ALEXANDRIA
NATURAL RESOURCES INVENTORY

Prepared for:
Alexandria Conservation Commission

Jeffry N. Littleton
Moosewood Ecological LLC
Innovative Conservation Solutions for New England
PO Box 9—Chesterfield, NH 03443
jeff@moosewoodecological.com
(603) 831-1980

ALEXANDRIA
NATURAL RESOURCES INVENTORY

Prepared for:
Alexandria Conservation Commission

JEFFRY N. LITTLETON
Principal Ecologist

Moosewood Ecological LLC
Innovative Conservation Solutions for New England

PO Box 9
Chesterfield, NH 03443
(603) 831-1980
Jeff@moosewoodecological.com
www.moosewoodecological.com

July 2013 (first edition)
December 2016 (revised edition)

Cover photographs – *Left*: Smith River from Berry Road; *Top Right*: Alexandria Bog viewed from Foster Pond Road with Pine Hill and Forbes Mountain in the background; *Bottom Right*: pitcher plants and brilliant deep-red sphagnum moss observed in a unique peatland ecosystem; *Center*: broad-winged hawk hunting atop a red spruce observed along the headwaters of Patten Brook along Washburn Road.

TABLE OF CONTENTS

INTRODUCTION

Natural Resources and Land Use Planning

Currently, New Hampshire's population is growing at a rate that is twofold that of the other New England states. The population has doubled in the forty years leading up to the turn of the century in 2000, and there was a rise in population of 17.2% between 1990 and 2004 alone. This rate of growth is followed by VT (10.4%), RI (7.7%), ME (7.3%), MA (6.7%), and CT (6.7%). Furthermore, it has been projected that the state will experience an increase of 23% from 1997 to 2020. New Hampshire's growth and development pressure will tax the state's natural resources if not managed with diligence.

One of the first steps in planning for growth and development is to conduct a natural resources inventory (NRI). This effort helps to better understand what natural resources are within a town and where they are located. As such, an NRI is a list and description of the natural elements found within and adjacent to a town (or even a watershed or larger region). These can include such elements as wetlands, aquifers, ponds, rivers, forests, plants, soils, and wildlife. These data elements can be created from existing sources or from field-based assessments to better reflect the extent of natural resources within a community.

New Hampshire statutes mandate that communities shall create an NRI. This is generally the responsibility of the Conservation Commission, whose purpose is "for the proper utilization and protection of natural resources and for the protection of watershed resources" of the town. In particular, RSA 36-A:2 continues to state that "Such commission shall conduct researches into its local land and water areas [and] … shall keep an index of all open space and natural, aesthetic or ecological areas within the city or town … with the plan of obtaining information pertinent to the proper utilization of such areas, including lands owned by the state or lands owned by a town or city. It shall keep an index of all marshlands, swamps and all other wetlands in a like manner…"

An NRI can serve as the basis for developing innovative land use planning that can be adopted to help protect various resources, such as wetlands, wildlife habitats, and biological diversity. Biological diversity, or biodiversity, refers to the variety, variability, and complexity of life in all its forms and includes various ecological processes (for

example, nutrient cycling, flooding, fires, wind events, and succession) that have helped to shape species over time.

Biodiversity includes various levels of ecological organization such as individual species and their genes that have evolved over time, as well as the many intricate plant and wildlife populations. It refers to even higher levels of organization including the assemblage of ecological communities[1] and even entire ecosystems, such as wetlands, woodlands, and rivers. Therefore, the concept of biodiversity encompasses all levels of biological organization and the interactions of living organisms within their physical environments. It is at the heart of this understanding of the dynamics of biodiversity that we seek to develop protection strategies, helping to ensure a healthy environment for humans, as well as all other life forms.

Planning for the conservation of natural resources and biodiversity is not a new concept altogether. It has helped in such efforts as the recovery of the American bald eagle; assisted in building preserves and managing other lands for species of conservation concern, as well as our most common species; aided in the identification of biodiversity hot spots; and helped to identify and protect critical wildlife habitats within our landscape. It has been a center piece for natural resources protection, restoration, and adaptive management for the past four decades.

