirsium muticum)* (G5/S3) often grow in the shore zone. On moss-covered banks and outcrops at several locations, small-flowered wood-rush *(Luzula parviflora)* (G5/S2) was found. In Vermont and other northern New England states this rare plant is more typically found in the high mountains.

Where the gradient slackens, there are small patches of alluvial shrubland along the river. In other slack-water reaches the river cuts across forested pointbar deposits, thus creating a floodplain situation where both scouring and deposition, mostly of sand, occur. This is a type of mixed, high-gradient floodplain forest that was too small to be mapped. While the vegetation is not drastically different from surrounding forest, the alluvial soils are. In abandoned stream channels were small examples of mixed northern seepage swamp forest.

In the lower half of this stretch, the Black Branch runs a steeper pitch. At an elevation of approximately 460 m it drops through a ravine with scenic cascades and a small (7 m) waterfall. The bedrock here is a very blocky fracturing granitic type. On the steep slopes leading down to the falls area is some relatively undisturbed forest including some very large northern white cedar; one measured 77 cm dbh. The forest tends to be of a mixed composition, containing yellow birch and red maple in addition to red spruce, balsam fir, and cedar. In places on the steep slopes are unusual seeps that are dominated by various mosses and dwarf scouring rush.

Management Overview
Excluding this area, if not an even wider corridor, from timber cutting would increase the quality of the forest communities, and eventually lead to old-growth conditions. This would also buffer the stream from impacts associated with logging. The site is likely a high-quality aquatic habitat that should be evaluated, if it already has not been. There are areas along this stretch of stream that look suitable for the state-endangered auricled twayblade *(Listera auriculata)* (G3/S1), which was found at a downstream location during the inventory. Additional survey for this globally rare species is needed.

Quartzite-Phyllite-Schist Mountain Land

Quartzite-phyllite-schist mountain land occurs on both Gile Mountain and Albee formation bedrock types. Not enough study was done to reveal whether these two formations are different enough chemically so as to influence vegetation and other biota differently. In fact, except for specific known areas of more enriched forested natural communities, differences between granitic and quartzite-phyllite-schist mountain land were not striking. Additional research might reveal that the differences are slight or that the different bedrock types have a substantial influence on the vegetation composition and abundance of related natural communities on the different landforms. Because of the lack of information, and the known potential for somewhat carbonate-rich strata to occur in Gile Mountain rocks, the granitic mountain land was classified separately from the quartzite-phyllite-schist mountain land. The differences, however, appear to be somewhat localized and not necessarily always related to bedrock formation. Other factors such as hydrology, slope shape and position, or very local bedrock mineralogy may actually have greater influence on natural community properties than the bedrock formation type.

The quartzite-phyllite-schist mountain landforms surround the granite plutons. Most of the terrain of this type in the project area consists of the mountain rim around the Nulhegan Basin—specifically, the Potash Mountains, Notch Pond Mountain and the area around Lewis Pond. These are generally northern hardwood slopes, and parts are in better than average condition for

northern hardwood forest natural communities in the Refuge and WMA. Lewis Pond and the adjacent natural communities sit in a large, well-defined mountain basin; the site is very interesting and state-significant.

Notch Pond Mountain

The north slope of Notch Pond Mountain is very steep and very bouldery; the elevation change is 270 m in a distance of 500-550 m, for an average slope of 54% (28°). Red spruce-hardwood boulder-slope forest covers the mid- and lower-slope; this is the most impressive and most intact upland forest natural community on the public lands. The upper slope features extremely steep montane yellow birch-red spruce forest, here expressed as paper birch-red spruce forest, and the broadly rounded summit (630 m) has montane yellow birch-sugar maple-red spruce forest. An abrupt ecological boundary occurs at the base of the mountain where the bedrock slope abruptly meets the coniferous lowlands of the Nulhegan Basin in the area of Buxton Pond (see site description above).

Red spruce-hardwood forest boulder slope variant is a distinctive forest type with characteristics of both red spruce-hardwood forest and montane yellow birch-red spruce forest, but with a unique suite of characteristics related to steepness and rockiness. (See the section on proposed natural community types and variants in Chapter 2 for a more thorough discussion.) The large, dominant trees in the natural community on Notch Pond Mountain are yellow birch, red spruce and red maple that measure 60-70 cm dbh. The overstory appears to be uneven age, and has diameters ranging from 35 to 70 cm. Sugar maple is present on benches and more moderate parts of the slope.

A shaded, moist acidic ledge outcrops on the upppersloppe. Few vascular plants were seen on the ledge, on which grew a number of mosses. The ledge is within montane spruce-paper birch-yellow birch forest that also features large trees to 60 cm dbh. Above the steep, ledgy montane forest, the summit forest has been logged. Species are a mix of northern hardwoods and beech and the natural community has characteristics of montane yellow birch-sugar maple-red spruce forest and northern hardwood forest; due to its elevation it was mapped as the montane type.

Management Overview

As with most of the more mature forests in New England, this site was spared from logging because of its extremely sloping and rocky conditions. It is a physiographic anomaly and is not representative of mountain slopes in general. Nevertheless, the forest structure is more representative of old-growth forest conditions than other places in the uplands. Curiously, there is no large woody debris on the slope; it was perhaps consumed by fire. The quality of the Notch Pond Mountain ecosystem will be enhanced by allowing the adjacent harvested forest stands to grow under a natural dynamics regime, both on the slopes and in the adjacent coniferous lowlands.

Management recommendation:

- Consider Notch Pond Mountain to be a focal point for restoration of old-growth upland forest in the WMA,
- Negotiate management or purchase agreements with the owner of an inholding on the east slope of the mountain.

Lewis Pond Basin

The Lewis Pond Basin is a medium-high elevation (550 m), small, exceptionally seepy basin that is separated from the Nulhegan Basin by a series of small hills. The site is a contact zone between

Gile Mountain formation quartzite-phyllite-schist and the granitic Averill Pluton. North of the basin, Lewis and Gore mountains rise to 780 m and 970 m, respectively. The seepiness and the mineral enrichment of this part of the landscape combine to create appropriate conditions for a number of high-quality natural communities.

Natural communities at the site include very good examples of minerotrophic northern white cedar swamp, northern white cedar sloping seepage forest, mixed northern seepage swamp, red spruce-hardwood seepage forest, northern hardwood seepage forest, spruce-fir-tamarack swamp, and an open seep. There are also good, but small, examples of sweet gale shoreline swamp, beaver meadow and alder swamp. In the deepest part of the basin lies 28-ha Lewis Pond, a good example of a wilderness-like, dystrophic pond and the largest body of water within the public landholdings.

Lewis Pond is home to state-threatened northeastern bladderwort *(Utricularia resupinata)* (G4/S1), as well as rare Farwell's milfoil *(Myriophyllum farwellii)* (G5/S2) and uncommon purple bladderwort *(Utricularia purpurea)* (G5/S3). A resurvey of the pond by the VT DEC in 2001 discovered the former and latter species for the first time; the initial survey was done in 1989.

The minerotrophic cedar swamp in the Lewis Pond Basin is one of the largest examples, and perhaps the most species diverse, of its natural community type in the former Champion lands. Unlike many cedar swamps, moss cover is not abundant and herbaceous growth is dense; there are also many small streamlets flowing through the swamp forest. Dominant cedars are greater than 50 cm dbh; two that were aged were 171 (37 cm dbh) and 207 years (40 cm dbh). The older tree is one of only three trees aged during the statewide cedar swamp inventory that were over 200 years old (the other two were in the McConnell Pond tract and Wenlock WMA). A cored 37 cm-dbh red spruce was 156 years old. Although there is a narrow skid trail through the swamp, there were very few trees harvested except to cut the trail. Some spruce and fir were harvested from around the edges of the swamp during adjacent logging operations, and limited, few-tree blowdowns occurred in these areas. Of the greater than 30 herb species observed, one rare and one uncommon species were noted—Kamtschatkan bedstraw *(Galium kamtschaticum)* (G5/S2S3) and swamp thistle *(Cirsium muticum)* (G5/S3).

To the east, the cedar swamp blends into a relatively large mixed northern seepage swamp. Tip-ups are frequent and the broken canopy consists of large northern white cedar, balsam fir, red maple, black ash, few sugar maple, plus super-canopy white spruce. In the understory are loose and gangly thickets of speckled alder, with an abundance of black ash saplings, and some white spruce regeneration. Like the minerotrophic cedar swamp, plant diversity is high. Mosses include an abundance of species indicating minerotrophic conditions, including *Mnium* sp., *Rhytidiadelphis triquetrus*, and *Sphagnum squarrosum*. Typical bog mosses (*Sphagnum* spp.) were notably absent. The very wet soil in this swamp consisted of 1.5 m-deep, well-decomposed woody peat over cobbly, coarse sand. The uncommon swamp thistle *(Cirsium muticum)* (G5/S3) was also noted in the mixed seepage swamp.

At the head of the seepage swamp, where a stream flows off the hillside and hits the flat of the Lewis Pond Basin, is an open seep of approximately 200m^2. This naturally herbaceous community is a saturated meadow of sedges *(Carex gynandra, C. stipata, C. scabrata),* bristly aster, tall white bog-orchid, marsh violet, wild mint, northeastern mannagrass, swamp buttercup, mad-dog skullcap and other species. It is an interesting, rarely encountered type that is an excellent demonstration of the small-scale heterogeneity related to physiography and hydrology.

The slope north of the cedar swamp is northern hardwood seepage forest, and between the two is a band of northern white cedar sloping seepage forest that is in equally good condition as the cedar swamp. Much of the northern hardwood seepage forest has been logged, but an intact area is a fine example of this uncommon type. Additional areas of northern hardwood and red-spruce hardwood seepage forest occur throughout the site, and most are relatively intact. Logger Brook feeds Lewis Pond from the mountains to the north, and that stream appears to be a high-quality aquatic natural community, for which a rather nice forested buffer was left intact.

Animal surveys were not done at this site, with the exception of Jim MacDougall's work on odonates at Lewis Pond. As reported by Miller (2001), MacDougall observed a rare and an uncommon "emerald," *Somatochlora cingulata* (S2) and *S. albicincta* (S3), at the pond. (MacDougall may also have recorded *Leucorhinnia glacialis* (S3) from the pond, but location information for this species was unclear in the report.) Andrews (2001) noted that a representative sampling site south of Lewis Pond, Lewis Pond Hill Southeast, was among the more productive sites for amphibian sampling, due to a combination of "moist upland deciduous habitat with seepage areas and nearby breeding...." One may extrapolate that the seepy Lewis Pond Basin may also provide good habitat for a number of salamander species.

According to the NNHP database, Lewis Pond is a known nesting site for common loon (*Gavia immer*) (G5/S2B). Rusty blackbird (*Euphagus carolinus*) (G5/S3B) is also known from the pond area.

Management Overview

The Lewis Pond Basin is a unique and significant natural community complex within the Nulhegan Basin. In its own right Lewis Pond, the largest pond in the project area, is a significant aquatic natural community. What happens in the basin, as well as on the pond itself, will influence the quality of the pond. The generally intact natural communities in the Lewis Pond Basin are in a matrix of regenerating hardwood and red spruce-hardwood clearcuts. To increase the conservation value of the site, regenerating stands should be permitted to re-grow and the area should be managed for high levels of ecological integrity. The Lewis Pond Basin is an area that connects mountain forests with the Nulhegan lowlands. It is also an unusually moist area with high potential for diverse assemblages of many taxa. No "through" roads separate the site from the mountains, but dead-end roads are present. On one of these, at the base of Lewis Mountain, is a large gravel pit.

Management recommendations:

- Close and re-vegetate the road on the east side of the pond, and "retire" the pit to allow for reconnection of the mountains with the Lewis Pond Basin. Because of the network of roads on the former Champion lands, and the access needs of Essex Timber Company, there may be few opportunities for unimpeded connectivity between mountain and basin landforms. This site presents a good opportunity to assess the value of such a connection,
- Efforts to maintain the quality of Lewis Pond itself should be made in concert with the Department of Environmental Conservation, Lakes and Ponds Program. The goal should be to maintain or increase the quality of the pond. A DEC "Lake Assessment Form" (August 2001) notes, "If the USFW's (sic) management of the watershed curbs the silty-periphyton phenomenon in this lake, it will uncover a very scenic sandy/rocky bottom."
- As the camp leases expire or are bought-out, remove all structures and debris, close the camp access roads, and allow Lewis Pond to return to its natural status as a "wilderness pond."

Stagnant-Ice Valley and Flats

This landform consists of low relief, mid-elevation terrain in West Mountain WMA. It includes the valley through which Paul Stream flows and the gently sloping land east of West Mountain. During glacial ablation, the area was surely a fascinating landscape of a downwasting glacier, ice blocks and thundering waters. Well-defined glacio-fluvial and glacio-lacustrine features include many pieces of eskers, bouldery kames and kame terraces, and littoral sands deposited in an ice-dammed pro-glacial lake. The general glacial deposit is similar to that in the Nulhegan Basin that we call coarse-loamy, cobbly (washed?) till.

The stagnant-ice landscape includes most of the ponds in the project area and many state-significant wetlands; both the ponds and broad wetlands likely lie in small, ice-block basins, the largest of which is the Ferdinand Bog basin. Narrower wetlands occur in stream valleys. The upland is largely red spruce-hardwood forest with lower pockets of lowland spruce-fir forest. Similar to the situation in the Nulhegan Basin, the tops of larger hills support sugar maple, and the concomitant northern hardwood forest natural communities.

Dennis Pond Basin

The Dennis Pond Basin, including Dennis Pond, Mud Pond and the adjacent wetlands, is an ecological treasure. The site is one of the most significant and interesting natural areas in Vermont. Extremely high-quality poor fen and the dystrophic ponds they surround are the largest natural communities in the complex. The site is known to support seven rare and five uncommon plant species (see below), one rare waterfowl species (pied-billed grebe *(Podilymbus podiceps)* (G5/S2B), two rare tiger beetle species *(Cicindela longilabris* (G5/S2), *C. purpurea* (G5/SU)), and three uncommon (S3) odonate species *(Gomphus adelphus, Ophiogomphus* cf. *mainensis, Somatochlora* cf. *elongata)* (Miller 2001). In addition, it functions as a communal breeding site for amphibians (Andrews 2001) and has high species diversity and brood production of waterfowl and marsh birds (relative to the rest of the study area and perhaps the entire biophysical region) (Longcore 2000). Lambert (2000) located, in addition to pied-billed grebe, the uncommon species American bittern *(Botaurus lentiginosus)* (G4/S3B) and rusty blackbird *(Euphagus carolinus)* (G5/S3B), and state-endangered osprey *(Pandion haliaetus)* (G5/S2B); it is probable that the osprey were foraging from their nest site on Mud Pond. Dennis Pond is also a diversity hotspot for butterflies and odonates, and the only known site in Essex County for New England buckmoth *(Hemileuca lucina)* (Miller 2001).

The wetland sits in a narrow basin on the periphery of which is lowland spruce-fir forest and, on steeply sloping bedrock, a high quality, but small, hemlock-red spruce forest. Throughout the wetland are small bits of lowland spruce-fir forest on esker fragments. Where an esker fragment meets the pond there is a peaty sand pondshore natural community, which is a type that is only known from a few places in Vermont, all in the Nulhegan/West Mountain landscape. The best known example is not on the former Champion lands, but is nearby on the shore of Nulhegan Pond.

Peatland covers 55 ha around Dennis Pond, with an additional five hectares associated with Mud Pond. Of this, poor fen accounts for 51 ha, dwarf shrub bog covers approximately one hectare, and peaty alder swamp occurs on eight hectares of the wetland.

Rare plants are a prominent feature in the poor fen. Although patchily distributed, bog sedge *(Carex exilis)* (G5/S2) is very common and in places even dominant. Bog aster *(Aster nemoralis)* (G5/S2) is well distributed throughout the fen community and is, in some areas, abundant. One-

flowered muhlenbergia *(Muhlenbergia uniflora)* (G5/S2?), a delicate grass of peatlands, sandy shores, and graminoid wetlands, occurs in several locations in the fen, but is particularly abundant along the pond shore. One of the rarest plants in Vermont, state-threatened northern yellow-eyed grass *(Xyris montana)* (G4/S1), grows in few locations on the pond shore and very wet spots within the poor fen; inventory in 2000 did not locate as many of the small groups of northern yellow-eyed grass as did a survey in 1989 and frequent monitoring of population size and distribution is recommended. Another state-threatened plant, pod-grass *(Scheuchzeria palustris* ssp. *americana)* (G5/S1), has been observed at both Mud Pond and Dennis Pond. The Mud Pond population, with at least 300 individuals, is the largest known from the project area, and probably the state as a whole. Observation of pod-grass from Dennis Pond dates back to 1981 and the accompanying information is scant; the species occurrence was not relocated in 2000 or 2001, despite diligent searching. Another rare plant, found only in the Mud Pond poor fen, is northern fir-clubmoss *(Huperzia selago)* (G5/S1). Near the clubmoss was a small population of northeastern sedge *(Carex cryptolepis)*(G4/S3). Shining rose *(Rosa nitida)* (G5/formerly SH, to be re-ranked S1), a shrub now known from a number of minerotrophic, peaty sites in the Northeast Highlands, occurs in scattered locations in the complex also, as does uncommon mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3).

Microtopography and hydrology, and in response to these the vegetation, vary on a very small scale within the Dennis and Mud pond wetlands. Several days of detailed field work would be necessary to differentiate and map the peatland natural communities to a more refined level than has presently been accomplished. For example, Sorenson (1989) lists the following natural communities in the complex: bog [now considered poor fen], sedge meadow, alder shrub swamp, forested swamp and shallow, peat-bottom, tannic-water pond with gravel/sand shores; he also mentions "water tracks," inlet areas, wet sphagnum lawn, and a low-shrub zone. Each of these types is distinguishable by physiography (including landscape position and microtopography), hydrology and vegetation; to map such detail from aerial photographs did not seem reliably accurate. Therefore, the natural community map lumps most of the variation within the type 'poor fen,' with some areas being predominantly shrubby, some areas sedge-dominated, and some areas mostly open sphagnum with scattered sedges and forbs.

Among the general dominant plants in the poor fen are leatherleaf, bog rosemary, the sedges *Carex trisperma, C. echinata, C. exilis,* and *C. utriculata,* small and large cranberries, a beak-rush *(Rhynchospora alba),* bog aster, Virginia cottongrass, and rhodora. The dominant mosses are *Sphagnum rubellum, S. papillosum,* and *S. fallax.* Worthy of mention are additional species uncommon in Vermont—Michaux sedge *(Carex michauxiana)* (G5/S3), tuberous grass-pink *(Calopogon tuberosus)* (G5/S3), and rose pogonia *(Pogonia ophioglossoides)* (G5/S3). The rare moss *Scorpidium scorpioides* (S1S2) is another significant addition to the rarities now known from the Dennis Pond wetlands.

Located between spruce-fir esker forest and lowland spruce-fir forest on the southwest periphery of the wetland is a hectare of dwarf shrub bog. The area was not visited during mapping in 2000, but was mapped as bog rather than poor fen because of its aerial photo signature. Landscape position—isolated from the large, open fen and away from stream or pond waters—also suggests that this section of peatland is less minerotrophic and more likely to be dwarf shrub bog than poor fen.

The Dennis Pond sandy shoreline is a very specialized, small natural community type, peaty sand pondshore, which is very rare in Vermont. Whereas most of the pondshore has peatland dominated by sedges *(Carex lasiocarpa, C. exilis, C. utriculata)* adjacent to open water, the stretch of sandy shoreline features areas of bare sand as well as areas of sandy peat. The plants

that grow there are rather scattered and tend to have tufted or prostrate growth forms. Species of the Dennis Pond sandy shore include sedges *(Carex lasiocarpa, C. exilis, C. michauxiana, C. flava)*, a rush *(Juncus canadensis)*, pipewort, long-leaved sundew, hooded bladderwort, bog club-moss, a beak-rush *(Rhynchospora fusca)*, a panic-grass *(Panicum* sp.), and the rare plants one-flowered muhlenbergia *(Muhlenbergia uniflora)* (G5/S2?), and state-threatened northern yellow-eyed grass *(Xyris montana)* (G5/S1).