This form of land use planning is not static but one that is ever-changing. It is a vision that should be based on the principles of conservation biology and incorporates the current ecological structure of a given area (such as a town, a watershed, or an entire region). Thus, conservation planning strives to incorporate the socio-economic fabric of our world with that of the ecological structure. This effort can help build more sustainable, more resilient New Hampshire communities into the future as a result of implementing comprehensive land use planning that includes our natural environment and built infrastructure.

The need for this type of informed land use planning is becoming more evident. Ecosystems and their inhabitants have long been susceptible to long-term degradation from overexploitation and misuse of natural resources. This has led to a precipitous

[1] An ecological community is a group of two or more populations of different species found in the same place.

decline in several species, some even resulting in extinction altogether. It has also led to the loss of critical habitats. While the past few decades certainly have seen a positive change in resource management and protection, there has been a distinct rise in conservation planning efforts within the 21st century, especially in New Hampshire.

Statement of Purpose

The first phase of the Alexandria Natural Resources Inventory (NRI) was initiated in May 2012. An initial report was presented to the town in July 2013. The second phase was initiated in April 2016 to include more broad scale field assessments. The overall purpose was to prepare an NRI to support Alexandria's natural resource protection efforts, provide a basis for informed land use planning, and promote community education. Goals of the project included 1) the development of a series of natural resources maps, and 2) conducting field assessments to document current conditions, verify wildlife habitats, and record wildlife and plant species observations.

These assessments were made from roadside surveys, as well as site visits on properties whose landowners provided access to record such information. This effort helps to achieve two objectives. First, field assessments help to verify existing data on wildlife habitats. For instance, the NH Fish and Game Wildlife Action Plan has mapped a variety of wildlife habitats throughout the state. While this is a great effort at learning about NH's important habitats it is imperative to verify its accuracy. Second, it provides the opportunity to better understand Alexandria's biological diversity and other significant ecological features. A detailed narrative of the site assessments has been included in Appendix A. However, excerpts have been included in the various chapters that follow.

As such, the Alexandria NRI directly addresses various aspects of the 2010 Master Plan. Protection of natural resources is directly addressed in the Vision Statement and is included in two main goals listed in the Master Plan on p. 6, as follows:

- To preserve and protect the predominantly rural character of the town.

- To identify and protect natural resources: ecological features, bodies of water, streams, wetlands, floodplains, stream banks, woodlands, aquifers, open spaces, wildlife habitats, and forests.

Furthermore, the 2010 Master Plan continues to list explicit goals for topics focused on natural resources protection and town planning. The following is a list of topics, goals, and recommendations that pertain to the Alexandria NRI, as found on pages 7-8 of the 2010 Master Plan:

Land Use

Goal: Locate, identify, and label wetlands, floodplains, protected lands, roads, and placement for future subdivisions

Recommendations:

- Collect data and identify the datasets on maps.
- Map details of existing land use in Alexandria.
- Establish ordinances and regulations designed to preserve and protect the rural character of Alexandria.
- Restrict industrial use to specific areas in town.
- Endorse "green" approach to subdivision regulations.
- Inventory all roads and natural resources.

Conservation

Goal: To protect the environment such as, wetlands, stone fences (land boundaries) water (both surface and groundwater), lakes, streams and wildlife as well as particular locations of unusual trees and flora/fauna.

Recommendations:

- Encourage land donations, conservation easements and land trusts.
- Recommend that the Alexandria Bog be established as a prime wetland.
- Develop and implement environmental education within the community.

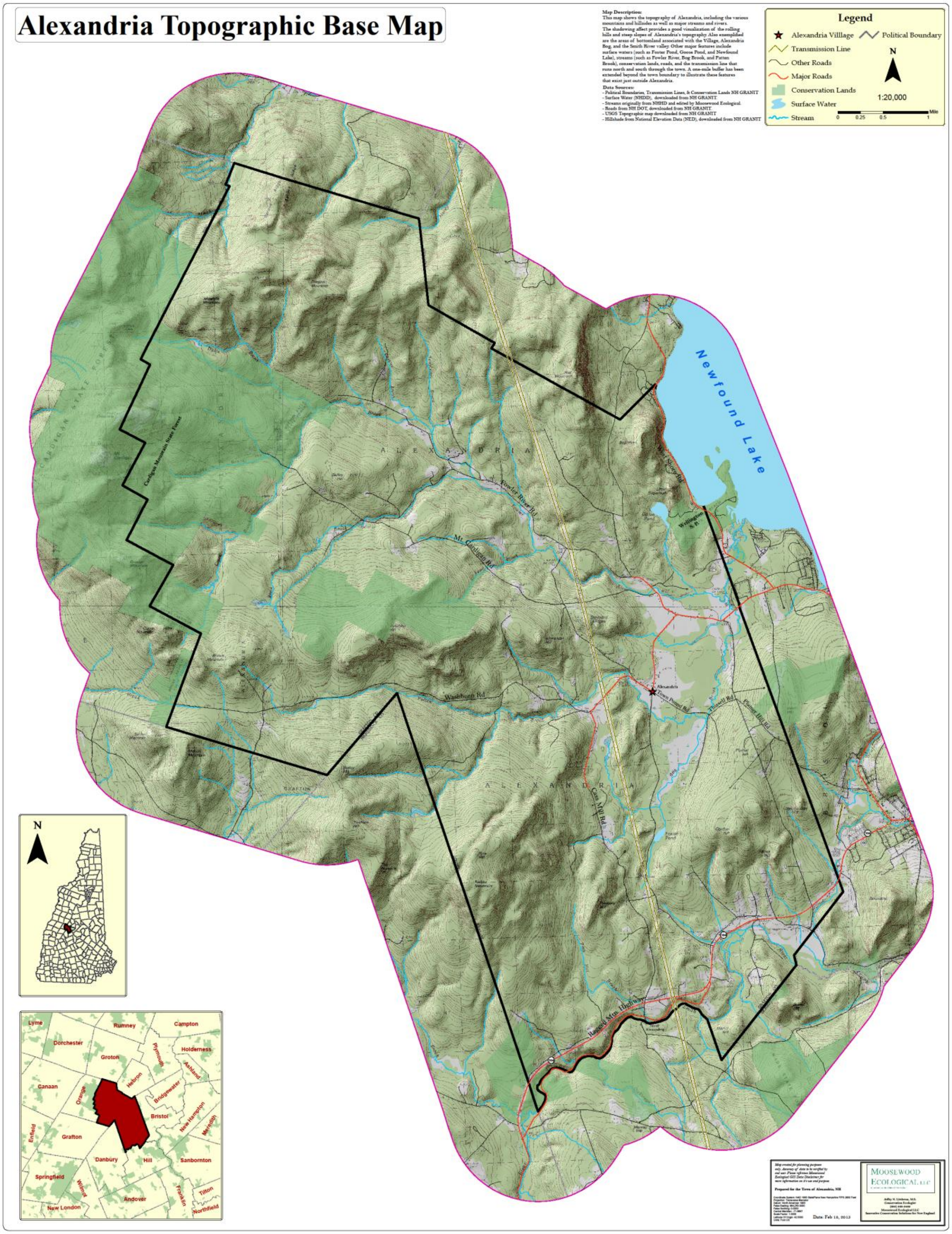
Alexandria's Physical Landscape

Located in the Lakes Region of New Hampshire, Alexandria is a small, mostly rural community of about 1,500 year-round residents. The town covers nearly 44 square miles, or about 28,000 acres. Much of Alexandria is characterized by its mountainous terrain with steep slopes and fast-flowing brooks (Map 1, Page 6). The shadowing effect on the topographic map helps to illuminate this fact. In addition, large unfragmented blocks of forests dominate Alexandria's landscape.

The Village and the surrounding area are located in the lowlands, which are mostly flat, having been shaped over time by the Fowler River, Patten Brook, and Bog Brook. Areas along the Smith River are relatively flat as well. In addition to rivers and brooks, other major water bodies include Foster Pond, Goose Pond, and Newfound Lake.

Wetlands are scattered throughout the town and are relatively small due to widespread steep slopes. These small wetlands can be found at the headwater streams that form at the base of the steep slopes. Larger wetlands can be found around the Village. The most notable and well known wetland is the Alexandria Bog. This is the largest and most diverse wetland complex in town.