Eight hectares of deep peat alder swamp occur at the Dennis Pond inlet and in smaller patches on the south side of the wetland. Speckled alder, one to three meters tall, creates a closed shrub canopy, beneath which is a sphagnum carpet with a low-diversity assortment of sedges and forbs.

Dennis Pond itself, at 13.4 ha, is in the medium size-class for ponds in the study area. It is a dystrophic pond with small and large, sedge islands, which are concentrated at the inlet and outlet. The islands are likely integral to the waterfowl habitat quality of the site. The only other similar habitat in the study area is Ferdinand Bog, which has a flowing stream with backwater sloughs projecting through sedge vegetation, but no broader, ponded area. One rare and two uncommon aquatic plants are known from the pond. The uncommon species are humped bladderwort *(Utricularia gibba)* (G5/S3) and hidden-fruited bladderwort *(Utricularia geminiscapa)* (G4G5/S3). The rare aquatic plant is low or Farwell's water-milfoil *(Myriophyllum humile, M. farwellii,* respectively), (both G5/S2); positive identification of the rare plant was not made because a small water-milfoil fragment that was observed during a 1990 inventory (by K. Enright and R. O'Connell) did not have any fruits, which are necessary for reliable species determination between these two closely related, diminutive milfoils. Mud Pond (2.25 ha) is also a dystrophic pond. It has apparently never been inventoried for aquatic macrophytes.

The wetland complex continues to the west of Mud Pond and its poor fen, where there is another poor fen within a mosaic of sweet gale shoreline swamp, northern white cedar swamp, the slack waters of Notch Pond Brook, and lowland spruce-fir forest on esker fragments. North of Mud Pond is an esker fragment that separates the peatland from Notch Pond Brook. The brook flows through mature cedar swamp and narrow stretches of deep, shady mixed northern floodplain forest that is similar to that natural community occurrence on the Upper North Branch in the Refuge. The remoteness, intactness, and tranquility of these forests are noteworthy.

At the west end of Mud Pond are two emergent white pine trees on the edge of the cedar swamp and black spruce swamp. One tree serves as a small great blue heron rookery, which had five active nests in 2001. Perched atop the other was an active osprey *(Pandion haliaetus)* (state-endangered, G5/S2B) nest.

Management Overview

As mentioned previously, the Dennis Pond-Mud Pond complex is one of the premier natural areas in Vermont. It truly is a "one-of-a-kind" gem. Furthermore, the site (or at least part of it) is, according to legally binding deed restrictions, a Special Treatment Area (STA)—a piece of land managed in perpetuity for highest levels of ecological integrity. Active management of the ecosystem must, therefore, be conducted with the intention of "advanc[ing] the goal of allowing the STA to function as an ecosystem with minimal intervention." Hence, management of the site must be held to the strictest standards of stewardship and conservation.

Owners of the Dennis Pond-Mud Pond complex include the State of Vermont, The Nature Conservancy (purchased in 2001) and private landowners, including Essex Timber Company. Most of the Dennis Pond portion is within the bounds of West Mountain WMA, but a northern slice is not; it was not part of the Champion landholdings. The Mud Pond system is now mostly

owned by The Nature Conservancy and Essex Timber. Portions of the complex that are still owned without easements should be the focus of conservation acquisitions to complete protection of the extremely valuable site.

Logging roads tightly border the wetlands, and snowmobile/ATV trails that cross the Dennis Pond fen receive light to moderate use. Several camps on the northern shore are on terrain somewhat above the pond basin.

Additional scientific study is suggested prior to developing detailed, well-informed management recommendations. Specific useful information includes the dynamics and hydrologic fluctuations of the ecosystem, including the history and future potential of beaver impacts, and autecological information on the rare species at the site. A more general and equally important concern is the negotiation of management agreements with Essex Timber, who holds title to parts of the wetland system and the adjacent uplands, if these have not previously been conducted.

Major past management impacts to the system include the following: snowmobile and ATV entry onto the peat mat, construction of gravel roads that fragment the wetland from the surrounding upland forests, construction of camps along the east shore, logging of lowland spruce-fir forest (including spruce-fir esker forest) within the complex, and probable alterations (temporary) to sediment loads after landscape-scale clearcutting.

Management recommendations:

- Make all efforts to curtail entry and travel of any vehicle in the peatland,
- Discourage pedestrian access onto the peat mat,
- Discourage boating of any sort in the ponds during the waterfowl breeding season,
- Study hydrology and ecosystem dynamics, including site-specific historical ecology and "near-surface" peat-core studies, and autecology of rare plants in order to understand management issues such as potential beaver inundation of parts of the wetland,
- Allow natural succession and natural disturbances, including natural stream hydrology, to direct vegetation change within the entire complex, except where rare species may be threatened,
- Close to vehicular traffic the gravel road west of the wetland and study the potential ecological tradeoffs of removing versus leaving the roadbed as is (e.g., erosion and sediment loading in the wetland, easier versus more difficult vehicular, boat and pedestrian access),
- Discuss closure/removal of road on east side of complex with private landowners, and
- Work toward acquiring fee-title to the portion of the complex that was not part of the Champion landholdings.

West Mountain Pond Basin

West Mountain Pond (23.7 ha) is the second largest water body on the WMA. The pond is fed by West Mountain Brook, the only mountain stream whose watershed is entirely within the public landholding. The brook tumbles down West Mountain and reaches level ground at the West Mountain Pond basin, where it first flows through 36 ha of northern white cedar swamp and black spruce swamp. An additional feature of the basin is a string of esker fragments that runs north-south through the swamp. Significant aspects of the site are the relatively old northern white cedar swamp, rare plants in and on the margins of the pond and smaller open and forested wetlands, including a small poor fen to the east of the pond. State-endangered osprey *(Pandion haliaetus)* (G5/S2B) have successfully fledged young from a nest at West Mountain Pond since

1997. Common loon *(Gavia immer)* (G5/S2B), also state-endangered, are also known to have nested in the pond.

No faunal species inventories were conducted in the area, but Engstrom did hear a gray treefrog *(Hyla crucifer)* calling. Andrews (2001) did not locate the species in the study area, but heard and saw gray treefrogs nearby along Route 102. Lambert (2001) found that the lowland conifer complex and the red spruce-hardwood forest had highest breeding bird diversity in the study area, including a number of conservation priority species. West Mountain Pond Basin is one of several patches of the lowland conifer complex in the WMA and is surrounded by red spruce-hardwood forest; therefore, one would expect that the site is significant for breeding birds.

The pond itself is a fine example of a dystrophic pond, characterized by tannic, shallow waters. Much of the western side is less than one meter deep, and the deepest water is shy of three meters. One rare plant, Farwell's milfoil *(Myriophyllum farwellii)* (G5/S2) is known from the pond, as is uncommon purple bladderwort *(Utricularia purpurea)* (G5/S3). A number of camps have been erected on the north and east shores.

Northern white cedar swamp is the largest natural community of the wetland system west of the pond. The swamp is predominantly the more minerotrophic type of cedar swamp, yet part is boreal acidic cedar swamp. Six hectares of the 36-ha-forested wetland are currently beaver-flooded. The cedar swamp is in excellent condition, with a 20-60 cm dbh overstory that includes 120-150 year-old trees. Forest structure is quite variable; in general the forest has a closed canopy with a well-developed understory and little for a shrub layer. Areas of incomplete canopy closure are common, however, especially where small stream channels and standing water make for an exceedingly wet substrate. One very wet, and likely more minerotrophic, part of the swamp is a shrubby red maple-northern white cedar natural community; that type of swamp rarely occurs in the study area, but does resemble natural communities located on the floodplain of the Clyde River. On the western margin of the swamp complex is a band of mixed northern seepage swamp, a natural community type that, as is the case here, is usually restricted to narrow seepage zones, often at the base of a slope or in a saddle. The patchy, open tree canopy is a mix of hardwood and conifer species, including northern white cedar, red spruce, balsam fir, black ash, and yellow birch. Because of the openness of the canopy, the shrub layer, comprised largely of speckled alder thickets, is moderately dense. Recent and previous beaver activity in the cedar swamp makes the site an excellent one for the study of the interactions of beaver inundation and cedar swamp vegetation and succession.

Sand lenses in the 1.5-m-deep sapric peat soil may indicate periodic flood events during which West Mountain Brook roared down the mountain and deposited layers of sediment throughout the swamp.

On the northwest shore of West Mountain Pond is a five-hectare black spruce swamp, with a very small area of black spruce woodland bog. On the shoreline in the swamp and bog is a population of bog aster *(Aster nemoralis)* (G5/S2S3), a rare plant of peatlands.

Lowland spruce-fir forest nearly encircles the pond; an eight-hectare patch at the southeast corner of the cedar swamp has been clearcut; additionally, a strip of cedar or spruce-fir-tamarack swamp adjacent on the west has been cut. In the wetland strip is a small population of invasive common reed *(Phragmites australis)*.

The pond-shore spruce-fir forest at West Mountain Pond is not as spectacular as in some of the steeper-sloped pond basins such as Wheeler and South America ponds. Nevertheless, the forest is

among the most intact bits of lowland conifer woods in the WMA. Relatively large diameter black spruce, hemlock, northern white cedar and yellow birch comprise the overstory, beneath which is, in some places, a thicket of spruce and fir regeneration and, in others, an abundance of mountain-holly. The bryophyte carpet of liverwort *(Bazzania trilobata)* and Schreber's moss *(Pleurozium schreberi)* is very characteristic of better-drained lowland spruce-fir forests. Bunchberry, twinflower, and others complete the boreal gestalt.

Three significant wetland areas very near to, but not hydrologically connected to, West Mountain Pond are herein described as part of the larger West Mountain Pond site. One consists of adjacent kettle wetlands, and the other two are linear basins with swamp forests.

East of the pond lie several small, high-quality wetland natural communities. The most striking of these is a classic kettle-hole with poor fen ringing a tiny, circular pond. An immature merganser and wood duck were observed resting among the yellow waterlily on the quiet water of the dystrophic pond. Sedges *(Carex limosa, Dulichium arundinaceum)* are the dominant vascular plants on the floating sphagnum *(Sphagnum girgensohnii, S. fallax)* mat. The species list is textbook for poor fens, including a beak-rush *(Rhynchospora alba),* Virginia cottongrass, bog-bean, the sedge *Carex pauciflora,* pitcher-plant, round-leaved sundew, large cranberry, leatherleaf, bog-rosemary, bog laurel and many more. There is a high probability of locating rare or uncommon species at such a site, but botanists in 1989 and 2000 did not discover any.

Surrounding the poor fen is a sphagnous, conifer swamp comprised of tamarack, black spruce and northern white cedar. Recent logging in the surrounding upland has crept into the edge of the swamp forest, where some of the larger trees have been harvested and skidder tracks scar the sphagnum. Nevertheless, the natural community is still very intact and two hectares of wetland forest have maintained the appearance of a remote, undisturbed pond-fen-swamp system. A second kettle hole to the north is completely forested, and has also been subjected to some selective logging in recent years. These swamp forest natural communities are mapped as spruce-fir-tamarack swamp, yet they have strong affinities with boreal acidic northern white cedar swamp. Distinguishing factors between the cedar-end of the spruce-fir-tamarack swamp spectrum and the tamarack-end of the boreal acidic cedar swamp spectrum are not yet clear. Neither physical factors nor successional patterns have been studied enough to clarify the distinction. At any rate, the little-disturbed kettle hole wetland-aquatic system is one of the most scenic spots in the WMA.

A wedge-shaped conifer patch south of West Mountain Pond consists of intact boreal acidic northern white cedar swamp, and partially clearcut spruce-fir-tamarack swamp and lowland spruce-fir forest. The two-hectare cedar swamp features deep (>120cm) peat, a carpet of sphagnum *(S. girgensohnii, S.* cf. *angustifolium),* and an overstory of 25-40 cm dbh black spruce, northern white cedar and balsam fir. Northwestward, toward the pond, is a clearcut wetland with shallow peat-over-rock soil. Although within meters of West Mountain Pond, the wetland is in a trapped drainage separated from the pond by a low ridge. No unusual species were located, but it is an unusual little ecosystem that somewhat resembles the "high flats" at the headwaters of Paul Stream and the base of West Mountain.

Six hundred meters east of West Mountain Pond is a linear lowland that drains into Paul Stream, upstream of West Mountain Brook. The lowland has a 200 m-wide band of very wet lowland spruce-fir forest surrounded by well drained lowland spruce-fir forest. The latter forest was clearcut and is presently covered with a doghair thicket of two to three meter spruce and fir. The wet area was not recently logged and has intact forest, estimated to be a 130-year-old stand.

Part of this linear lowland is considered a Natural Heritage Program element occurrence of Northern White Cedar Swamp (CP3B1B0000.001), but we have mapped the site as wet lowland spruce-fir forest. In the Northeast Highlands biophysical region and throughout parts of the eastern boreal forest, northern white cedar regularly occurs within the spruce-fir forest. Dry areas are clearly not "cedar swamp" and thus are easily classified as dry to mesic lowland spruce-fir forest. Medium- to deep-organic-soil areas dominated by cedar fall clearly within the boreal acidic northern white cedar swamp natural community. Between these two extremes, however, is a wide range of forest types with shallow to medium organic soils, or very wet mineral soils, and mixed conifer tree strata including black spruce, red spruce, balsam fir, tamarack and northern white cedar. This site sits within that intermediate range of physical and canopy conditions.

The parent material of the wet forest site is a "boulder train," a linear deposit of flat-topped boulders, cobbles, and sand. The boulder-tops are in and slightly above supersaturated soil. Trees are growing only atop the boulders, with some roots extending into the peat and water. The physical site description is not characteristic of the range of conditions typically encountered in cedar swamps, and therefore the natural community is mapped as a wet lowland spruce-fir forest. Dominant trees are black spruce (or hybrid red/black spruce), northern white cedar, white pine, balsam fir and tamarack. Diameters of the canopy generally range from 25 to 35 cm dbh. The ground is sphagnum-covered. Characteristic boreal shrubs are present, particularly in areas where cutting has occurred and light penetrates the dense canopy; common species are velvetleaf and early low blueberries, sheep laurel and mountain-holly. A sampling of part of the site in 1985 revealed ages of 78-116 years for northern white cedar.

The boulder-train cedar-spruce-pine-tamarack forest needs to be revisited and investigated more closely in the future. In the course of natural community mapping in 2000 it was cursorily visited, but it deserves to be documented more thoroughly.

Management Overview

The West Mountain Pond aquatic and wetland ecosystem is, according to legally binding deed restrictions, a Special Treatment Area (STA)—a piece of land managed in perpetuity for highest levels of ecological integrity. Active management of the ecosystem must, therefore, be conducted with the intention of "advanc[ing] the goal of allowing the STA to function as an ecosystem with minimal intervention."

Major past management impacts to the system include the following: construction of a gravel road that has disrupted the natural drainage to and within the cedar swamp system west of West Mountain Pond, gravel extraction from eskers north and south of cedar swamps, construction of camps along the shore of West Mountain Pond, and clearcutting of lowland spruce-fir forest southwest of the pond and surrounding red spruce-hardwood forest.

Management recommendations:

- Allow natural succession and natural disturbances, including natural stream hydrology, to direct vegetation change within the entire complex,
- Remove the gravel road north of the pond and swamp forests, and allow natural hydrology to redevelop,
- Eradicate *Phragmites* population known from clearcut area in southern tip of the cedar swamp system, and
- Grade the gravel pits to allow for more rapid re-vegetation.

Ferdinand Bog

Ferdinand Bog is the largest open wetland in West Mountain WMA and in all of the former Champion lands. More than just an open area of peatland (what we normally think of as a bog or poor fen), the Ferdinand Bog system also includes forested peatland, shrub swamp, alluvial shrubland, and floodplain forest, as well as a substantial amount of lowland spruce-fir forest. The complex includes many natural community types; it has the greatest natural community diversity of any similarly sized site in the project area. The extremely high natural community diversity is primarily related to the glacial geomorphology and hydrology of the site.

The Ferdinand Bog complex is located in a narrow, mid-elevation basin (approximately 450 m elevation) that was likely the site of large, stagnant ice blocks in the period of glacial retreat. The complex geomorphology developed as glacio-fluvial deposits were laid adjacent to the ice blocks, and the landscape further developed in response to a long post-glacial history of alluvial processes.

The surrounding uplands are largely northern hardwood forest, although narrow fringes and small patches in and around the lowland are red spruce-hardwood forest. Prominent peaks, which rise to 850-1030 m, feature montane spruce-fir forest at the higher elevations.

Paul Stream flows through the wetland and is a primary factor in the natural community composition of the Ferdinand Bog system, especially the upstream portion. Upstream from the open peatland is a very interesting alluvial and backswamp system of alluvial shrubland, and floodplain forest, woodland and meadow, in association with forested peatlands (northern white cedar swamps, spruce-fir-tamarack swamps and black spruce swamps). It is a natural floodplain and swamp system with few current human impacts, and, apparently, little residual impact from any previous perturbations associated with logging (specifically damming and tree harvest). The residual impacts of such activities on the open peatland itself, however, are currently unknown; a major research effort would be required to determine ways in which past human activities in and around Ferdinand Bog have shaped the current vegetation of the open peatland.

One rare and one uncommon odonate species were observed at the site, *Calopteryx amata* (S2) and *Lestes congener* (S3) respectively, and Ferdinand Bog was found to be one of the highest diversity sites for both odonates and butterflies (Miller 2001). Bird species of state conservation interest that were observed were pied-billed grebe *(Podilymbus podiceps)* (G5/S2B) (Lambert 2000) and American bittern *(Botaurus lentiginosus)* (G4/S3B). Ferdinand Bog is one of several sizable blocks of lowland conifer and red spruce-hardwood forest in the WMA, and therefore likely functions as important breeding habitat for the diversity of birds that Lambert (2000) notes depend on such natural communities and complexes. Andrews (2001) found the site to be within the mid-range of amphibian diversity. The mix of alluvial, marsh and open water natural communities north of the open bog may prove to be more important sites for herps and reptiles. Mink frog *(Rana septentrionalis)* presence in Ferdinand Bog is worthy of mention. While not a rare or uncommon species, this amphibian has a more northerly distribution and Andrews (2001) notes, "It has the most limited Vermont distribution of any species of herptile found at this site. The study site is the center of Vermont's range for this species and I could see this species being the amphibian flagship species for this site." It was observed in West Mountain WMA, Wenlock WMA and the Conte Refuge; Ferdinand Bog is the only known location of mink frog in West Mountain WMA.

The open "bog" is an unusual type of peatland that apparently has no correlates in Vermont. The peatland is to some extent minerotrophic and aerated; that is, oxygenated, somewhat nutrient-

enriched water, from stream inflows, subsurface flows and groundwater, allows for the growth of plant species that do not persist in very low-nutrient and anaerobic soils. Examples of such species are northern white cedar, sweet gale, shining rose, alder-leaved buckthorn, royal fern and a sedge *(Carex vesicaria)*. Because of the level of nutrients and oxygen in the soils (plural as there may be several soil types within the peatland), Ferdinand Bog should more accurately be called a fen. Most of the open peatland, however, does not fit the descriptions of fen types recognized in Vermont (see Thompson and Sorenson 2000), nor does it fit well the descriptions of other related peat-soil natural communities such as Sweet Gale Shoreline Swamp, although that is the most similar natural community type. The bulk of the open peatland has, therefore, been called Sweet Gale-Northern White cedar Poor Fen (refer to proposed natural community variant description in Chapter 2). The natural community may occur only in the Ferdinand Bog system, has not been studied in detail, and has not been analyzed in relation to similar natural community types in the state or regionally. Sweet Gale-Northern White Cedar Poor Fen, therefore, is broadly construed and ranges in physiognomy from shrub-graminoid to woodland.