Alexandria includes two state-owned conserved lands. A portion of Cardigan Mountain State Forest is located in the northwest part of town. Wellington State Park can be found adjacent to Newfound Lake, extending into Bristol. Other tracts of privately-owned conservation lands exist as well. The largest area can be found on Hutchins Hill, mostly located within the Fowler River watershed.


Alexandria Topographic Base Map
Map Description:
This map shows the topography of Alexandria, including the various mountains and hillsides as well as major streams and rivers.
The shadowing affect provides a good visualization of the rolling hills and steep slopes of Alexandria's topography. Also exemplified are the areas of bottomland associated with the Village, Alexandria Bog, and the Smith River valley. Other major features include surface waters (such as Foster Pond, Goose Pond, and Newfound Lake), streams (such as Fowler River, Bog Brook, and Patten Brook), conservation lands, roads, and the transmission line that runs north and south through the town. A one-mile buffer has been extended beyond the town boundary to illustrate these features that exist just outside Alexandria.
Data Sources:
- Political Boundaries, Transmission Lines, & Conservation Lands NH GRANIT
- Surface Water (NHDD), downloaded from NH GRANIT
- Streams originally from NHHD and edited by Moosewood Ecological
- Roads from NH DOT, downloaded from NH GRANIT
- USGS Topographic map downloaded from NH GRANIT
- Hillshade from National Elevation Data (NED), downloaded from NH GRANIT
Legend
Alexandria Villlage
Political Boundary
Transmission Line
Other Roads
Major Roads
Conservation Lands
Surface Water
Stream
N
1:20,000
0 0.25 0.5 1 Mile
Newfound Lake
Fowler River Rd
Mt. Cardigan Rd
Washburn Rd
Town Pound Rd
Cass Mill Rd
N
Lyme
Rumney
Campton
Dorchester
Groton
Holderness
Plymouth
Ashland
Canaan
Orange
Hebron
Bridgewater
Bristol
New Hampton
Meredith
Enfield
Grafton
Danbury
Hill
Sanbornton
Springfield
Wilmot
Andover
Franklin
Tilton
New London
Northfield
Prepared for the Town of Alexandria, NH
Date: Feb 16, 2012
MOOSEWOOD ECOLOGICAL LLC

WATER RESOURCES

Water resources represent some of our most fragile ecosystems and are particularly sensitive to certain types of land use. Water resources comprise a variety of natural features, including both surface water and groundwater resources. Such features include our ponds and lakes, streams and rivers, wetlands, and aquifers. In terms of their importance, these resources provide a variety of ecological functions and societal values, including:

- Water quality maintenance
- Flood control
- Wildlife and fisheries habitat
- Drinking water sources
- Recreation
- Visual quality and aesthetics
- Rare and endangered species habitat and natural communities
- Groundwater recharge and discharge
- Shoreline stabilization
- Educational and scientific value
- Overall biological diversity of Alexandria

Surface Waters and Streams

Alexandria contains a variety of surface water bodies, including rivers, streams, ponds, and lakes, that are distributed throughout the town (Map 2, Page 18). Not only do water bodies provide a multitude of benefits such as fishing, hunting, boating, swimming, and nature watching, they are also extremely significant for diverse wildlife and plants that depend upon these resources for part or all of their life cycle needs. Generally, major threats to water resources include potential water quality degradation and habitat loss due to surrounding land uses, including unsustainable forestry and agricultural practices and land conversion associated with various types of developments (residential, commercial, industrial, institutional, and roadways).

Lakes and ponds in Alexandria cover approximately 81 acres, including three named water bodies (Table 1). Although Newfound Lake totals 4,451 acres, there are only 60 acres located within the town boundary. These water bodies have been recognized and labeled as such by the NH Dept. of Environmental Services and/or the US Geological Survey. Two of the waterbodies, Newfound Lake and Goose Pond, are included on the NH Dept. of Environmental Services Consolidated List of Water Bodies subject to the Shoreland Water Quality Protection Act under RSA 483-B[2]. The third water body is Foster Pond along Bog Road.

Table 1. Summary of ponds and lakes in Alexandria.