Rare and uncommon plant species known to live in the natural community are shining rose *(Rosa nitida)* (G5/formerly SH, to be re-ranked S1) and mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3), which are both very common, and Michaux sedge *(Carex michauxiana)* (G5/S3), which is more patchily distributed.

Poor fen that is more typical of those found statewide is located in several smaller areas on the periphery of the sweet gale-northern white cedar poor fen. These natural communities are significant for the presence of an uncommon sedge, *Carex cryptolepis* (G4/S3), and an unverified rare cotton-grass, rough cotton-grass *(Eriophorum tenellum)* (G5/SU). Also, the uncommon sedge *Carex michauxiana* is more common in at least two poor fen communities than in the sweet gale-northern white cedar poor fen.

Forested swamp in the southeast portion of Ferdinand Bog is of very high quality. Mature boreal acidic northern white cedar swamp that includes trees over 150 years old highlights the swamp forests. Over one-half of the boreal acidic northern white cedar swamp is in very good condition; the community has been bisected by a gravel road and the portion to the south is less spectacular, but still of high quality.

At the south end of the cedar swamp is an undisturbed black spruce woodland bog. No rare or uncommon plant species were found in either the cedar swamp or the woodland bog; these areas, however, were visited late in the growing season and species of conservation interest may have not been evident at that time.

West of the boreal acidic cedar swamp are intact black spruce swamp and northern white cedar swamp natural communities. On the south end, these forested swamps are nearly surrounded by lowland spruce-fir forest that has been clearcut. When the spruce-fir canopy re-establishes and natural thinning of the regeneration occurs, the entire south area of Ferdinand Bog will constitute an excellent piece of northern coniferous lowland and swamp forest. If dispersal to the area is possible, state-endangered spruce grouse *(Dendragapus canadensis)* are likely to find appropriate habitat conditions in the lowland conifer forest mosaic of Ferdinand Bog, based on Fritz (1979, cited in Alexander and Chipman 1993) information that patch size of suitable habitat should be at least 100 ha.

The portion of the Ferdinand Bog wetland system upstream from the open wetland is a very high-quality mosaic of mixed northern floodplain forest, alder-cedar floodplain woodland, alluvial shrubland/woodland, northern white cedar swamp, and beaver ponds and meadows. Each of these

types has its own distinctive combination of soil, hydrology and vegetation. Alder-cedar floodplain woodland and mixed northern floodplain forest are both natural community types described for the first time in Vermont from the Ferdinand Bog system (see descriptions of proposed natural community types and variants in Chapter 2). The former may be a type unique to the upper Paul Stream floodplain; the latter, or variations of it, surely was more widespread prior to clearing of land in all of the major river valleys. The only rare or uncommon plant currently known from any of these riparian natural communities is a grass, Wiegand's wild-rye *(Elymus wiegandii)* (G?/S3).

The upper Paul Stream riparian ecosystem above the Ferdinand Bog complex is also significant. Highlights of this part of the site are the extensive chain of alder swamps, beaver meadows and ponds, and very high-quality boreal acidic cedar swamps. A relatively large, minerotrophic cedar swamp along one of the branches of Paul Stream has both been impacted by beaver and logged, whereas the boreal acidic swamps adjacent are intact. At least one of the swamps is a site of the uncommon shrub, mountain fly-honeysuckle *(Lonicera caerulea var. villosa)* (G5/S3). The stream tributary that flows through the minerotrophic cedar swamp is a site of the uncommon and showy semi-aquatic moss, *Fontinalis antipyretica.*

Management Overview
The Ferdinand Bog wetland-lowland ecosystem is, according to legally binding deed restrictions, a Special Treatment Area (STA)—a piece of land managed in perpetuity for highest levels of ecological integrity. Active management of the ecosystem must, therefore, be conducted with the intention of "advanc[ing] the goal of allowing the STA to function as an ecosystem with minimal intervention."

Major past management impacts to the system include the following: construction of gravel roads that fragment the complex in several areas (the most severe of which is probably the road that crosses south of the open peatland), undocumented (but probable) temporary artificial impoundment of portions of the wetlands for log-drives, clearcutting of lowland spruce-fir forest, and gravel extraction from an esker south of the open peatland.

Management recommendations:

- Allow natural succession and natural disturbances to direct vegetation change within the entire complex,
- Remove the gravel road (to its terminus on the east side of the wetland) and wooden bridge that cross at the south end of the open wetland and allow re-vegetation of the roadbed,
- Remove the gravel road that crosses Paul Stream north of the open wetland and runs adjacent to the east side,
- Remove the main gravel road that runs adjacent to the west side of the complex, at a minimum from near South America Pond to Madison Brook,
- Grade the gravel pit to allow for more rapid re-vegetation, and
- Consider spruce grouse (re-)introduction, when vegetation structure is appropriate.

Wheeler Ponds Basin

The aquatic, palustrine and riverine site comprised of Wheeler Stream, Wheeler and Little Wheeler ponds, and associated wetlands is highly significant because of its rare plants and intact rare, uncommon and common natural communities. The area is another of the coniferous lowland and open wetland systems of West Mountain WMA. Significant natural communities within the site are intermediate fen, sweet gale shoreline swamp, peaty sand pondshore, black spruce

swamp, alder swamp, beaver meadow, spruce-fir-tamarack swamp, and dystrophic pond. A private landowner has a 50-ha inholding on the west side of Wheeler Pond.

Little Wheeler Pond (2.89 ha) is the smallest body of water in West Mountain WMA (Mud Pond is slightly smaller but is not currently part of the WMA) but it has high ecological and botanical significance. The open wetland on the pond's southern and western shores is comprised of two high-quality natural communities, sweet gale shoreline swamp and intermediate fen. The fen is the only known site in Vermont of Pickering's reed-grass *(Calamagrostis pickeringii)* (G4/formerly SH, to be re-ranked S1).

On the northwest shore, amongst a mosaic of intermediate fen and sweet gale shoreline swamp is a tiny area of peaty sand pondshore. Newly described as a result of this inventory, this very rare natural community type appears to be restricted to the Northeast Highlands biophysical region. In 2001, a very small population of state-threatened northern yellow-eyed-grass *(Xyris montana)* (G4/S1) was discovered growing in the pondshore community. A small population of shore sedge *(Carex lenticularis)* (G5/S2S3) also was observed, both on the peaty sand pondshore and near the pond outlet.

Intermediate fen is a rare (S2) natural community in Vermont, and, although small, the Little Wheeler Pond fen is an intact, well-buffered example. In fact, only two intermediate fens were located on the former Champion lands, where the most common open peatland types are poor fen and black spruce woodland bog. The intermediate fen is the site of Pickering's reed-grass, as well as bog-rush *(Cladium mariscoides)* (G5/S2S3), a rare plant of open peatlands, Michaux sedge *(Carex michauxiana)* (G5/S3), and hidden-fruited bladderwort *(Utricularia geminiscapa)* (G4G5/S3).

Sweet gale shoreline swamp occurs rarely on the former Champion lands, and the one at the inlet of Little Wheeler Pond is of high quality. The swamp at the (Big) Wheeler Pond inlet is slightly larger, but is partially flooded and less characteristic of the type. Rare shining rose *(Rosa nitida)* (G5/formerly SH, to be re-ranked as S1) grows at the site.

Little Wheeler Pond is a dystrophic pond. Uncommon purple bladderwort *(Utricularia purpurea)* (G5/S3) occurs in the open water and/or perhaps in the fen and sweet gale swamp; no further information is available and the species (located in 1982) was not noticed in 2000-2001, but is most probably extant. An otter was seen entering the pond from the west and then swimming about. There are three camps at the north end; one is set back approximately 75 meters from the pond. An abandoned, decaying, wooden rowboat lies, at the north end of the intermediate fen, near the peaty sand pondshore.

Of local significance is a granitic outcrop perched above the northwest side of Little Wheeler Pond. While too small to be of state-significance, this temperate acidic outcrop is the only example of the natural community type in the study area and is in excellent condition. The open rock outcrop also stands out as one of the very few naturally open upland communities in the general region.

The portion of Wheeler Stream that flows from Wheeler to Little Wheeler pond is a short, steep, spectacular stretch of babbling brook. Large boulders form a steep, south rim of Little Wheeler Pond, and the fast-flowing stream features a nice pool-riffle complex. It may, therefore, be a distinct (and uncommon in the WMA, but more common on the upper branches of the Nulhegan) aquatic ecosystem of significance to amphibian, fish and stream invertebrate species.

Wheeler Pond (27.93 ha) is the largest body of water in West Mountain WMA. The pond is an excellent example of a dystrophic lake—in fact it is listed as one of the best examples of the type by the Aquatic Classification Workgroup (1998). Three rare plants, one of which is of regional concern and is protected as state-threatened, and one uncommon species are known from the pond. These are state-threatened Northeastern bladderwort *(Utricularia resupinata)* (G4/STS1), slender naiad *(Najas gracillima)* (G5/S1), Farwell's milfoil *(Myriophyllum farwellii)* (G5/S2), and purple bladderwort *(Utricularia purpurea)* (G5/S3). The dominant aquatic vascular plants include pipewort, white water-lily, water-shield, spike-rush *(Eleocharis* sp.), delicate milfoil *(Myriophyllum tenellum),* and water-lobelia *(Lobelia dortmanna).* Water fills nearly the entire basin and, thus, there are no adjacent forested wetlands. There are, however, small open wetlands in the pond basin.

Sweet gale shoreline swamp is located at both the inlet and the outlet of Wheeler Pond. Neither of these swamps is a particularly high quality example; this is probably due to elevated water level wrought by the construction of a gravel road and stream crossing, with fill and bridge, at the outlet. Natural Heritage Program files suggest that this road was relatively new at the time of Sorenson's 1989 survey. The natural community type is uncommon (S3) in Vermont and most occurrences are in the northeastern part of the state. The sweet gale shoreline swamp at the north end of Wheeler Pond currently exists as islands of vegetation in a matrix of open water. Year-round inundation of the swamp has resulted in a fragmented shrub swamp with emergent islands dominated by a sedge very characteristic of the natural community *(Carex lasiocarpa)*, royal fern, meadowsweet, sweet gale and speckled alder. Restoration of the natural hydrology is likely to improve the integrity of the sweet gale shoreline swamp

Sweet gale shoreline swamp at the inlet (south end of pond) is larger and somewhat more intact than that at the outlet. The northern section of open wetland is mapped as shallow emergent marsh. The area was likely sweet gale swamp in which elevated water level has led to dominance by tussock sedge, bluejoint grass and royal fern. Associate plants such as sweet gale, leatherleaf, northern white cedar, tamarack and marsh St. John's-wort indicate a close relationship between the sedge- and grass-dominated marsh and the shrub-dominated sweet gale community adjacent on the south. Vegetation of the sweet gale swamp is more-or-less typical of the type; dominants include sweet gale, speckled alder, meadowsweet, leatherleaf, wild-raisin, sedges *(Carex utriculata, C. lasiocarpa, C. stricta),* and bluejoint grass. Marsh cinquefoil occurs in the swamp but is apparently rare in the study area; it was very surprising that the species, which is not uncommon in several types of wet, peaty, open wetlands throughout the state, was not observed more often.

Wheeler Stream is fascinating if not only for the way it wraps entirely around a two-kilometer-long esker. The upstream half flows south, the downstream half flows north, and the two sections are only 50-100 m apart, with the narrow esker separating them. Not only are the flows in opposite directions, but also the character of the stream sections strongly contrast. The upstream half is beaver-dammed nearly its full length, whereas the downstream half is a free-flowing stream, much of which features a stony bottom and is well shaded by the streamside forest.

The upstream portion of Wheeler Stream is a fine example of a naturally functioning "beaver brook." Currently no ponds are part of the complex, which, rather, features stream waters flowing through alder swamps and shallow emergent marsh ("beaver meadows"). The meadows are variously dominated by different grasses and sedges—a function of depth of water table and meadow age. A very wet area adjacent to water often features the grass *Glyceria canadensis,* sedges *(Dulichium arundinaceum, Carex vesicaria)* and swamp candles, whereas back from the water, slightly higher and drier, the sedge *Carex vesicaria*, wool-grass *(Scirpus cyperinus)* and

swamp candles may dominate. A drier, older meadow is often characterized by co-dominance of bluejoint grass and *Carex vesicaria;* the low shrubs speckled alder, meadowsweet and sweet gale are typically scattered. The shrub swamp portion of the beaver and stream wetlands includes both areas that have succeeded to shrubs from meadow and undammed, slow-water parts where alders grow in the shallows. Depending on water depth, the herbaceous flora of the alder swamps can vary widely. Deeper water swamps have alders and ferns on mounds. Well-developed shrub vegetation on drier sites can have a diverse flora that includes royal and sensitive ferns, tall meadow-rue, northern water-horehound, small bedstraw, a variety of sedges, and the shrubs leatherleaf, sweet gale and winterberry. Alder swamps that have recently succeeded from meadow often feature an herb layer heavily dominated by bluejoint grass. Where alder swamps are adjacent to coniferous swamps, it is common to see scattered black spruce trees. Mountain fly-honeysuckle *(Lonicera caerulea* var. *villosa)* (G5/S3) is occasional along the edges of the shrub swamps and beaver meadows.

The esker fragment features one of the older stands of lowland spruce-fir forest on the public landholdings. It appears to be an even-aged, or perhaps two-aged, stand, and red spruce is dominant. The dominant trees measure 30-40 cm dbh, whereas subdominant trees in the overstory and subcanopy are typically 15-30 cm dbh. A cored 40.5 cm-dbh red spruce was 75-80 years old. Associate trees on the esker are black spruce, hemlock, and white pine, while red maple, paper birch and northern white cedar are less abundant. A dense layer of 50 cm-tall regeneration consists of balsam fir, red spruce and hemlock. Velvetleaf blueberry and early low blueberry are common shrubs; less common are sheep-laurel wild-raisin, mountain-holly and the small tree, mountain-ash. The most common herbs are bunchberry (dominant), wild sarsaparilla, goldthread, bluebead lily, wintergreen, creeping snowberry, twinflower, bracken and trailing arbutus. Schreber's moss, windswept moss and the liverwort *Bazzania trilobata* grow as a discontinuous ground carpet. Because this particular natural community is spruce-fir forest on a somewhat excessively to excessively drained esker, it should not be seen as typical of lowland spruce-fir natural communities throughout the WMA and Refuge. It is most similar to other spruce-fir communities on glacio-fluvial deposits.

Another high-quality lowland spruce-fir natural community borders Wheeler Pond on the east. There, the steep lakeside slope was spared from recent logging and displays a nice bit of older forest. As with the esker forest, this natural community occurs on a very spatially restricted landform that is not representative of the broader landscape, and, thus, this intact natural community should not be considered to represent an older forest typical of the broader landscape. The lakeside slope is composed of well to somewhat excessively drained fine sand and loamy fine sand, with bedrock outcrops. Hence, drainage and texture of the soil are similar to that of the esker, and the forest composition is also. White pine, red spruce, hemlock, paper birch, bigtooth aspen and scattered northern white cedar comprise the overstory; 50-60 cm-dbh white pine tower over the other trees. The shrub and herb flora resemble that described above. Three species not often seen during the study were noted—pipsissewa, spotted coral-root, and rounded shinleaf.

East of the bend in Wheeler Stream is a high-quality forested wetland consisting of both spruce-fir-tamarack swamp and black spruce swamp. The spruce-fir-tamarack swamp has a closed canopy of black spruce and balsam fir; cinnamon fern dominates the herb layer and the associate species include a sedge *(Carex trisperma),* twinflower and dwarf raspberry. Of note is the presence of "lung lichen" *(Lobaria pulmonaria)* on red maple trunks; the large lichen is apparently uncommon in Vermont and is seen most often on the trunks of maples and ashes in moist, older forests.

The black spruce swamp forest occurs adjacent to Wheeler Stream, embedded in a matrix of spruce-fir-tamarack swamp. Black spruce swamp is distinguished by several characteristics including a more open canopy consisting entirely, or nearly so, of black spruce; an abundance of ericaceous shrubs such as Labrador tea, sheep- and bog-laurels, and rhodora; and a group of herbs that are also present in open bogs. Among the herbs are sedges *(Carex paupercula, C. pauciflora),* pitcher-plant and three-leaved false Solomon's-seal. In both of the swamp types, a carpet of sphagnum *(Sphagnum* spp.) mosses is common.

A single gray jay *(Perisoreus canadensis)* (G5/S1S2B) was observed in the forested swamps in late July, presumably after the breeding season. Adjacent to the coniferous swamps is 60 ha of lowland spruce-fir forest, 80% of which has been recently clearcut. In fact, the whole Wheeler Stream lowland includes over 120 ha of lowland and wetland coniferous forest. As the forests regenerate from the recent clearcuts, this sizeable chunk of lowland conifer habitat will likely gain in importance for boreal forest animals.

Management Overview

The integrity of the aquatic and wetland ecosystems is very good, and the presence of numerous rare plants confers extremely high conservation importance on the Wheeler and Little Wheeler Pond lowland-wetland-aquatic system. Management should be designed to protect and enhance the ecological values to the highest level possible.

Major past management impacts to the system include the following: construction of a gravel road that has disrupted the natural drainage between Wheeler and Little Wheeler ponds and has apparently diminished the integrity of sweet gale shoreline swamps in Wheeler Pond, clearcutting of lowland spruce-fir forest and spruce-fir-tamarack swamp, gravel extraction from areas east and west of Wheeler Pond outlet and south of Wheeler Stream, construction of camps along the shores of both ponds and at the bend in Wheeler Stream, rowboat abandonment in the Little Wheeler Pond intermediate fen, and dumping of garbage (primarily bottles and cans) on the bank of Wheeler Stream by the camp at the bend.

Management recommendations:

- Allow natural succession and natural disturbances, including natural stream hydrology, to direct vegetation change within the entire complex,
- Remove the gravel road and stream crossing between the two ponds and allow natural stream hydrology to redevelop; allow the roadbed to re-vegetate,
- Remove the roads on the west side of the site (one from the north and one from the south) and allow the roadbeds to re-vegetate,
- Clean up all waste associated with the camps,
- Negotiate management agreement with private landowner on west side of Wheeler Pond, and
- Grade the gravel pits to allow for more rapid re-vegetation.

Chapter 4. Representative Sampling Sites

Purpose

In order to stratify inventory of fauna (amphibians, reptiles, birds, small mammals, odonates and diurnal lepidoptera) by natural community type, sampling sites representative of both common and large, extraordinary upland and wetland natural community types were chosen prior to the 2000 field season. Six upland and six wetland sites were selected to be the natural-community sampling framework for animal inventory (Table 5). Most of the animal biologists sampled all 12 representative sites. An additional 24 wetland and five upland sites were listed as optional inventory sites.

Methodology

Topographic map and aerial photograph interpretation, in conjunction with existing written information, were used to select representative sites. The sites were chosen to represent intact examples of spatially dominant natural communities. Existing information about wetland, especially peatland, natural communities was substantial (Thompson 1989, Sorenson and Thompson 1989), but there was a severe lack of information about upland natural communities before the 2000 field season. Because of a very short time period for the selection and finalization of representative sites, wetland representative sampling sites were selected without the benefit of field checks; we depended on existing reports and our aerial photo interpretation. Upland representative sampling sites, however, were pre-selected by aerial photo interpretation, but a final selection of sites was not made before field checks in early May 2000.

The basic criteria for selecting sites were 1) representation of the spatially dominant wetland and upland natural community types, and 2) highest available level of ecological integrity for a given natural community type in the study area. Several of the wetland natural communities selected as representative sampling sites do not cover large areas on the land, but they are of special importance as major contributors of natural openings in the forest matrix.

Representative sampling site boundaries were not delineated on the ground. Instead, site maps were made by drawing approximate boundaries on topographic maps. Copies of these maps, along with verbal descriptions of the vegetation, physiography, and access were distributed. In the field, access points and easiest routes were flagged. If confused about location, animal biologists consulted with the project ecologists.

The judgment and experience of the field researchers was relied upon to the extent that it was assumed they knew when they had wandered into a distinctively different natural community. For the wetland sites, clear wetland and vegetation-structure (physiognomy) boundaries were likely interpreted with high accuracy by the biologists. In addition, many of the upland sites were clearly bounded by young, cutover vegetation, so that crossing over into an adjacent natural community was unlikely. The accuracy of representative natural community sampling efforts by animal biologists can be assessed using the GIS themes that each biologist submitted.

Permanent natural community sampling plots were established in the twelve representative sampling sites. Sampling methodology followed "Quantitative Community Characterization" techniques developed by The Nature Conservancy Eastern Regional Office and modified by the

Table 5.
Representative Sampling Sites, West Mtn. WMA and Nulhegan Basin Division-Conte NFWR

Natural Community Type*	Site Name	Initial Natural Community Type^	Management Unit
Black Spruce Swamp	Big Swamp	Black Spruce Swamp	Conte Refuge
Black Spruce Bog	Mollie Beattie Bog	Black Spruce Bog/Dwarf Shrub Bog	Conte Refuge
Sweet Gale-Cedar Poor Fen	Ferdinand Bog	Dwarf Shrub Bog/Poor Fen/Intermediate Fen	West Mtn. WMA
Poor Fen	Dennis Pond Wetlands	Dwarf Shrub Bog/Poor Fen/Intermediate Fen	West Mtn. WMA
Alluvial Shrubland & Alluvial Grassland/Meadow	North Notch Swamp	Alluvial Shrub Swamp & Alluvial Graminoid Meadows	Conte Refuge and Wenlock WMA
Beaver Meadow, Alder Swamp & Deep Peat Alder Swamp	Upper Yellow Branch Open Wetland Complex	Beaver Meadow/Sedge Meadow/Marsh	Conte Refuge
Northern Hardwood Forest & Sugar Maple-White Ash-Jack-in-the-Pulpit Northern Hardwood Forest	Lewis Pond Southeast Hill	Northern Hardwood Forest	Conte Refuge
Northern Hardwood Forest	Maidstone Lake Hills West	Northern Hardwood Forest	West Mtn. WMA
Lowland Spruce-Fir-Red Maple-(Aspen) Forest	North Branch Hill East	Red Spruce-Northern Hardwood Forest	Conte Refuge
Red Spruce-Hardwood Forest, Well Drained Sands	Paul Stream Lower Slope West	Red Spruce-Northern Hardwood Forest	West Mtn. WMA
Lowland Spruce-Fir Forest	Lower Yellow Branch Spruce-Fir Flats	Lowland Spruce-Fir Forest	Conte Refuge
Montane Yellow Birch-Red Spruce Forest & Montane Spruce-Fir Forest	West Mountain Ridgeline	Montane Yellow Birch-Red Spruce Forest	West Mtn. WMA

* Natural community type(s) actually mapped at the site.
^ Natural community type(s) estimated in preseason.

Vermont Nongame and Natural Heritage Program. An additional modification by the project ecologists was to sample herbaceous and low shrub vegetation in 1x1 m subplots. Size of the full plots varied according to natural community type and TNC sampling recommendations, but all forest plots were 0.1 ha (20 x 50 m). Plot data are housed with the Nongame and Natural Heritage Program, Vermont Department of Fish and Wildlife, Waterbury, Vermont. Project ecologists will retain copies of the original field forms Plot location data were collected using Trimble Geoexplorer 3 GPS receivers. Locations are in the "plot_locations_merge1" shape file.

Representative Wetland Natural Community Sampling Sites

Six wetland natural community types, or complexes of spatially and vegetatively closely related types, were denoted as representative sampling sites (Table 5). Because these sites were found to be highly significant natural areas, they are described in some detail above in the section entitled "Descriptions of Landforms and State-Significant Sites," in Chapter 3.

The extensive acreage of black spruce swamp was known to be one of the most interesting features of the Nulhegan Basin, and the largest and most intact example, Big Swamp, was selected as a representative sampling site. Black spruce woodland bogs are common throughout the basin, and the largest of these, Mollie Beattie Bog (aka Western Bog) was selected to represent the natural community type. The West Mountain WMA has two well known large peatlands, both of which are more minerotrophic than the open peatland natural community type common in the Nulhegan Basin; thus, both Ferdinand Bog and Dennis Pond Wetlands were selected as representative sampling sites. They are two different types of poor fen natural communities, and both are systems that are unique in Vermont. To represent floodplain systems, both alluvial shrublands and alluvial meadows, a 2.5 km length of the extensive floodplain along the mainstem of the Nulhegan River and the lower portion of the North Branch was chosen; the site was named North Notch Shrub Swamp to indicate its geographic location north of Notch Pond Mountain. *(N.B. In the significant-site descriptions, the North Notch Shrub Swamp is named the Nulhegan Floodplain.)* Beaver complexes contribute substantially to the vegetative heterogeneity of the study area; they are likely the most common type of natural openings in the landscape. A large beaver meadow complex along the Yellow Branch of the Nulhegan River was selected as representative; it was named Upper Yellow Branch Open Wetland Complex.

Two other types of wetland natural community types were listed as optional sampling sites. Sweet gale shoreline swamp occurs in small areas adjacent to ponds and slow moving streams in the Northeast Highlands. The example at the inlet to Wheeler Pond was recommended for sampling. Subsequent fieldwork showed that the example at Little Wheeler Pond is of higher quality. Deep broadleaf marsh was preliminarily thought to occur in Tuttle and Dennis ponds, and is thus was listed initially as a sampling option. Neither location has a good representation of the natural community type. Tuttle Pond was visited only by the project ecologists, and Dennis Pond was sampled as part of the Dennis Pond Wetlands system. These deepwater marshes are very small and are not good representatives of the natural community type as it exists throughout the state.

Representative Upland Natural Community Sampling Sites

Locating high-quality upland sampling sites that were representative of the general landscape was much more challenging than selecting sites in the wetlands. Timber harvest has severely altered the vegetation of the forests, and most low- and mid-elevation natural communities have been

logged heavily within the past 20 years. Nevertheless, some reasonably intact northern hardwood sites were located, and some acceptable mixed forest and conifer forest fragments were chosen.

Two northern hardwood forest sites that had less human disturbance and better than average forest structure were selected. Lewis Pond Hill Southeast is on the moderately to steeply sloping east-face of a 620-m hill. The site is one of the richer northern hardwood forests in the study area. Although it is not "rich enough" to be classified as rich northern hardwood forest, it is fertile enough to be classified as sugar maple-white ash-jack-in-the-pulpit northern hardwood forest variant. Bedrock at the site is Gile Mountain formation quartzite-phyllite-schist, a slightly carbonate-rich rock. The bedrock in the Lewis Pond area appears to have a higher concentration of carbonates than the Gile Mountain rocks have in other parts of the WMA and Refuge. Maidstone Lake Hills West features a northern hardwood forest on the steep, ledgy west slope of a 545 m hill. In contrast to Lewis Pond hill, this forest is on granite of the Maidstone Pluton. There is a patchy, but substantial component of hemlock in the hardwood-dominated canopy. Two additional northern hardwood forest natural communities were suggested as optional. Both are near Lewis Pond Hill Southeast and are within the same geologic type; they are not, however, as steep and they extend over a range of aspects.

Red spruce-hardwood forest occurs on a substantial portion of the landscape. Two representative sampling sites were selected that are physiographically very different. After a season of fieldwork, we believe that one of the sites, North Branch Hill East, is more likely a successional phase of a lowland spruce-fir forest. The site, located in the southwest corner of the Refuge, currently supports a mixed canopy of red maple, yellow birch, quaking aspen, and spruce and fir; it has been mapped as lowland spruce-fir forest: red maple-aspen variant (3c). The site has a shallow, moist, rocky soil on a very gently sloping hill, 380 to 395 m elevation. The other red spruce-hardwood forest representative site, Paul Stream Lower Slope West, is on a sandy glacio-fluvial or glacio-lacustrine deposit adjacent to the Paul Stream valley. The deep soil is a strongly acidic, very bright spodosol. The dominant trees are yellow birch and red maple, and, in the sapling layer, red spruce; sugar maple is rare. Elevation of the sandy slope ranges from 365 to 385 m. An optional site, Riverbend Kame, is another mixed forest that may in fact be a successional phase of lowland spruce-fir forest. Neither of these red spruce-hardwood forest sampling sites is actually representative of the natural community type as it occurs over large areas of the landscape; the heavy logging and lack of field knowledge at the time when sites had to be chosen accounts for these less-than-optimum choices. The best choice would have been Stevens Brook Knoll, a more mature red spruce-hardwood forest with more typical physical landscape characteristics; that area is described as a state-significant site in Chapter 3.

Lowland spruce-fir forest is the predominant natural community in the Nulhegan Basin, but high-quality examples in the Refuge are few. Lower Yellow Branch Spruce-Fir Flats is one of the largest remaining fragments. The site is a mix of the wet-mesic and well-drained spruce-fir forest, with cedar swamps in the lowest pockets. Black spruce and balsam fir are the strongly dominant canopy species. Narrow strip cuts oriented east-west have made inroads in parts of the representative site. An optional sampling site for lowland spruce-fir forest, Lower North Branch Spruce-Fir, is located adjacent to the North Branch Hill East sampling site. The Lower North Branch site is on a west-facing slope east of the North Branch itself. It is a well-drained forest dominated by balsam fir, with lesser amounts of black spruce. Patches of recent blowdown occur within this forest that has seen a small amount of recent logging.

High-elevation natural communities are uncommon on the WMA and Refuge. The most extensive high-elevation area is the summit and ridge of West Mountain, where the West Mountain Ridgeline representative sampling site is located. The site includes both montane

yellow birch-red spruce forest and montane spruce-fir forest. There is little purely red spruce-balsam fir forest; most of the ridgeline is co-dominated by paper birch and red spruce, with yellow birch intermixed. The ridgeline and summit natural communities, 760 to 830 m elevation, really straddle the line between the montane spruce-fir and montane birch-spruce-fir natural communities, with a blend of the characteristics of each. For a more complete description, see the West Mountain site description in the section on state-significant sites in Chapter 3.

A final optional upland representative sampling site was selected because it represented the most mature upland forest conditions seen in the study area at the time of selection. Notch Pond Mountain Northeast is a very steep, ledgy and bouldery north-facing slope, with an elevation range from 630 to 350 m. The natural communities on the slope are montane yellow birch-red spruce forest and red spruce-hardwood forest. For a more complete description, see the discussion of state-significant sites in Chapter 3.

Chapter 5. Rare, Threatened, Endangered and Uncommon Plants of West Mountain WMA and Nulhegan Basin Division-Conte NFWR

The inventory for rare and uncommon plants, including species listed by the NNHP as threatened and endangered in Vermont, was accomplished simultaneously with mapping and inventory of natural communities. Prior to the field season the NNHP printed a list from their database of species known from the former Champion lands in Vermont. This list and both ecologists background knowledge of the Vermont flora provided a general idea of which species to look for during the inventory. Although they are a substantial component of the lowland and wetland flora, mosses and liverworts were not surveyed as part of the inventory. Except in passing, aquatic plants were not inventoried for this project; most of the aquatic plant records are from Vermont Department of Environmental Conservation, Water Quality Division lake surveys conducted in 1990 by Kitty Enright and Rose O'Connell.

In addition to the rare plant information provided below, a list of vascular plants found in both West Mountain WMA and the Conte Refuge was compiled from the authors' field notes. This preliminary flora is found in Appendix 3. This is not comprehensive, since some habitats, like artificially disturbed ground and the aquatics of the rivers and ponds, were not completely inventoried. However, with 495 species recorded, this list represents most of the vascular plants likely to be encountered in the project area.

No systematic search methods were used, other than extra time spent looking for plants in natural communities likely to support rare species. Specimens were collected for identification and documentation of rare plants. Color photographs were taken in lieu of specimens when identification could be easily made from photos, or in cases of extreme rarity. Specimens will be deposited at the University of Vermont's Pringle Herbarium. Locations of most rare and uncommon plants were recorded using Trimble GeoExplorer 3 GPS receivers. Rare plant sites not recorded with GPS were marked on topographic maps and subsequently digitized into a GIS theme. The rare and uncommon plant data are documented in an ArcView/ArcInfo point theme entitled "plntall.*" General information on the rare plant population and the natural community in which it is located was recorded in field notebooks, with some information entered directly into the GPS data logger. All data were compiled into an attribute table that accompanies the GIS shape file.

No federally listed plants were found in either the Conte Refuge or West Mountain WMA. No federally listed plants are presently known, nor were historically documented, from Essex County, Vermont.

A total of 46 plant species listed by the NNHP as rare and uncommon in Vermont are now known to occur on both West Mountain WMA and the Conte Refuge (Table 6). An additional two rare species were found on the Nulhegan floodplain in Wenlock WMA, immediately adjacent to the Refuge; these species very likely occur within the Refuge also. Over half of the 46 species were new for the former Champion lands. Most, however, were known from Essex County prior to the inventory.

Three species discovered during the inventory are listed as "state historical," meaning they have not been found in the state for at least 20 years. One of these species, Pickering's reed bent-grass

Table 6. Rare and Uncommon Vascular Plants of West Mountain WMA and Nulhegan Basin Division-Conte NFWR

Common Name	Scientific Name	State Rank	Global Rank	State Status	Regional Status*	First Observed	Last Observed	Conte Refuge	West Mtn. WMA
Slender wheatgrass	*Agropyron trachycaulum*	S3	G5T5			2001	2001	X	
Bog Aster	*Aster nemoralis*	S2S3	G5			1981	2001		X
Pickering's Reed Bent-grass	*Calamagrostis pickeringii*	SH	G4		2	2000	2001		X
Tuberous Grass-pink	*Calopogon tuberosus*	S3	G5			?	2001	X	X
Water Sedge	*Carex aquatilis*	S2S3	G5			2000	2000	X	
Northeastern Sedge	*Carex cryptolepis*	S3	G4			2000	2000		X
Bog Sedge	*Carex exilis*	S2	G5			1988	2001	X	X
Shore Sedge	*Carex lenticularis*	S2S3	G5			2000	2001	X	X
Michaux Sedge	*Carex michauxiana*	S3	G5			?	2000		X
Wiegand's Sedge	*Carex wiegandii*	SH	G3		1	2000	2001	X	
Swamp Thistle	*Cirsium muticum*	S3	G5			2000	2001	X	X
Bog-rush	*Cladium mariscoides*	S2S3	G5			?	2001		X
Olive Spikerush	*Eleocharis olivacea*	S1	G5			2001	2001		X
Wiegand's Wild-rye	*Elymus wiegandii*	S3	G?			1998	2000	X	
Rough Cotton-grass	*Eriophorum tenellum*	SU	G5			2000	2000		X
Northern Bedstraw	*Galium boreale var. hyssopifolium*	S3	G5			2000	2000	X	
Kamtschatkan Bedstraw	*Galium kamtschaticum*	S2S3	G5		Ind.	2000	2001	X	X
Small Bedstraw	*Galium trifidum*	S3	G5			2000	2001	X	X
Large-leaved Avens	*Geum macrophyllum*	S3	G5			2000	2001	X	X
Woodland Cudweed	*Gnaphalium sylvaticum (syn. Omalotheca sylvatica)*	S1	G5	E	Ind.	2001	2001	X	
Northern Fir-clubmoss	*Huperzia selago*	S1	G5			2001	2001		X
Auricled Twayblade	*Listera auriculata*	S1	G3	E	1	2000	2001	X	
American Shore-grass	*Littorella americana*	S2	G5			1899	2001		X
Mountain Fly-honeysuckle	*Lonicera caerulea var. villosa*	S3	G5			?	2001	X	X
Small-flowered Wood-rush	*Luzula parviflora*	S2	G5			2000	2001	X	

Table 6 (cont.). Rare and Uncommon Vascular Plants of West Mountain WMA and Nulhegan Basin Division-Conte NFWR

Tall Millet-grass	*Milium effusum*	S3	G5			2000	2000	X	X
Fall Dropseed Muhly	*Muhlenbergia uniflora*	S2?	G5			2000	2001	X	X
Farwell's Water-milfoil	*Myriophyllum farwellii*	S2	G5			1989	2001	X	X
Slender Naiad	*Najas gracillima*	S1	G5			1985	1990		X
Guadalupe Naiad	*Najas guadalupensis*	S1	G5		Ind.	1990	1990		X
Sweet Coltsfoot	*Petasites frigidus var. palmatus*	S1	G5T5	T		1989	2001		X
White-fringed Orchis	*Platanthera blephariglottis*	S1	G4G5			2000	2000	X	X
Drooping Bluegrass	*Poa saltuensis*	S2S3	G5?			2000	2001	X	X
Rose Pogonia	*Pogonia ophioglossoides*	S3	G5			?	2001	X	X
Snail-seed Pondweed	*Potamogeton bicupulatus*	S2	G4?			1990	1990		X
Fernald's Alkali Grass	*Puccinellia fernaldii (syn. P. pallida)*	S3	G5			2000	2001	X	X
Bristly Crowfoot	*Ranunculus pensylvanicus*	S2	G5			2001	2001		X
Shining Rose	*Rosa nitida*	SH	G5			2000	2001	X	X
Pod-grass	*Scheuchzeria palustris ssp. americana*	S1	G5T5	T		1981	2001	X	X
Water Bur-reed	*Sparganium fluctuans*	S2	G5			2000	2000	X	
Hidden Bladderwort	*Utricularia geminiscapa*	S3	G4G5			1982?	2000		X
Humped Bladderwort	*Utricularia gibba*	S3	G5			1990	1990		X
Purple Bladderwort	*Utricularia purpurea*	S3	G5			1982	2001	x	X
Northeastern Bladderwort	*Utricularia resupinata*	S1	G4	T	2(a)	1990	2001	X	X
Lingonberry	*Vaccinium vitis-idaea*	S1	G5			1988	2001	X	
Northern Yellow-eyed-grass	*Xyris montana*	S1	G4	T		1989	2001		X
Rare plants in Wenlock WMA, immediately adjacent to Conte Refuge									
Contracted Sedge	*Carex arcta*	S1	G5	E	3 (VT)	2001	2001		
Nodding Trillium	*Trillium cernuum*	S2	G5			2000	2000		

(Calamagrostis pickeringii) (G4/SH) was known in Vermont from a single specimen collected over a century ago by the well-known Vermont botanist, Cyrus Pringle. No information other than "Vermont" is given on this specimen's label found at the U.S. National Herbarium in Washington, D.C. (Brainerd et al. 1900). Likewise, Wiegand's sedge *(Carex wiegandii)* (G3/SH) was another historical species found during the inventory that has not been seen in the state for nearly 100 years and was known from only two sites in Vermont (not including three unverified records from the 1960s). Shining rose *(Rosa nitida)* (G5/SH), the third state historical species, was found at a number of locations in the project area. However, during an inventory of the Memphremagog Watershed wetlands in 1998, this rose species was observed in wetlands adjacent to the western edge of the Nulhegan Basin, and farther down the Clyde River.

In addition to the historical species, other species considered rare include 12 very rare (S1) and 13 rare (S2 or S2S3) species. Seventeen of the 46 species are ranked as uncommon (S3), and one species (rough cotton-grass *(Eriophorum tenellum)* (G5/SU)) is thought to be rare, but the status is really unknown.