Surface Water Body Name	Size
Newfound Lake	4,450.7 acres*
Goose Pond	15.5 acres
Foster Pond	5.9 acres

SOURCE: USGS topography, GRANIT hydrogrpahy datasets, NH DES RSA 483-B.

Water bodies in **bold type** are jurisdictional designations by NH DES and subject to the Shoreland Water Quality Protection Act under RSA 483-B.

* This is the total acreage of Newfound Lake. There are roughly 60 acres of Newfound Lake that occurs in Alexandria.

[2] The Shoreland Water Quality Protection Act (RSA 483-B) is a state statute that was prepared to protect water quality for designated public waters. The Act establishes minimum standards for various setbacks from the reference line based on land use within the designated 250-foot buffer. For most new construction, as well as land excavating and filling, a state permit may be required (certain exemptions apply). All great ponds (greater than 10 acres), fourth order streams or higher, and state-designated rivers have been identified by the NH Dept. of Environmental Services (NH DES) as those water bodies that are subject to the Act. For more details on the Act, as well as certified administrative rules, refer to the NH DES at http://des.nh.gov/organization/divisions/water/wetlands/cspa/index.htm

Foster Pond as viewed from Bog Road is a very familiar pond in Alexandria. Foster Pond is part of a much larger wetland associated with Alexandria Bog. This open water habitat helps to increase and maintain biological diversity, offering habitat for many species such as waterfowl, river otter, amphibians, and fish.

Nearly 90 miles of rivers and streams have been mapped in Alexandria (Table 2, Page 10). The most commonly known waterways include Smith River, Fowler River, Patten Brook, Bog Brook, Brock Brook, and Clark Brook. Many of the other streams form the headwaters that feed these waterways, which are significant for providing cold, well-oxygenated water for fish and other aquatic life. Most of these headwater streams form high on mountain slopes, including Oregon Mountain, Mowglis Mountain, Cardigan Mountain, Orange Mountain, Crane Mountain, and Brown Mountain. Of the many rivers and streams, two are included on the NH DES Consolidated List of Water Bodies subject to the Shoreland Water Quality Protection Act under RSA 483-B, including the Fowler River and Smith River. The Fowler River comes under the jurisdiction of the Act at the juncture at Bog Brook, whereas the Smith River is jurisdictional along its entire length through Alexandria.

Table 2. Summary of rivers and streams in Alexandria.

Stream Name	Length
Fowler River	4.2 miles
Smith River	12.5 miles
Patten Brook	6.9 miles
Bog Brook	5.1 miles
Brock Brook	3.3 miles
Clark Brook	5.7 miles
Other Streams	52.1 miles

SOURCE: USGS topography, GRANIT hydrography datasets, and NH DES RSA 483-B.

Watercourses in **bold type** are jurisdictional designations by NH DES and subject to the Shoreland Water Quality Protection Act under RSA 483-B.

The upper section of Patten Brook roughly parallels Washburn Road before heading southeast where it meets Alexandria Bog. This section can be viewed from Bog Rd. Streams provide significant habitat for aquatic and semi-aquatic wildlife such as fish, insects, beaver, mink, and river otter. The adjacent forested riparian habitat serves as wildlife corridors for many mammals as they travel throughout the town.

Wetlands

Wetlands are not always wet. They generally include familiar places such as marshes, wet meadows, beaver impoundments, swamps, fens, bogs, and other surface water bodies. As noted above, they perform a variety of ecological functions, such as providing significant habitats for wildlife and plants, maintaining good water quality, providing storage during a flood event, and sources for recreation. In New Hampshire,

wetlands are defined as "an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soils conditions." They are regulated by the NH Dept. of Environmental Services Wetlands Bureau[3].

The US Fish and Wildlife Service's National Wetlands Inventory (NWI) and US Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) hydric soils were mapped to better understand the extent of wetlands within Alexandria. These combined datasets provide for a more balanced approach at wetlands mapping.

The NWI is a hierarchal system of classification that was designed to map wetlands throughout the contiguous United States. The purpose was to determine wetlands loss over time. It also serves as a systematic method for comparing wetlands within a defined geographic location (i.e., town or watershed). The NWI provides some very useful information including the type of wetland as well as its hydrology, associated plant communities, water chemistry, and other modifiers such as human dams and beaver influence.