Six plants found in the project area are protected by Vermont's Endangered Species Law (10 V.S.A. Chap. 123). Auricled twayblade *(Listera auriculata)* (G3/S1) is a state-endangered orchid, extant at only one other location in Vermont. Woodland cudweed *(Gnaphalium sylvaticum)* (G5/S1) is the second state-endangered plant species found on the former Champion lands; it is the fourth record of the species in Vermont. The state-threatened species include two emergent wetland species, pod-grass *(Scheuchzeria palustris* ssp. *americana)* (G5/S1) and northern yellow-eyed grass *(Xyris montana)* (G4/S1), one wetland species often found in cedar swamps, sweet coltsfoot *(Petasites* frigidus var. *palmatus)* (G5T5/S1), and an insectivorous aquatic plant, northeastern bladderwort *(Utricularia resupinata)* (G4/S1). A seventh state-protected plant observed in the area is contracted sedge *(Carex arcta)* (G5/S1), a state-threatened species growing in the Nulhegan floodplain in Wenlock WMA.

On a global scale, only auricled twayblade and Wiegand's sedge are threatened (G3), while four species, northern yellow-eyed grass, northeastern sedge *(Carex cryptolepis)* (G4/S3), snail-seed pondweed *(Potamogeton bicupulatus)* (G4?/S2), and Pickering's reed bent-grass, are apparently secure, but perhaps locally rare (G4). These global, or worldwide, ranks are assigned by the international network of Natural Heritage Program Data Centers.

Being globally rare, both the auricled twayblade and Wiegand's sedge are also in the highest category of conservation concern in the New England region—Division 1 of the New England Plant Conservation Program's list (Brumback and Mehrhoff 1996). Division 2 of this regional list includes Pickering's reed bent-grass and northeastern bladderwort. Guadalupe naiad *(Najas guadalupensis)* (G5/S1), Kamtschatkan bedstraw *(Galium kamtschaticum)* (G5/S2S3), woodland cudweed *(Gnaphalium sylvaticum)* (G5/S1), and northern fir-clubmoss *(Huperzia selago)* (G5/S1) fall into an indeterminate category of species that need more research before they can be categorized.

It is interesting to note that 30 species (65%) of the 46 rare and uncommon species are wetland species, while 10 (22%) are aquatics. Only six plants (13%) are typically upland species. These are tall millet-grass *(Milium effusum)* (G5/S3), drooping bluegrass *(Poa saltuensis)* (G5?/S2), slender wheatgrass *(Agropyron trachycaulum)* (G5T5/S3), woodland cudweed *(Gnaphalium sylvaticum)* (G5/S1), small-flowered wood-rush *(Luzula parviflora)* (G5/S2), and northern bedstraw *(Galium boreale)* (G5/S3). The latter, however, is most often found in wet habitats, despite its occurrence in a dry location in the Conte Refuge. While the GIS analysis will provide more details, it is apparent that the natural communities that harbor the greatest number of rare

plants are the open peatlands, particularly the dwarf shrub bogs and fens. Other natural communities important for rare and uncommon plants include alluvial shrubland, alder swamp, and spruce-fir-tamarack swamp. The ponds, especially Wheeler Pond, are very important for rare plant diversity.

The biogeographic affinities of most of the rare and uncommon species lie in northeastern North America. In general, this is the region bounded by Newfoundland or Nova Scotia across to northern Minnesota, south to northern Indiana and Ohio and east to northern New Jersey. Some of the northern species also cross the continent in the north to Alaska. Lingonberry *(Vaccinium vitis-idaea)* (G5/S1), small-flowered wood-rush *(Luzula parviflora)* (G5/S2), Kamtschatkan bedstraw *(Galium kamtschaticum)* (G5/S2S3), northern bedstraw *(Galium boreale)* (G5/S3), woodland cudweed *(Gnaphalium sylvaticum)* (G5/S1), and pod-grass *(Scheuchzeria palustris* ssp. *americana)* (G5/S1) are circumboreal species, although the varieties in our area are likely restricted to North America. Almost 20% of the species, however, range widely in eastern North America; these include several of the aquatics, most orchids, and bog-rush *(Cladium mariscoides)* (G5/S3). Some of the aquatics, such as the Guadalupe naiad and purple bladderwort *(Utricularia purpurea)* (G5/S3), even range into the tropics. In general terms the study area is at the middle to southern end of most species' ranges. In contrast, a little ways south in the Connecticut River valley, numerous species are at the northern edge of their ranges, and likewise in the Champlain Valley there are substantial numbers of species at the northern or western edge of their ranges.

Two herbaceous species not on the NNHP list, creeping spearwort *(Ranunculus reptans)* and northern chickweed *(Stellaria borealis),* might warrant inclusion as uncommon species on the project lands. Both species were observed several times during the inventory, yet the authors have rarely encountered them in Vermont outside the project area. Likewise, bristly blackberry *(Rubus setosus)* is another species that might be included on this list of rare and uncommon plants. It was found quite abundantly on the Nulhegan floodplain in the Conte Refuge, and in a few places near Paul Stream in the WMA. According to Jenkins and Zika's 1991 unpublished, provisional checklist of Vermont vascular plants, this is a species possibly missing from the Vermont flora.

In addition to the vascular plant rarities, two species of rare mosses were documented during the inventory. Dung moss, *Splachnum ampullaceum* (S2S3) was observed in scattered locations, principally in black spruce swamps and woodland bogs. The other known rare moss, *Scorpidium scorpioides* (S1S2), was found in a poor fen.

Chapter 6. Invasive Plants of West Mountain WMA and Nulhegan Basin Division-Conte NFWR

Exotic and invasive plants are less of a problem in the Nulhegan Basin and West Mountain WMA than in many places in Vermont and the rest of New England. The fortunate paucity of invasive plants can be attributed to several factors. Foremost among these is that these areas, except for small patches along the Nulhegan River and Paul Stream, have remained continuously forested throughout the post-European settlement period. This contrasts with so much of New England, which has been cleared for pasture or plowed agricultural fields; such conversions from the natural vegetation invite exotic plants, including many species that are invasive. In addition, because of the northern latitude and general remoteness of the lands the arrival and/or spread of many of the Eurasian species considered to be invasive exotics have been recent. Compared to valley locations in Vermont and regions farther south, seed source for these species in the project area and surrounding landscape is not nearly so widespread and abundant.

Floodplain natural communities are among those that are particularly prone to disruption by invasive exotic plants. It is remarkable, from a statewide perspective, that the floodplains and riparian zones of the Nulhegan River, Paul Stream, and the smaller streams in the area, virtually lack invasive exotic species.

Ponds and lakes are also especially prone to invasions of exotic plants. The ponds of the WMA and Refuge are apparently free of Eurasian milfoil and other invasive aquatic plants. Aquatic nuisance plants can invade even intact ecosystems. Therefore the need for caution is greater with regard to invasive aquatics.

The great majority of the observed occurrences of invasive plants are in roadside ditches, and populations are currently small. None of the natural communities of the study area have been invaded, although exotic species that are not considered to be invasive are established in scattered locations in a few natural community types.

Two exotic species that are considered invasive were documented in the study area: common reed *(Phragmites australis),* which accounted for 15 of 16 recorded invasive plant occurrences, and common buckthorn *(Rhamnus cathartica),* which was observed in a single location. The paragraphs below provide general information on the biology of these two species, along with notes on their status in the project area.

The locations of all invasive plant observations are documented in an ArcView shape file entitled "exotplts.*"

Common Reed

Common reed has gained a reputation as one of the most pernicious invasive herbaceous plants in eastern North America. The tall grass has a nearly worldwide distribution and is considered native to Vermont (Seymour 1997). Nevertheless, even if native to some natural communities in eastern North America, it is not native to any natural community within the former Champion lands and thus takes its place with other invasive plants that displace native flora. Common reed is one of the most aggressive plants in emergent wetlands, both natural and anthropogenic. It reproduces clonally by stout rhizomes and can quickly out-compete native vegetation. Common reed should be eradicated when discovered in new locations (Crow and Hellquist 2000).

The species was observed in three locations within West Mountain WMA, 11 locations in the Refuge, and one location on private land close to the boundaries of both public landholdings. In all but one case, the clones were growing adjacent to roads, usually in ditches but sometimes on flats or landings. One site in the WMA (south of West Mountain Pond) is within a spruce-fir-tamarack swamp that has been clearcut within the past several years.

All of the clones appear to have established recently, for they are all small. Clone sizes range from 10 to 200 stems, and they cover areas as small as 5 square meters to as large as only 150 square meters.

All clones should be removed as soon as possible. Each site should be monitored annually for 3 to 5 years after eradication to assure that eradication has been complete and that there are no subsequent re-invasions. Invasive plant control experts should be consulted and the utility and appropriateness of the various available control techniques should be assessed.

Although the *Phragmites* problem is almost non-existent in the WMA and Refuge, an eradication and control plan should be developed. To assure the best success, the plan should be developed with collaboration among the state and federal land managers and the landowners of adjacent private lands.

Common Buckthorn

Native to Eurasia, common buckthorn is one of the most pernicious invasive exotic woody plants in New England. It is a bird-dispersed, tall shrub or small tree that can establish in great abundance in a wide range of habitat conditions. Dense growth can impact native plant establishment, growth and abundance. Common buckthorn is rarely seen in intact forest ecosystems, but if a seed source is available it readily establishes in disturbed forest, old fields, old woodland pastures and floodplain forest and woodland.

A single mature plant was observed on the floodplain of the North Branch of the Nulhegan River in alluvial shrubland. The location, as recorded by a Trimble GeoExplorer 3 GPS receiver, is on Refuge land, less than one meter northwest of the property line with a private inholding.

Extirpation of the buckthorn plant should be a priority and should be done in 2001 before the summer's crop of seed is set. Although there is certainly some seed source in the general area, common buckthorn is rare. A single tree, such as this one on the floodplain can produce many hundreds of viable seeds and can become a source of infestation of the floodplain. The lack of exotics on the floodplain of the Nulhegan and its tributaries is one of its distinguishing characteristics, and every attempt to keep exotics out of the floodplain ecosystem should be made.

For this lone plant, mechanical uprooting and removal of the entire plant from the site is probably adequate. If the roots cannot be removed, cutting the stem(s) and spot-application of herbicide is another good option. For choice of herbicide, consult with experts in USFWS or The Nature Conservancy.

Periodic monitoring of the alluvial floodplain communities is recommended so that any other individuals that are present or seed in can be controlled immediately, preferably before they begin to produce fruits.

Avoiding Future Problems

Future invasive plant problems can best be avoided by limiting human disturbances in the Refuge and WMA, by monitoring roadways and gravel extraction sites, and by eradicating populations of invasives as soon as they are detected. Of course, the history of plant invasions indicates that it is difficult to accurately predict which exotic species will become invasive, at what time and in what locations. For the most part, maintaining intact natural systems is the best defense against future problems with invasive upland and wetland plant species.

Invasive aquatic plants, however, require a different strategy. Because many aquatic plants are adapted to vegetative reproduction from plant fragments, keeping even vegetative pieces of aquatic plants—exotic invasives as well as native plants not indigenous to the ponds—out of the waters is crucial. Eurasian water-milfoil *(Myriophyllum spicatum)* and water-chestnut *(Trapa natans)* are well known nuisance plants in New England's lakes and ponds, and public information materials have been widely disseminated. Providing a powerful message about the high-quality aquatic ecosystems of the WMA and Refuge and their current lack of invasive exotic aquatic plants will be important. The fact that large motors are not allowed in the ponds of the area is an asset to maintaining ponds free of invasives, but even small electric trolling motors, which are allowed, can harbor plant fragments. These small motors are easier to clean, however, and with a good public information campaign, it is hoped that stray fragments will not be dispersed into the waters.

Quite simply, erecting large, apparent signs warning of the need for care is fundamental to the continued health of the ponds. The signs need to indicate not only that boats, motors and trailers must be cleaned, but also that bait buckets and minnow traps present a threat of nuisance species introductions. An extra measure that could be implemented at times of higher use is to establish a network of volunteer "boat monitors" at the major entry points into the WMA and Refuge. These volunteers could help check motors, hulls and trailers, and would send a strong message that it is responsible stewardship to carefully clean the vessels.

Other Non-Native Species

In addition to the two invasive exotic species located, several non-invasive exotic species that occur in the study area warrant mention because of their ability to establish and persist not only roadsides, but also in natural communities. Coltsfoot *(Tussilago farfara)*, self-heal *(Prunella vulgaris)*, hemp-nettle *(Galeopsis tetrahit)*, and dandelion *(Taraxacum officinale)* were all observed in various locations along streams, either in floodplain woodlands, on sand or gravel bars, or on stream shores. Additionally, helleborine *(Epipactis helleborine)* was noted in some of the forested natural communities. All of these species are widespread in the northeastern United States; they are common both in mechanically disturbed ground and in rather intact and sometimes even remote forest locations. Stream corridors, with their frequent natural disturbances, seem to be particularly conducive to the growth and dispersal of non-native and native weed species. The mentioned species are naturalized in the region and would be difficult to extirpate even if attempted. They do not threaten the ecological integrity of the natural communities in which they occur, both because of the small sizes of the known populations and because of their generally non-invasive characteristics. An exception to this may be the occurrence of coltsfoot on river bars, where the plants can establish rather densely; they may, however, not be displacing native species.

Sixteen other non-invasive exotic species were observed in the Refuge and WMA. All 25 non-native species are marked with asterisks in the vascular plant flora (Appendix 3). Most of these other non-native species are restricted to artificially disturbed ground along roads and on log

landings. They will likely persist in such areas as long as they are kept open and periodic soil disturbance occurs. A thorough inventory of roadsides would reveal many other non-native species not listed in the provisional flora of the area.

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Appendices

Appendix 1. Vascular Plant Flora Alphabetized by Common Name.

Common name	Scientific name
Acuminate wood-rush	*Luzula acuminata*
Alder-leaved buckthorn	*Rhamnus alnifolia*
Alloploid rattlesnake-plantain	*Goodyera tesselata*
Alternate-leaved dogwood	*Cornus alternifolia*
American beech	*Fagus grandifolia*
American brooklime	*Veronica americana*
American bur-reed	*Sparganium americanum*
American elm	*Ulmus americana*
American mannagrass	*Glyceria grandis*
American mountain-ash	*Sorbus americana*
American shore-grass	*Littorella americana*
American water-horehound	*Lycopus americanus*
Annual bluegrass	**Poa annua*[1]
Arrow-leaved tearthumb	*Polygonum sagitattum*
Aurcled twayblade	*Listera auriculata*
Autumn bent-grass	*Agrostiis perennans*
Balsam fir	*Abies balsamea*
Balsam poplar	*Populus balsamifera*
Bartram's shadbush	*Amelanchier bartramiana*
Beaked hazelnut	*Corylus cornuta*
Beaked sedge	*Carex utriculata*
Bearded shorthusk	*Brachyelytrum erectum*
Bebb's willow	*Salix bebbiana*
Beech drops	*Epifagus virginiana*
Bent-down sedge	*Carex deflexa*
Bigtooth aspen	*Populus grandidentata*
Black ash	*Fraxinus nigra*
Black bulrush	*Scirpus atrovirens*
Black cherry	*Prunus serotina*
Black chokeberry	*Aronia melanocarpa*
Black huckleberry	*Gaylussacia baccata*
Black spruce	*Picea mariana*
Blackberry	*Rubus allegheniensis*
Bladdery sedge	*Carex vesicaria*
Blue cohosh	*Caulophyllum thalictroides*
Blue flag	*Iris versicolor*
Blue ground-cedar	*Diphasiastrum tristachyum*
Bluebead lily	*Clintonia borealis*
Bluejoint grass	*Calamagrostis canadensis*
Bluets	*Hedyotis caerulea*
Blunt broom sedge	*Carex tribuloides*
Blunt spikerush	*Eleocharis obtusa*
Blunt-leaved pondweed	*Potamogeton obtusifolius*
Bog aster	*Aster nemoralis*
Bog laurel	*Kalmia polifolia*
Bog rosemary	*Andromeda glaucophylla*
Bog sedge	*Carex exilis*
Bog-rush	*Cladium mariscoides*
Bog-stitchwort	*Stellaria cf. alsine*
Bracken fern	*Pteridium aquilinum*
Braun's holly-fern	*Polysticuhm braunii*
Bristly black currant	*Ribes lacustre*
Bristly blackberry	*Rubus setosus*
Bristly clubmoss	*Lycopodium annotinum*
Bristly crowfoot	*Ranunculus pensylvanicus*
Bristly sarsparilla	*Aralia hispida*
Broad-leaved arrowhead	*Sagittaria latifolia*
Broad-leaved twayblade	*Listera convallarioides*
Brome-like sedge	*Carex bromoides*
Brownish sedge	*Carex brunnescens*
Bublet fern	*Cystopteris bulbifera*
Buckbean	*Menyanthes trifoliata*
Bulb-bearing water hemlock	*Cicuta bulbifera*
Bulb-styled sedge	*Bulbostylis capillaris*
Bunchberry	*Cornus canadensis*
Bush-honeysuckle	*Diervilla lonicera*
Canada goldenrod	*Solidago canadensis*
Canada honeysuckle	*Lonicera canadensis*
Canada lily	*Lilium canadense*
Canada mayflower	*Maianthemum canadense*
Canada rush	*Juncus canadensis*
Canada violet	*Viola canadensis*
Canada wild-rye	*Elymus canadensis*
Canada yew	*Taxus canadensis*
Charming sedge	*Carex blanda*
Choke cherry	*Prunus virginiana*
Christmas fern	*Polystichum acrostichoides*
Cinnamon fern	*Osmunda cinnamomea*
Club-spur rein-orchid	*Habenaria clavellata*
Colonial sedge	*Carex communis*
Coltsfoot	**Tussilago farfara*
Common scouring rush	*Equisetum hyemale*
Common bladderwort	*Utricularia vulgaris*

[1] Asterisk indicates non-native species

Common buckthorn	**Rhamnus cathartica*
Common cattail	*Typha latifolia*
Common cinquefoil	*Potentilla simplex*
Common elderberry	*Sambucus canadensis*
Common golden alexanders	*Zizia aurea*
Common hops	*Humulus lupulus*
Common horsetail	*Equisetum arvense*
Common mullein	**Verbascum thapsus*
Common pussy willow	*Salix discolor*
Common reed	**Phragmites australis*
Common St. John's-wort	**Hypericum perforatum*
Common strawberry	*Fragaria virginiana*
Common water-purslane	*Ludwigia palustris*
Common wood-sorrel	*Oxalis acetosella*
Common yellow wood-sorrel	*Oxalis cf. stricta*
Contracted sedge	*Carex arctata*
Contracted sedge	*Carex arcta*
Cow parsnip	*Heracleum maximum*
Cow vetch	**Vicia cracca*
Crawford's sedge	*Carex crawfordii*
Creeping snowberry	*Gaultheria hispidula*
Creeping spearwort	*Ranunculus reptans*
Crested wood-fern	*Dryopteris cristata*
Dandelion	**Taraxacum officinale*
Delicate water-milfoil	*Myriophyllum tenellum*
Delicate-stemmed sedge	*Carex leptalea*
Dewdrop	*Dalibarda repens*
Dewey's sedge	*Carex deweyana*
Downy violet	*Viola pubescens*
Drooping bluegrass	*Poa saltuensis*
Drooping woodreed	*Cinna latifolia*
Duckweed	*Lemna minor*
Dusty goldenrod	*Solidago puberula*
Dutchman's breeches	*Dicentra cucullaria*
Dwarf enchanter's-nightshade	*Circaea alpina*
Dwarf ginseng	*Panax trifolium*
Dwarf raspberry	*Rubus pubescens*
Dwarf St. John's-wort	*Hypericum mutilum*
Dye-making bedstraw	*Galium tinctorium*
Early coral-root	*Corallorhiza trifida*
Early goldenrod	*Solidago juncea*
Early yellow violet	*Viola rotundifolia*
Emergent bur-reed	*Sparganium emersum*
English plantain	**Plantago lanceolata*
Evening primrose	*Oenothera biennis*
Fall dropseed muhly	*Muhlenbergia uniflora*
False buckwheat	*Polygonum scandens*
False hellebore	*Veratrum viride*
False melic	*Schizachne purpurascens*
False Solomon's seal	*Smilacina racemosa*
Farwell's water-milfoil	*Myriophyllum farwellii*
Fernald's alkali-grass	*Puccinellia fernaldii*
Few-flowered sedge	*Carex pauciflora*
Few-seeded sedge	*Carex oligosperma*
Finely-nerved sedge	*Carex leptonervia*
Fir-clubmoss	*Huperzia selago*
Fireweed	*Epilobium angustifolium*
Flat-branched tree club-moss	*Lycopodium obscurum*
Flat-stemmed bluegrass	**Poa compressa*
Flat-topped aster	*Aster umbellatus*
Floating bur-reed	*Sparganium fluctuans*
Floating mannagrass	*Glyceria borealis*
Foamflower	*Tiarella cordifolia*
Fowl mannagrass	*Glyceria striata*
Fragile fern	*Cystopteris fragilis*
Fringed bindweed	*Polygonum cilinode*
Fringed brome	*Bromus ciliatus*
Fringed loosestrife	*Lysimachia ciliata*
Giant goldenrod	*Solidago gigantea*
Giant redtop	**Agrostis gigantea*
Golden ragwort	*Senecio aurea*
Golden saxifrage	*Chrysosplenium americanum*
Goldie's wood-fern	*Dryopteris goldiana*
Goldthread	*Coptis trifolia*
Grass pink	*Calopogon tuberosus*
Grass-leaved goldenrod	*Euthamia graminifolia*
Grass-like pondweed	*Potamogeton gramineus*
Gray birch	*Betula populifolia*
Gray goldenrod	*Solidago nemoralis*
Great angelica	*Angelica atropurpurea*
Greenish-flowered pyrola	*Pyrola chlorantha*
Green-keeled cottongrass	*Eriophorum viridicarinatum*
Ground-cedar	*Diphasiastrum digitatum*
Guadalupe naiad	*Najas guadalupensis*
Gynandrous sedge	*Carex gynandra*
Hairy-fruited sedge	*Carex lasiocarpa*
Hare's tail cotton-grass	*Eriophorum vaginatum var. spissum*
Hawkweed	*Hieracium sp.*
Hawthorn	*Crataegus sp.*
Hay-scented fern	*Dennstaedtia punctilobula*

Heart-leaved paper birch	*Betula papyrifera var. cordifolia*
Helleborine	**Epipactis helleborine*
Hemlock	*Tsuga canadensis*
Hemlock parsley	*Conioselinum chinense*
Hemp nettle	**Galeopsis tetrahit*
Hidden bladderwort	*Utricularia geminiscapa*
Highbush-cranberry	*Viburnum opulus var americanum*
Hoary sedge	*Carex canescens*
Hobblebush	*Viburnum alnifolium*
Hooked crowfoot	*Ranunculus recurvatus*
Hop hornbeam	*Ostrya virginiana*
Hop-like sedge	*Carex lupulina*
Horned bladderwort	*Utricularia cornuta*
Hudson Bay bulrush	*Scirpus hudsonianus*
Humped bladderwort	*Utricularia gibba*
Indian cucumber root	*Medeola virginiana*
Indian pipe	*Monotropa uniflora*
Intermediate wood-fern	*Dryopteris intermedia*
Interrupted fern	*Osmunda claytoniana*
Jack-in-the-pulpit	*Arisaema triphyllum*
Kamtschatkan bedstraw	*Galium kamtschaticum*
Kentucky bluegrass	*Poa pratensis*
Kidney-leaved violet	*Viola renifolia*
Labrador tea	*Ledum groenlandicum*
Lady fern	*Athyrium filix-femina*
Large cranberry	*Vaccinium macrocarpon*
Large-leaved aster	*Aster macrophyllus*
Large-leaved avens	*Geum macrophyllum*
Large-leaved goldenrod	*Solidago macrophylla*
Large-leaved pondweed	*Potamogeton amplifolius*
Leafy muhly	*Muhlenbergia frondosa*
Leatherleaf	*Chamaedaphne calyculata*
Lesser bladderwort	*Utricularia minor*
Ligonberry	*Vaccinium vitis-idaea*
Little floating-heart	*Nymphoides cordata*
Long beech fern	*Phegopteris connectilis*
Long-awned sedge	*Carex crinita*
Longleaf bluet	*Hedyotis longifolia*
Low rough aster	*Aster radula*
Low sweet blueberry	*Vaccinium angustifolium*
Mad-dog skullcap	*Scutellaria lateriflora*
Maidenhair fern	*Adiantum pedatum*
Many-flowered wood-rush	*Luzula multiflora*
Marginal wood-fern	*Dryopteris marginalis*
Marsh bedstraw	*Galium palustre*
Marsh blue violet	*Viola cucullata*
Marsh bluegrass	*Poa palustris*
Marsh cinquefoil	*Potentilla palustris*
Marsh fern	*Thelypteris palustris*
Marsh marigold	*Caltha palustris*
Marsh skullcap	*Scutellaria epilobifolia*
Marsh speedwell	*Veronica scutellata*
Marsh St. John's-wort	*Triadenum fraseri*
Meadow-sweet	*Spiraea alba var. latifolia*
Michaux's sedge	*Carex michauxiana*
Monkey flower	*Mimulus ringens*
Mountain maple	*Acer spicatum*
Mountain wood-fern	*Dryopteris campyloptera*
Mountain-fly honeysuckle	*Lonicera caerulea var. villosa*
Mountain-holly	*Nemopanthus mucronatus*
Mud sedge	*Carex limosa*
Naked mitrewort	*Mitella nuda*
Nannyberry	*Viburnum lentago*
Narrow-leaved gentian	*Gentiana linearis*
Needle-shaped spikerush	*Eleocharis acicularis*
New England sedge	*Carex novae-angliae*
New York fern	*Thelypteris noveboracensis*
Nodding beggar-ticks	*Bidens cernua*
Nodding fescue	**Festuca elatior*
Nodding ladies'-tresses	*Spiranthes cernua*
Nodding trillium	*Trillium cernuum*
Northeastern bladderwort	*Utricularia resupinata*
Northeastern sedge	*Carex cryptolepis*
Northern bedstraw	*Galium boreale*
Northern bladderwort	*Utricularia intermedia*
Northern bog clubmoss	*Lycopodiella inundata*
Northern bog-goldenrod	*Solidago uliginosa*
Northern bugleweed	*Lycopus uniflorus*
Northern dewberry	*Rubus cf. flagellaris*
Northern green orchid	*Habenaria hyperborea*
Northern naiad	*Najas flexilis*
Northern panic-grass	*Panicum boreale*
Northern stitchwort	*Stellaria borealis*
Northern three-lobed bedstraw	*Galium trifidum*
Northern white cedar	*Thuja occidentalis*
Northern willow-herb	*Epilobium ciliatum*
Northern yellow-eyed-grass	*Xyris montana*
Oak fern	*Gymnocarpium dryopteris*
Olive spikerush	*Eleocharis olivacea*
One-flowered pyrola	*Moneses uniflora*

One-sided pyrola	*Pyrola secunda*
Ostrich fern	*Matteuccia struthiopteris*
Ovate spikerush	*Eleocharis ovata*
Ox-eye daisy	**Chrysanthemum leucanthemum*
Paintbrush	**Hieracium aurantiacum*
Painted trillium	*Trillium undulatum*
Pale St. John's-wort	*Hypericum ellipticum*
Pale touch-me-not	*Impatiens pallida*
Paper birch	*Betula papyrifera*
Partridgeberry	*Mitchella repens*
Path rush	*Juncus tenuis*
Pearlwort	*Sagina procumbens*
Pedunculate sedge	*Carex pedunculata*
Pennsylvania bitter cress	*Cardamine pensylvanica*
Pennywort	*Hydrocotyle americana*
Pickerelweed	*Pontederia cordata*
Pickering's reed bent-grass	*Calamagrostis pickeringii*
Pin cherry	*Prunus pensylvanica*
Pink corydalis	*Corydalis sempervirens*
Pink lady's slipper	*Cypripedium acaule*
Pipewort	*Eriocaulon aquaticum*
Pipsissewa	*Chimaphila umbellata*
Pitcher plant	*Sarracenia purpurea*
Plantain-leaved sedge	*Carex plantaginea*
Pod-grass	*Scheuchzeria palustris ssp. americana*
Pointed broom sedge	*Carex scoparia*
Poison-ivy	*Toxicodendron radicans*
Poor sedge	*Carex paupercula*
Poverty grass	*Danthonia spicata*
Prickly gooseberry	*Ribes cynosbati*
Prickly sedge	*Carex echinata*
Projecting sedge	*Carex projecta*
Purple bladderwort	*Utricularia purpurea*
Purple fringed rein-orchid	*Habenaria psycodes*
Purple-flowering raspberry	*Rubus odoratus*
Purple-stemmed aster	*Aster puniceus*
Quaking aspen	*Populus tremuloides*
Quillwort	*Isoetes sp.*
Ragged-robin	**Lychnis flos-cucli*
Rattlesnake fern	*Botrychium virginianum*
Rattlesnake mannagrass	*Glyceria canadensis*
rattlesnake-plantain	*Goodyera pubescens*
Rattlesnake-plantain	*Goodyera repens*
Red baneberry	*Actaea rubra*
Red fescue	*Festuca rubra*
Red maple	*Acer rubrum*
Red oak	*Quercus rubra*
Red pine	*Pinus resinosa*
Red raspberry	*Rubus idaeus*
Red spruce	*Picea rubens*
Red trillium	*Trillium erectum*
Red-berried elder	*Sambucus racemosa ssp. pubens var. pubens*
Red-osier dogwood	*Cornus sericea*
Reed canary grass	*Phalaris arundinacea*
Rhodora	*Rhododendron canadense*
Rice cutgrass	*Leersia oryzoides*
Right-angled sedge	*Carex normalis*
Riverbank wild-rye	*Elymus riparius*
Roadside agrimony	*Agrimonia cf. striata*
Robbins' ragwort	*Senecio schweinitzianus (robbinsii)*
Rock polypody	*Polypodium virginianum*
Rose pogonia	*Pogonia ophioglossoides*
Rose twisted stalk	*Streptopus roseus*
Rough bedstraw	*Galium asprellum*
Rough cinquefoil	*Potentilla norvegica*
Rough goldenrod	*Solidago rugosa*
Rough-leaved mountain-rice	*Oryzopsis asperifolia*
Rough-stemmed sedge	*Carex scabrata*
Rounded shinleaf	*Pyrola rotundifolia*
Round-leaved sundew	*Drosera rotundifolia*
Royal fern	*Osmunda regalis*
Rugosa rose	**Rosa rugosa*
Running shadbush	*Amelanchier spicata*
Sallow sedge	*Carex lurida*
Sandbar willow	*Salix exigua*
Sand-spurrey	**Spergularia rubra*
Scouring-rush	*Equisetum scirpoides*
Self-heal	**Prunella vulgaris*
Sensitive fern	*Onoclea sensibilis*
Sessile-fruited arrow-head	*Sagittaria rigida*
Sheep laurel	*Kalmia angustifolia*
Sheep sorrel	**Rumex acetosella*
Shining clubmoss	*Huperzia lucidula*
Shining rose	*Rosa nitida*
Shining willow	*Salix lucida*
Shinleaf	*Pyrola elliptica*
Shore sedge	*Carex lenticularis*
Short-tailed rush	*Juncus brevicaudatus*
Silky willow	*Salix sericea*
Silverrod	*Solidago bicolor*

Silvery glade fern	*Deparia acrostichoides*
Skunk currant	*Ribes glandulosum*
Slender cottongrass	*Eriophorum gracile*
Slender mannagrass	*Glyceria melicaria*
Slender naiad	*Najas gracillima*
Slender sedge	*Carex gracillima*
Slender spikerush	*Eleocharis tenuis*
Slender wheatgrass	*Agropyron trachycaulum*
Small cranberry	*Vaccinium oxycoccos*
Small sundrops	*Oenothera perennis*
Small-flowered crowfoot	*Ranunculus abortivus*
Small-flowered wood-rush	*Luzula parviflora*
Small-fruited bulrush	*Scirpus microcarpus*
Small's spikerush	*Eleocharis smallii*
Smooth greenbriar	*Smilax herbacea*
Smooth shadbush	*Amelanchier laevis*
Snail-seed pondweed	*Potamogeton bicupulatus*
Soft rush	*Juncus effusus*
Softstem bulrush	*Scirpus validus*
Solomon's seal	*Polygonatum pubescens*
Sooty beakrush	*Rhynchospora fusca*
Spatulate-leaved sundew	*Drosera intermedia*
Speckled alder	*Alnus incana*
spikenard	*Aralia racemosa*
Spotted coral-root	*Corallorhiza maculata*
Spotted joe-pye weed	*Eupatorium maculatum*
Spotted St. John's-wort	*Hypericum punctatum*
Spotted touch-me-not	*Impatiens capensis*
Spreading dogbane	*Apocynum androsaemifolium*
Spring beauty	*Claytonia caroliniana*
Squirrel corn	*Dicentra canadensis*
Staghorn clubmoss	*Lycopodium clavatum*
Starflower	*Trientalis borealis*
Steeplebush	*Spiraea tomentosa*
Stinging nettle	*Urtica dioica*
Stipitate sedge	*Carex stipata*
Striped maple	*Acer pensylvanicum*
Sugar maple	*Acer saccharum*
Swamp buttercup	*Ranunculus hispidus var. caricetorum*
Swamp candles	*Lysimachia terrestris*
Swamp dewberry	*Rubus hispidus*
Swamp milkweed	*Asclepias incarnata*
Swamp red currant	*Ribes triste*
Swamp rose	*Rosa palustris*
Swamp saxifrage	*Saxifraga pensylvanica*
Swamp thistle	*Cirsium muticum*
Sweet cicely	*Osmorhiza claytonii*
Sweet coltsfoot	*Petasites frigidus var. palmatus*
Sweet everlasting	*Gnaphalium obtusifolium*
Sweet gale	*Myrica gale*
Sweet grass	*Hierchloe odorata*
Sweet vernal grass	**Anthoxanthum odoratum*
Sweet white violet	*Viola cf. blanda*
Sweet-flag	*Acorus americanus*
Sweet-scented bedstraw	*Galium triflorum*
Swimming pondweed	*Potamogeton natans*
Swollen sedge	*Carex intumescens*
Tall buttercup	**Ranunculus acris*
Tall lettuce	*Lactuca biennis*
Tall meadow rue	*Thalictrum pubescens*
Tall millet-grass	*Milium effusum*
Tall white aster	*Aster lanceolatus*
Tall white bog-orchid	*Habenaria dilitata*
Tall white lettuce	*Prenanthes altissima*
Tamarack	*Larix laricina*
Thread-like rush	*Juncus filiformis*
Three-leaved false Solomon's seal	*Smilacina trifolia*
Three-seeded sedge	*Carex trisperma*
Three-way sedge	*Dulichium arundinaceum*
Ticklegrass	*Agrostis hyemalis var. scabra*
Timothy	**Phleum pratense*
Toothed wood-fern	*Dryopteris carthusiana*
Trailing arbutus	*Epigaea repens*
Tree clubmoss	*Lycopodium dendroideum*
Trout lily	*Erythronium americanum*
Tuckerman's sedge	*Carex tuckermanii*
Turned-backward sedge	*Carex retrorsa*
Tussock sedge	*Carex stricta*
Twinflower	*Linnaea borealis*
Twisted sedge	*Carex torta*
Two-leaved toothwort	*Cardamine diphylla*
Two-seeded sedge	*Carex disperma*
Upon-the-water pondweed	*Potamogeton epihydrus*
Variegated scouring-rush	*Equisetum variegatum*
Velvetleaf blueberry	*Vaccinium myrtilloides*
Very-small pondweed	*Potamogeton pusillus*
Virginia cotton-grass	*Eriophorum virginicum*
Virginia creeper	*Parthenocissus quinquefolia*
Virginia wild-rye	*Elymus virginicus*
Virgin's bower	*Clematis virginiana*

Water avens	*Geum rivale*
Water bulrush	*Scirpus cf subterminalis*
Water horsetail	*Equisetum fluviatile*
Water lobelia	*Lobelia dortmanna*
Water parsnip	*Sium suave*
Water sedge	*Carex aquatilis*
Water-arum	*Calla palustris*
Water-pepper	*Polygonum hydropiper*
Watershield	*Brasenia schreberi*
Water-starwort	*Callitriche palustris*
Weak sedge	*Carex debilis*
Wedge-grass	*Sphenopholis intermedia var. major*
White ash	*Fraxinus americana*
White avens	*Geum canadense*
White baneberry	*Actaea alba*
White beakrush	*Rhynchospora alba*
White boneset	*Eupatorium perfoliatum*
White fringed rein-orchid	*Habenaria blephariglottis*
White mandarin	*Streptopus amplexifolius*
White pine	*Pinus strobus*
White snakeroot	*Eupatorium rugosum*
White spruce	*Picea glauca*
White turtlehead	*Chelone glabra*
White waterlily	*Nymphaea odorata*
Whorled aster	*Aster acuminatus*
Wiegand's sedge	*Carex wiegandii*
Wiegand's wild-rye	*Elymus wiegandii*
Wild ginger	*Asarum canadensis*
Wild lettuce	*Lactuca canadensis*
Wild mint	*Mentha arvensis*
Wild oat-grass	*Danthonia compressa*
Wild sarsaparilla	*Aralia nudicaulis*
Wild white violet	*Viola cf macloskeyi*
Wilderness violet	*Viola selkirkii*
Wild-oats	*Uvularia sessilifolia*
Wild-raisin	*Viburnum nudum var. cassinoides*
Willow-herb	*Epilobium sp.*
Winterberry holly	*Ilex verticillata*
Wintergreen	*Gaultheria procumbens*
Witch-grass	*Agropyron repens*
Wood anemone	*Anemone quinqufolia*
Wood nettle	*Laportea canadensis*
Wood strawberry	*Fragaria vesca*
Woodland cudweed	*Gnaphalium sylvaticum*
Woodland horsetail	*Equisetum sylveticum*
Woods' bluegrass	*Poa alsodes*
Woolgrass	*Scirpus cyperinus*
Wool-grass	*Scirpus cyperinus var. brachypodus*
Woolly panic-grass	*Panicum lanuginosum*
Woolly-headed willow	*Salix eriocephala*
Wooly blue violet	*Viola sororia*
Yarrow	**Achillea millefolium*
Yellow birch	*Betula alleghaniensis*
Yellow rattle	**Rhinanthus crista-galli*
Yellow waterlily	*Nuphar variegata*
Yellowish sedge	*Carex flava*
Zigzag goldenrod	*Solidago flexicaulis*

Appendix 2. Guidelines for State Significance. Vermont Nongame and Natural Heritage Program, 5 November 1996.

GUIDELINES FOR STATE SIGNIFICANCE

Although these are intended as guidelines only, they are meant to represent the default position and any deviation from then would need to be justified.

Meeting any of the following criteria would constitute state significance for the purposes of NNHP inventories and for mapping and entering into the NNHP database.

SPECIES

--- the presence of any state listed (T & E) species, regardless of rank;
--- the presence of any S1 or S2 species regardless of rank.
--- the presence of an G3/S3 species with an EO rank of A or B.

Note that split rank species default to the lower ranking, e.g. an S2/S3 species is treated as an S2 and mapped regardless of its EO rank.

COMMUNITIES

--- the presence of any S1 or S2 communities with an EO rank of A, B, or C;
--- the presence of an S3 or S4 community with an EO rank of A or B;
--- the presence of a S5 community with an EO rank of A.

HABITATS

--- the presence of communal breeding/hibernating areas such as heron rookeries, or bat cave/mine, or vernal pool/amphibian breeding area with significant usage. Note that there are presently no ranking specs for these habitats, and that the above criteria do not distinguish between natural and artificial examples.

SITE

--- some allowances should be made for a cluster of somewhat significant natural communities occurring at a site provided there is some connection between them. Such sites would require at least 2 communities within 1 level of significance and a strong justification for a connection between them. Such a connection could be hydrologic as a small fen within a large marsh or colluvial as a rich woods below a talus slope.

11/5/96

Appendix 3. Partial Flora of Vascular Plants of Nulhegan Basin Division-Conte NFWR and West Mountain WMA.

Scientific name[1]	Common name	West Mtn. WMA	Conte Refuge
Abies balsamea	Balsam fir	x	x
Acer pensylvanicum	Striped maple	x	x
Acer rubrum	Red maple	x	x
Acer saccharum	Sugar maple	x	x
Acer spicatum	Mountain maple	x	x
**Achillea millefolium*[2]	*Yarrow	x	
Acorus americanus	Sweet-flag		x
Actaea alba	White baneberry	x	x
Actaea rubra	Red baneberry	x	x
Adiantum pedatum	Maidenhair fern		x
Agrimonia cf. striata	Roadside agrimony	x	
Agropyron repens	Witch-grass		x
Agropyron trachycaulum	Slender wheatgrass		x
Agrostiis perennans	Autumn bent-grass	x	x
**Agrostis gigantea*	*Giant redtop		x
Agrostis hyemalis var. scabra	Ticklegrass		x
Alnus incana	Speckled alder	x	x
Amelanchier bartramiana	Bartram's shadbush	x	x
Amelanchier laevis	Smooth shadbush	x	x
Amelanchier spicata	Running shadbush	x	x
Andromeda glaucophylla	Bog rosemary	x	x
Anemone quinqufolia	Wood anemone		x
Angelica atropurpurea	Great angelica	x	
**Anthoxanthum odoratum*	*Sweet vernal grass		x
Apocynum androsaemifolium	Spreading dogbane	x	x
Aralia hispida	Bristly sarsparilla	x	x
Aralia nudicaulis	Wild sarsaparilla	x	x
Aralia racemosa	spikenard		x
Arisaema triphyllum	Jack-in-the-pulpit	x	x
Aronia melanocarpa	Black chokeberry	x	x
Asarum canadensis	Wild ginger		x
Asclepias incarnata	Swamp milkweed		x
Aster acuminatus	Whorled aster	x	x
Aster lanceolatus	Tall white aster	x	x
Aster macrophyllus	Large-leaved aster	x	x
Aster nemoralis	Bog aster	x	
Aster puniceus	Purple-stemmed aster	x	x
Aster radula	Low rough aster	x	x

[1] Nomenclature follows Gleason and Cronquist 1991.
[2] Asterisk indicates non-native species.

Aster umbellatus	Flat-topped aster	x	x
Athyrium filix-femina	Lady fern	x	x
Betula alleghaniensis	Yellow birch	x	x
Betula papyrifera	Paper birch	x	x
Betula papyrifera var. cordifolia	Heart-leaved paper birch	x	x
Betula populifolia	Gray birch	x	x
Bidens cernua	Nodding beggar-ticks	x	x
Botrychium virginianum	Rattlesnake fern	x	x
Brachyelytrum erectum	Bearded shorthusk	x	x
Brasenia schreberi	Watershield	x	x
Bromus ciliatus	Fringed brome	x	x
Bulbostylis capillaris	Bulb-styled sedge	x	x
Calamagrostis canadensis	Bluejoint grass	x	x
Calamagrostis pickeringii	Pickering's reed bent-grass	x	
Calla palustris	Water-arum	x	x
Callitriche palustris	Water-starwort	x	x
Calopogon tuberosus	Grass pink	x	x
Caltha palustris	Marsh marigold	x	x
Cardamine diphylla	Two-leaved toothwort		x
Cardamine pensylvanica	Pennsylvania bitter cress	x	x
Carex aquatilis	Water sedge		x
Carex arctata	Contracted sedge	x	x
Carex blanda	Charming sedge	x	x
Carex bromoides	Brome-like sedge	x	x
Carex brunnescens	Brownish sedge	x	x
Carex canescens	Hoary sedge	x	x
Carex communis	Colonial sedge	x	x
Carex crawfordii	Crawford's sedge	x	x
Carex crinita	Long-awned sedge		x
Carex cryptolepis	Northeastern sedge	x	x
Carex debilis	Weak sedge	x	x
Carex deflexa	Bent-down sedge	x	x
Carex deweyana	Dewey's sedge	x	x
Carex disperma	Two-seeded sedge	x	x
Carex echinata	Prickly sedge	x	x
Carex exilis	Bog sedge	x	x
Carex flava	Yellowish sedge	x	
Carex gracillima	Slender sedge	x	x
Carex gynandra	Gynandrous sedge	x	x
Carex intumescens	Swollen sedge	x	x
Carex lasiocarpa	Hairy-fruited sedge	x	x
Carex lenticularis	Shore sedge	x	x
Carex leptalea	Delicate-stemmed sedge	x	x
Carex leptonervia	Finely-nerved sedge	x	x
Carex limosa	Mud sedge	x	x

Carex lupulina	Hop-like sedge		x
Carex lurida	Sallow sedge	x	x
Carex michauxiana	Michaux's sedge	x	
Carex normalis	Right-angled sedge	x	
Carex novae-angliae	New England sedge	x	x
Carex oligosperma	Few-seeded sedge	x	x
Carex pauciflora	Few-flowered sedge	x	x
Carex paupercula	Poor sedge	x	x
Carex pedunculata	Pedunculate sedge	x	x
Carex plantaginea	Plantain-leaved sedge	x	x
Carex projecta	Projecting sedge	x	x
Carex retrorsa	Turned-backward sedge	x	x
Carex scabrata	Rough-stemmed sedge	x	x
Carex scoparia	Pointed broom sedge	x	
Carex stipata	Stipitate sedge	x	x
Carex stricta	Tussock sedge	x	x
Carex torta	Twisted sedge	x	x
Carex tribuloides	Blunt broom sedge	x	x
Carex trisperma	Three-seeded sedge	x	x
Carex tuckermanii	Tuckerman's sedge		x
Carex utriculata	Beaked sedge	x	x
Carex vesicaria	Bladdery sedge	x	x
Carex wiegandii	Wiegand's sedge		x
Caulophyllum thalictroides	Blue cohosh	x	x
Chamaedaphne calyculata	Leatherleaf	x	x
Chelone glabra	White turtlehead	x	x
Chimaphila umbellata	Pipsissewa	x	
**Chrysanthemum leucanthemum*	*Ox-eye daisy	x	x
Chrysosplenium americanum	Golden saxifrage	x	x
Cicuta bulbifera	Bulb-bearing water hemlock	x	x
Cinna latifolia	Drooping woodreed	x	x
Circaea alpina	Dwarf enchanter's nightshade	x	x
Cirsium muticum	Swamp thistle	x	x
Cladium mariscoides	Bog-rush	x	
Claytonia caroliniana	Spring beauty	x	x
Clematis virginiana	Virgin's bower	x	x
Clintonia borealis	Bluebead lily	x	x
Conioselinum chinense	Hemlock parsley	x	
Coptis trifolia	Goldthread	x	x
Corallorhiza maculata	Spotted coral-root	x	
Corallorhiza trifida	Early coral-root		x
Cornus alternifolia	Alternate-leaved dogwood	x	x
Cornus canadensis	Bunchberry	x	x
Cornus sericea	Red-osier dogwood	x	x
Corydalis sempervirens	Pink corydalis	x	

Corylus cornuta	Beaked hazelnut	x	x
Crataegus sp.	Hawthorn	x	x
Cypripedium acaule	Pink lady's slipper	x	x
Cystopteris bulbifera	Bublet fern		x
Cystopteris fragilis	Fragile fern	x	x
Dalibarda repens	Dewdrop	x	x
Danthonia compressa	Wild oat-grass	x	x
Danthonia spicata	Poverty grass	x	x
Dennstaedtia punctilobula	Hay-scented fern	x	x
Deparia acrostichoides	Silvery glade fern	x	x
Dicentra canadensis	Squirrel corn	x	x
Dicentra cucullaria	Dutchman's breeches	x	x
Diervilla lonicera	Bush-honeysuckle	x	x
Diphasiastrum digitatum	Ground-cedar	x	
Drosera intermedia	Spatulate-leaved sundew	x	x
Drosera rotundifolia	Round-leaved sundew	x	x
Dryopteris campyloptera	Mountain wood-fern	x	x
Dryopteris carthusiana	Toothed wood-fern	x	x
Dryopteris cristata	Crested wood-fern	x	x
Dryopteris goldiana	Goldie's wood-fern	x	x
Dryopteris intermedia	Intermediate wood-fern	x	x
Dryopteris marginalis	Marginal wood-fern	x	x
Dulichium arundinaceum	Three-way sedge	x	x
Eleocharis acicularis	Needle-shaped spikerush		x
Eleocharis obtusa	Blunt spikerush		x
Eleocharis olivacea	Olive spikerush	x	
Eleocharis ovata	Ovate spikerush	x	x
Eleocharis smallii	Small's spikerush	x	
Eleocharis tenuis	Slender spikerush	x	
Elymus canadensis	Canada wild-rye		x
Elymus riparius	Riverbank wild-rye		x
Elymus virginicus	Virginia wild-rye	x	x
Elymus wiegandii	Wiegand's wild-rye	x	x
Epifagus virginiana	Beech drops	x	x
Epigaea repens	Trailing arbutus	x	x
Epilobium angustifolium	Fireweed		x
Epilobium ciliatum	Northern willow-herb	x	x
Epilobium sp.	Willow-herb	x	x
**Epipactis helleborine*	*Helleborine	x	x
Equisetum arvense	Common horsetail	x	x
Equisetum fluviatile	Water horsetail	x	x
Equisetum hyemale	Common scouring rush		x
Equisetum scirpoides	Scouring-rush		x
Equisetum sylvaticum	Woodland horsetail	x	x
Equisetum variegatum	Variegated scouring-rush	x	x

Eriocaulon aquaticum	Pipewort	x	x
Eriophorum gracile	Slender cottongrass	x	
Eriophorum vaginatum var. spissum	Hare's tail cotton-grass	x	x
Eriophorum virginicum	Virginia cotton-grass	x	x
Eriophorum viridicarinatum	Green-keeled cottongrass	x	x
Erythronium americanum	Trout lily	x	x
Eupatorium maculatum	Spotted joe-pye weed	x	x
Eupatorium perfoliatum	White boneset	x	
Eupatorium rugosum	White snakeroot	x	x
Euthamia graminifolia	Grass-leaved goldenrod	x	x
Fagus grandifolia	American beech	x	x
**Festuca elatior*	*Nodding fescue		x
Festuca rubra	Red fescue		x
Fragaria vesca	Wood strawberry		x
Fragaria virginiana	Common strawberry	x	x
Fraxinus americana	White ash	x	x
Fraxinus nigra	Black ash	x	x
**Galeopsis tetrahit*	*Hemp nettle	x	x
Galium asprellum	Rough bedstraw	x	x
Galium boreale	Northern bedstraw		x
Galium kamtschaticum	Kamtschatkan bedstraw	x	x
Galium palustre	Marsh bedstraw	x	x
Galium tinctorium	Dye-making bedstraw		x
Galium trifidum	Northern three-lobed bedstraw	x	x
Galium triflorum	Sweet-scented bedstraw	x	x
Gaultheria hispidula	Creeping snowberry	x	x
Gaultheria procumbens	Wintergreen	x	x
Gaylussacia baccata	Black huckleberry	x	
Gentiana linearis	Narrow-leaved gentian		x
Geum canadense	White avens	x	x
Geum macrophyllum	Large-leaved avens	x	x
Geum rivale	Water avens	x	x
Glyceria borealis	Floating mannagrass	x	x
Glyceria canadensis	Rattlesnake mannagrass	x	x
Glyceria grandis	American mannagrass	x	x
Glyceria melicaria	Slender mannagrass	x	x
Glyceria striata	Fowl mannagrass	x	x
Gnaphalium obtusifolium	Sweet everlasting		x
Gnaphalium sylvaticum	Woodland cudweed		x
Goodyera pubescens	rattlesnake-plantain		x
Goodyera repens	Rattlesnake-plantain	x	x
Goodyera tesselata	Alloploid rattlesnake-plantain		x
Gymnocarpium dryopteris	Oak fern	x	x
Habenaria blephariglottis	White fringed rein-orchid	x	x
Habenaria clavellata	Club-spur rein-orchid	x	x
Habenaria dilitata	Tall white bog-orchid		x

Habenaria hyperborea	Northern green orchid		x
Habenaria psycodes	Purple fringed rein-orchid	x	x
Hedyotis caerulea	Bluets		x
Hedyotis longifolia	Longleaf bluet	x	
Heracleum maximum	Cow parsnip	x	x
**Hieracium aurantiacum*	*Paintbrush		x
Hieracium sp.	Hawkweed		x
Hierchloe odorata	Sweet grass		x
Humulus lupulus	Common hops		x
Huperzia lucidula	Shining clubmoss	x	x
Huperzia selago	Fir-clubmoss	x	
Hydrocotyle americana	Pennywort	x	
Hypericum ellipticum	Pale St. John's-wort		x
Hypericum mutilum	Dwarf St. John's-wort	x	x
**Hypericum perforatum*	*Common St. John's-wort	x	
Hypericum punctatum	Spotted St. John's-wort	x	x
Ilex verticillata	Winterberry holly	x	x
Impatiens capensis	Spotted touch-me-not	x	x
Impatiens pallida	Pale touch-me-not		x
Iris versicolor	Blue flag	x	x
Isoetes sp.	Quillwort	x	x
Juncus brevicaudatus	Short-tailed rush	x	x
Juncus canadensis	Canada rush	x	x
Juncus effusus	Soft rush	x	x
Juncus filiformis	Thread-like rush	x	x
Juncus tenuis	Path rush		x
Kalmia angustifolia	Sheep laurel	x	x
Kalmia polifolia	Bog laurel	x	x
Lactuca biennis	Tall lettuce		x
Lactuca canadensis	Wild lettuce		x
Laportea canadensis	Wood nettle	x	x
Larix laricina	Tamarack	x	x
Ledum groenlandicum	Labrador tea	x	x
Leersia oryzoides	Rice cutgrass	x	x
Lemna minor	Duckweed	x	
Lilium canadense	Canada lily	x	x
Linnaea borealis	Twinflower	x	x
Listera auriculata	Aurcled twayblade		x
Listera convallarioides	Broad-leaved twayblade		x
Littorella americana	American shore-grass	x	
Lobelia dortmanna	Water lobelia	x	
Lonicera caerulea var. villosa	Mountain-fly honeysuckle	x	x
Lonicera canadensis	Canada honeysuckle	x	x
Ludwigia palustris	Common water-purslane		x
Luzula acuminata	Acuminate wood-rush		x

Luzula multiflora	Many-flowered wood-rush	x	x
Luzula parviflora	Small-flowered wood-rush		x
**Lychnis flos-cucli*	*Ragged-robin		x
Lycopodiella inundata	Northern bog clubmoss	x	x
Lycopodium annotinum	Bristly clubmoss	x	x
Lycopodium clavatum	Staghorn clubmoss	x	x
Lycopodium dendroideum	Tree clubmoss	x	x
Lycopodium obscurum	Flat-branched tree club-moss	x	x
Lycopus americanus	American water-horehound		x
Lycopus uniflorus	Northern bugleweed	x	x
Lysimachia ciliata	Fringed loosestrife	x	x
Lysimachia terrestris	Swamp candles	x	x
Maianthemum canadense	Canada mayflower	x	x
Matteuccia struthiopteris	Ostrich fern	x	x
Medeola virginiana	Indian cucumber root	x	x
Mentha arvensis	Wild mint	x	x
Menyanthes trifoliata	Buckbean	x	x
Milium effusum	Tall millet-grass	x	x
Mimulus ringens	Monkey flower		x
Mitchella repens	Partridgeberry	x	x
Mitella nuda	Naked mitrewort	x	x
Moneses uniflora	One-flowered pyrola	x	x
Monotropa uniflora	Indian pipe	x	x
Muhlenbergia frondosa	Leafy muhly		x
Muhlenbergia uniflora	Fall dropseed muhly	x	x
Myrica gale	Sweet gale	x	x
Myriophyllum farwellii	Farwell's water-milfoil	x	x
Myriophyllum tenellum	Delicate water-milfoil	x	x
Najas flexilis	Northern naiad	x	
Najas gracillima	Slender naiad	x	
Najas guadalupensis	Guadalupe naiad	x	
Nemopanthus mucronatus	Mountain-holly	x	x
Nuphar variegata	Yellow waterlily	x	x
Nymphaea odorata	White waterlily	x	
Nymphoides cordata	Little floating-heart	x	
Oenothera biennis	Evening primrose	x	
Oenothera perennis	Small sundrops	x	x
Onoclea sensibilis	Sensitive fern	x	x
Oryzopsis asperifolia	Rough-leaved mountain-rice	x	x
Osmorhiza claytonii	Sweet cicely	x	x
Osmunda cinnamomea	Cinnamon fern	x	x
Osmunda claytoniana	Interrupted fern	x	x
Osmunda regalis	Royal fern	x	x
Ostrya virginiana	Hop hornbeam	x	x
Oxalis acetosella	Common wood-sorrel	x	x

Oxalis cf. stricta	Common yellow wood-sorrel		x
Panax trifolium	Dwarf ginseng	x	
Panicum boreale	Northern panic-grass	x	x
Panicum lanuginosum	Woolly panic-grass	x	x
Parthenocissus quinquefolia	Virginia creeper	x	
Petasites frigidus var. palmatus	Sweet coltsfoot	x	
Phalaris arundinacea	Reed canary grass	x	x
Phegopteris connectilis	Long beech fern	x	x
**Phleum pratense*	*Timothy	x	
**Phragmites australis*	*Common reed	x	x
Picea glauca	White spruce	x	x
Picea mariana	Black spruce	x	x
Picea rubens	Red spruce	x	x
Pinus resinosa	Red pine	x	
Pinus strobus	White pine	x	x
**Plantago lanceolata*	*English plantain		x
Poa alsodes	Woods' bluegrass		x
**Poa annua*	*Annual bluegrass		x
**Poa compressa*	*Flat-stemmed bluegrass		x
Poa palustris	Marsh bluegrass	x	x
Poa pratensis	Kentucky bluegrass		x
Poa saltuensis	Drooping bluegrass	x	x
Pogonia ophioglossoides	Rose pogonia	x	x
Polygonatum pubescens	Solomon's seal	x	x
Polygonum cilinode	Fringed bindweed	x	x
Polygonum hydropiper	Water-pepper	x	x
Polygonum sagitattum	Arrow-leaved tearthumb	x	x
Polygonum scandens	False buckwheat	x	
Polypodium virginianum	Rock polypody	x	x
Polystichum acrostichoides	Christmas fern	x	x
Polysticuhm braunii	Braun's holly-fern		x
Pontederia cordata	Pickerelweed	x	
Populus balsamifera	Balsam poplar	x	x
Populus grandidentata	Bigtooth aspen	x	x
Populus tremuloides	Quaking aspen	x	x
Potamogeton amplifolius	Large-leaved pondweed	x	
Potamogeton bicupulatus	Snail-seed pondweed	x	
Potamogeton epihydrus	Upon-the-water pondweed	x	x
Potamogeton gramineus	Grass-like pondweed	x	
Potamogeton natans	Swimming pondweed	x	
Potamogeton obtusifolius	Blunt-leaved pondweed	x	
Potamogeton pusillus	Very-small pondweed	x	x
Potentilla norvegica	Rough cinquefoil		x
Potentilla palustris	Marsh cinquefoil	x	
Potentilla simplex	Common cinquefoil		x

Prenanthes altissima	Tall white lettuce	x	x
**Prunella vulgaris*	*Self-heal	x	x
Prunus pensylvanica	Pin cherry	x	x
Prunus serotina	Black cherry	x	x
Prunus virginiana	Choke cherry	x	x
Pteridium aquilinum	Bracken fern	x	x
Puccinellia fernaldii	Fernald's alkali-grass	x	x
Pyrola chlorantha	Greenish-flowered pyrola		x
Pyrola elliptica	Shinleaf		x
Pyrola rotundifolia	Rounded shinleaf	x	
Pyrola secunda	One-sided pyrola	x	x
Quercus rubra	Red oak	x	
Ranunculus abortivus	Small-flowered crowfoot		x
**Ranunculus acris*	*Tall buttercup		x
Ranunculus hispidus var. caricetorum	Swamp buttercup	x	x
Ranunculus pensylvanicus	Bristly crowfoot	x	
Ranunculus recurvatus	Hooked crowfoot	x	x
Ranunculus reptans	Creeping spearwort	x	x
Rhamnus alnifolia	Alder-leaved buckthorn	x	x
**Rhamnus cathartica*	*Common buckthorn		x
**Rhinanthus crista-galli*	*Yellow rattle		x
Rhododendron canadense	Rhodora	x	x
Rhynchospora alba	White beakrush	x	x
Rhynchospora fusca	Sooty beakrush	x	
Ribes cynosbati	Prickly gooseberry		x
Ribes glandulosum	Skunk currant	x	x
Ribes lacustre	Bristly black currant	x	x
Ribes triste	Swamp red currant	x	x
Rosa nitida	Shining rose	x	x
Rosa palustris	Swamp rose	x	
**Rosa rugosa*	*Rugosa rose		x
Rubus allegheniensis	Blackberry	x	x
Rubus cf. flagellaris	Northern dewberry		x
Rubus hispidus	Swamp dewberry	x	
Rubus idaeus	Red raspberry	x	x
Rubus odoratus	Purple-flowering raspberry	x	
Rubus pubescens	Dwarf raspberry	x	x
Rubus setosus	Bristly blackberry		x
**Rumex acetosella*	*Sheep sorrel		x
Sagina procumbens	Pearlwort		x
Sagittaria latifolia	Broad-leaved arrowhead	x	x
Sagittaria rigida	Sessile-fruited arrow-head		x
Salix bebbiana	Bebb's willow	x	x
Salix discolor	Common pussy willow	x	x
Salix eriocephala	Woolly-headed willow	x	x
Salix exigua	Sandbar willow		x

Salix lucida	Shining willow	x	x
Salix sericea	Silky willow	x	x
Sambucus canadensis	Common elderberry	x	x
Sambucus racemosa ssp. pubens var. pubens	Red-berried elder	x	x
Sarracenia purpurea	Pitcher plant	x	x
Saxifraga pensylvanica	Swamp saxifrage		x
Scheuchzeria palustris ssp. americana	Pod-grass	x	x
Schizachne purpurascens	False melic	x	x
Scirpus atrovirens	Black bulrush	x	x
Scirpus cf subterminalis	Water bulrush	x	
Scirpus cyperinus	Woolgrass	x	x
Scirpus hudsonianus	Hudson Bay bulrush	x	
Scirpus microcarpus	Small-fruited bulrush	x	x
Scirpus validus	Softstem bulrush	x	
Scutellaria epilobifolia	Marsh skullcap	x	x
Scutellaria lateriflora	Mad-dog skullcap	x	
Senecio aurea	Golden ragwort		x
Senecio schweinitzianus (robbinsii)	Robbins' ragwort	x	x
Sium suave	Water parsnip	x	x
Smilacina racemosa	False Solomon's seal	x	x
Smilacina trifolia	Three-leaved false Solomon's seal	x	x
Smilax herbacea	Smooth greenbriar		x
Solidago bicolor	Silverrod	x	x
Solidago canadensis	Canada goldenrod	x	x
Solidago flexicaulis	Zigzag goldenrod	x	x
Solidago gigantea	Giant goldenrod		x
Solidago juncea	Early goldenrod		x
Solidago macrophylla	Large-leaved goldenrod	x	x
Solidago nemoralis	Gray goldenrod	x	x
Solidago puberula	Dusty goldenrod		x
Solidago rugosa	Rough goldenrod	x	x
Solidago uliginosa	Northern bog-goldenrod	x	
Sorbus americana	American mountain-ash	x	x
Sparganium americanum	American bur-reed	x	x
Sparganium emersum	Emergent bur-reed	x	x
Sparganium fluctuans	Floating bur-reed		x
**Spergularia rubra*	*Sand-spurrey		x
Sphenopholis intermedia var. major	Wedge-grass		x
Spiraea alba var. latifolia	Meadow-sweet	x	x
Spiraea tomentosa	Steeplebush	x	x
Spiranthes cernua	Nodding ladies'-tresses		x
Stellaria borealis	Northern stitchwort	x	x
Stellaria cf. alsine	Bog-stitchwort	x	
Streptopus amplexifolius	White mandarin	x	x
Streptopus roseus	Rose twisted stalk	x	x

**Taraxacum officinale*	*Dandelion	x	x
Taxus canadensis	Canada yew	x	x
Thalictrum pubescens	Tall meadow rue	x	x
Thelypteris noveboracensis	New York fern	x	x
Thelypteris palustris	Marsh fern	x	x
Thuja occidentalis	Northern white cedar	x	x
Tiarella cordifolia	Foamflower	x	x
Toxicodendron radicans	Poison-ivy	x	x
Triadenum fraseri	Marsh St. John's-wort	x	x
Trientalis borealis	Starflower	x	x
Trillium erectum	Red trillium	x	x
Trillium undulatum	Painted trillium	x	x
Tsuga canadensis	Hemlock	x	x
**Tussilago farfara*	*Coltsfoot	x	x
Typha latifolia	Common cattail	x	x
Ulmus americana	American elm	x	x
Urtica dioica	Stinging nettle	x	
Utricularia cornuta	Horned bladderwort	x	x
Utricularia geminiscapa	Hidden bladderwort	x	
Utricularia gibba	Humped bladderwort	x	
Utricularia intermedia	Northern bladderwort	x	
Utricularia minor	Lesser bladderwort	x	
Utricularia purpurea	Purple bladderwort	x	x
Utricularia resupinata	Northeastern bladderwort	x	x
Utricularia vulgaris	Common bladderwort	x	
Uvularia sessilifolia	Wild-oats	x	x
Vaccinium angustifolium	Low sweet blueberry	x	x
Vaccinium macrocarpon	Large cranberry	x	
Vaccinium myrtilloides	Velvetleaf blueberry	x	x
Vaccinium oxycoccos	Small cranberry	x	x
Vaccinium vitis-idaea	Ligonberry		x
Veratrum viride	False hellebore	x	x
**Verbascum thapsus*	*Common mullein	x	
Veronica americana	American brooklime	x	
Veronica scutellata	Marsh speedwell	x	x
Viburnum alnifolium	Hobblebush	x	x
Viburnum lentago	Nannyberry	x	x
Viburnum nudum var. cassinoides	Wild-raisin	x	x
Viburnum opulus var. americanum	Highbush-cranberry	x	x
**Vicia cracca*	*Cow vetch		x
Viola canadensis	Canada violet	x	x
Viola cf macloskeyi	Wild white violet	x	x
Viola cf. blanda	Sweet white violet	x	x
Viola cucullata	Marsh blue violet	x	x
Viola pubescens	Downy violet		x

Viola renifolia	Kidney-leaved violet	x	x
Viola rotundifolia	Early yellow violet	x	x
Viola selkirkii	Wilderness violet	x	x
Viola sororia	Wooly blue violet	x	x
Xyris montana	Northern yellow-eyed-grass	x	
Zizia aurea	Common golden alexanders		x

Species in adjacent Wenlock WMA

Carex arcta	Contracted sedge
Diphasiastrum tristachyum	Blue ground-cedar
Scirpus cyperinus var. brachypodus	Wool-grass
Trillium cernuum	Nodding trillium

Appendix 4. Informal List of Some Small Patches of More Mature Forest, Nulhegan Basin Division-Conte NFWR and West Mountain WMA.

The following is an informal attempt to list some of the small areas that stood out as being especially mature forest, in comparison to the bulk of the project area. The list does not include those areas that are discussed in more detail in the section on Significant Natural Community Complexes (Chapter 3). The listed areas are relatively small, and no attempt has been made to quantify the extent of the older forest in each location. It should be noted that riparian areas and pond perimeters contain some of the least disturbed forest.

Conte Refuge

Observation Point	Natural Community Type	Notes
282	Lowland spruce-fir forest	Below secondary summit, Sable Mtn.
315	Red spruce-hardwood forest	Upper Black Branch ravine; big cedar
324	Montane yellow birch-red spruce	Trisummit Mtn., Potash rim
2202-09	NH and NH seepage forest	Logger Branch headwaters
2559	Spruce ledge (2c)	Potash rim
2610	Northern hardwood forest	Adj. to powerline, upper Black Branch
2611	Lowland spruce-fir forest (3a)	East side, upper Black Branch
2614	Red spruce-hardwood forest	Below upper Black Branch falls

WMWMA

475	Hemlock-red spruce forest	N. of Wind Tunnel Camp, Dennis Pond outlet
982a	Northern hardwood forest	Maidstone Lake Hill east slope
996	Small cedar swamp - unmapped	Bouldery kame east of Ferdinand Bog
S. of 1002	Northern hardwood forest	Hill S. of Unknown Pond
2071	Red spruce-hardwood forest	Tuttle Pond outlet
2121	Lowland spruce-fir forest	N. of Walker Dam
2507	Hemlock-white pine-NH forest	Lower Paul Stream, N. side
2526	Hemlock-red spruce forest	Brendan Whittaker's stand

Appendix 5. GIS Layers Developed by Lapin and Engstrom for West Mtn. WMA and Nulhegan Basin Division-Conte NFWR

SHAPE FILE NAME	CONTENTS	DESCRIPTION
wmwma_2002_fullclip_nc	Natural community polygons, WMWMA, clipped to boundaries not including TNC acquisitions in Mud and Tuttle ponds areas	Polygons of natural communities
wmwma_nc_2002_reportfinal	Natural community polygons, WMWMA, includes acquisitions around Mud and Tuttle ponds, plus a part of Wenlock adjacent to the northwestern	Polygons of natural communities
wmwma_nc_2002final	Natural community polygons, WMWMA, full mapped area, extends beyond WMA boundaries in some areas	Polygons of natural communities
wsmtf01pt	Natural community attribute points, WMWMA	Points that carried natural community attributes for the polyline layer
Conte_and_floodplain_clip	Natural community polygons, Conte and adjacent area of Nulhegan River floodplain	Polygons of natural communities
Conte_2002_fullclip_nc	Natural community polygons, Conte, clipped to Refuge boundary	Polygons of natural communities
Conte_new_merge	Natural community polygons, Conte, full mapped area, extends beyond Refuge boundaries in some areas	Polygons of natural communities
contf01pt	Natural community attribute points, Conte	Points that carried natural community attributes that were then merged to polygon layer
gps1_ml_be	GPS observation points from Lapin and Engstrom field work, inclcuding some that were later on-screen digitized post field-season	A record of where ecologists have been in the field, May 2000-October 2001
gps2_ml_be	GPS observation points from Lapin and Engstrom field work, inclcuding some that were later on-screen digitized post field-season	A record of where ecologists have been in the field, May 2000-October 2002
pIntall	GPS locations and some on-screen digitized locations of rare and uncommon plant species	Includes data of boh field seasons (2000, 2001), with S ranks and EO ranks
exotplts	GPS locations and some on-screen digitized locations of invasive exotic plant species	Includes data of both field seasons (2000, 2001)

plots	GPS locations of Representative Sampling Site natural community plots	Data collected at centerline end stake
lndfrms2	Polygons of major landforms	Accompanies Landscape Mosaic-Level Ecosystem Classification
Phys2cl	Polygons of Some State Significant Complexes	Accompanies complex descriptions in Chapter 3, but is an incomplete layer in that it does not depict all the sites discussed
Nulhegan_sfpatches_bounded	Polygons of older conifer forest in the Nulhegan Basin	On-screen digitized from aerial and ortho-photos and field knowledge
Eco_altern_Conte	Polygons that refer to conservation analysis of the Nulhegan Basin	Accompanies text in separate report on Nulhegan Basin.
nulhegan_structure_corr	Polygons of areas of expected "irregular" successional pathway	Polygons that indicate areas in the Refuge where successional trajectories are "known" to be "irregular" in an 80-100 year time horizon (I.e. longer-term change in vegetation characteristic of a natural community); for use in spatio-temporal modeling of
landforms.avl	Legend file for lndfrms2 shapefile	
wmwma+.avl	Legend file for all "clips" of WMWMA natural community layers	Final polygon legend
conte.avl	Legend file for all "clips" of WMWMA natural community layers	Final polygon legend

Figure 1.
Natural Communities
West Mountain WMA,
and adjacent lands of The Nature Conservancy,
with a small portion of Wenlock WMA,
Essex County, VT

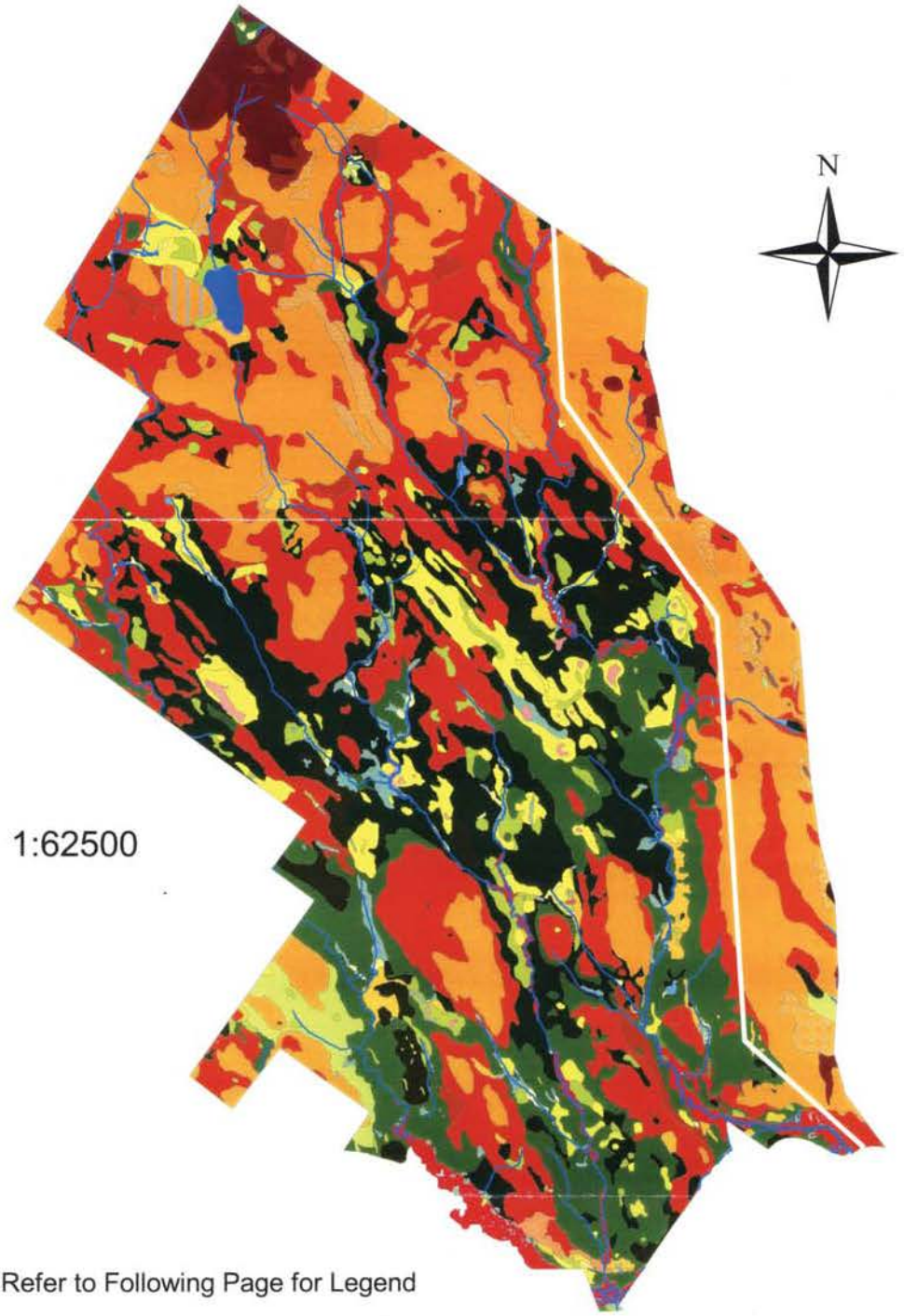
Please Refer to Following Page for Legend

Natural Community Mapping by Marc Lapin and Brett Engstrom, 2002.
With Additional GIS Processing by John DeLeo, Lyndon State College, and Michelle Babione, USFWS.
Streams and Rivers and WMA Boundary from VCGI.

Figure 1 (cont.). Natural Communities, West Mountain WMA, and adjacent lands of The Nature Conservancy, with a small portion of Wenlock WMA, Essex County, VT

LEGEND

Figure 2.
Natural Communities
Nulhegan Basin Division, Silvio O. Conte NFWR, and an adjacent portion of the Nulhegan River Floodplain, Essex County, VT



Please Refer to Following Page for Legend

Natural Community Mapping by Brett Engstrom and Marc Lapin, 2002.
With Additional GIS Processing by John DeLeo, Lyndon State College, and Michelle Babione, USFWS.
Streams and Rivers and Refuge Boundary from VCGI.

Figure 2 (cont.). Natural Communities, Nulhegan Basin Division, Silvio O. Conte NFWR, and an adjacent portion of the Nulhegan River Floodplain, Essex County, VT

LEGEND

Natural Communities, Nulhegan Basin Division

Natural Community and Variant Types

- Montane S-F Forest - 2
- S-F Ledge - 2c
- Lowland S-F Forest, mesic - 3a
- Lowland S-F, wet-mesic - 3b
- Lowland S-F-Red maple - 3c
- Lowland S-F, glaciofluvial - 3d
- Montane YB-RS Forest - 4
- Montane YB-SM-RS - 4a
- Montane YB-PB - 4b
- RS-Hardwood Forest - 5a
- RS-Hardwood, well drained - 5b
- RS-Hardwood, seepage - 5s
- Boreal Talus Woodland - 6
- NH Forest, classic - 8a
- SM-WA NH Forest - 8c
- YB-NH Forest - 8d
- NH Forest, beech dominant - 8g
- High-elevation NH Forest - 8h
- NH Forest, species poor - 8p
- NH Forest, seepage - 8s
- NH Forest, wet-mesic - 8w
- NH Talus Woodland - 13
- Erosional River Bluff - 27
- RM-BA Swamp - 45
- NWC Swamp - 51
- NWC Sloping Seepage Forest - 51a
- Boreal Acidic NWC Swamp - 51b
- S-F-T Swamp - 52
- RS-Hardwood Swamp - 52a
- Black Spruce Swamp - 53
- Seep - 55
- Vernal Pool - 56
- Dwarf Shrub Bog - 57
- BS Woodland Bog - 58
- Poor Fen - 61
- Shallow Marsh/Beaver Meadow - 64a
- Beaver Pond - 64c
- Beaver Wetland, undifferentiated - 64d
- River Sand/Gravel Shore - 72
- River Cobble Shore - 73
- Alluvial Shrubland - 77
- Alder Swamp - 78
- Alder Swamp, deep peat - 78a
- Sweet Gale Shoreline Swamp - 79
- Mixed Northern Seepage Swamp - 81
- Alluvial Meadow - 82
- Mixed Northern Floodplain Forest - 83
- Oxbow Marsh - 85
- Pond - 98

Streams and Rivers