Alexandria is estimated to have roughly 700 acres of wetlands dispersed throughout the town (Map 2, Page 18). Several smaller wetlands can be found in the higher elevations associated with headwater streams. Examples can be seen along Clark Brook and Brock Brook along relatively flat areas where runoff collects from Orange Mountain, Crane Mountain, and Brown Mountain. Another high elevation wetland is located at the headwaters of Davis Brook as water sheds from the Mount Cardigan ridgeline. A small wet meadow can be viewed from Washburn Road along Patten Brook.

As one descends into the Village, wetlands are generally larger. They are found along the lower portions of Patten Brook, Bog Brook, and Fowler River. Other significant wetlands are located along the Smith River in the southern part of Alexandria near NH Route 104.

[3] As defined by RSA 482-A:2.

This wet meadow along Patten Brook can be seen from Washburn Road. It was once a beaver pond. As beaver dams age and become inactive, they will become unstable. This can result in the dam breaking and the pond draining, leaving a mud flat. Typically, wetland plants will quickly start colonizing the area and change the habitat once again. Beavers are responsible for altering habitats thereby increasing biological diversity in Alexandria.

The best known and by far the largest wetland in town is the Alexandria Bog. At approximately 319 acres, this large wetland is a complex of various habitat types, from marsh to forested and shrub swamps to open water. These various habitats provide for high biological diversity of plants and wildlife. When compared to the rest of the wetlands in town, Alexandria Bog is expected to be among the highest ranked wetlands for ecological functions and values. High functional values include its wildlife habitat, scenic quality, educational and recreational value, flood water storage capabilities, water quality maintenance (sediment and nutrient trapping), rare species, and an exemplary natural community. The Bog is situated above the town's largest contiguous aquifer system that has the highest yield of water flow. Alexandria Bog is one of the most significant wetlands in town. Conducting a wetlands evaluation of the wetland would help to illuminate the importance of this ecosystem.

Another significant wetland ecosystem can be found to the west of Alexandria Bog. This wetland is also noted for its high ecological functions and values. It is a great example of a peatland ecosystem with various habitats, including shrub and forested swamps, sedge meadow, emergent marsh, and open water with pond lilies.

This red maple swamp can be found along the margins of Alexandria Bog. Hemlock-dominated swamps can be found as well. Forested swamps such as this one can help provide flood storage, as well as to slow floodwaters, helping to prevent downstream erosion from occurring. They help to trap sediments and toxicants from roadways, which helps to maintain good water quality. They also provide habitat for many species, including wood turtle and northern leopard frog.

Stratified Drift Aquifers

Groundwater resources are stored in two main types of aquifers and can serve as sources for drinking water. Aquifers can be located within saturated areas of sand and gravel deposits or in fractured bedrock (*bedrock aquifers*). In the past, as glaciers melted they left behind layers of coarse sediments including sand and gravel. The space between these sediments provides opportunity for groundwater storage and flow. Groundwater stored in *stratified drift aquifers* can serve as an excellent source for drinking water. Locating and protecting these geologic features can help to ensure a clean supply of drinking water for the community as these areas are vulnerable to contamination.

Alexandria contains just over 2,700 acres of stratified drift aquifers (Table 3, Page 14 and Map 2, Page 18). The Smith River aquifer system is approximately 1,490 acres in comparison to the largest aquifer (1,801 acres) in Alexandria located beneath Bog Brook/Alexandria Bog and the lower section of Fowler River. It is this aquifer system that contains some of the highest estimated yields of groundwater found just north of the Village. Therefore, wetlands and uplands associated with this aquifer system have the potential to help maintain a healthy, clean source for drinking water.

Aquifers are divided into categories based on *transmissivity*, which is the rate at which water moves through an aquifer and is measured in square feet per day (ft^2/day). Therefore, higher rates of transmissivity correspond to potentially higher yields of groundwater. Most of the aquifers in Alexandria have a transmissivity rate of less than

3,000ft^2/day. However, one area in particular is predicted to have as much as 4,000ft^2/day or even more. In fact, nearly 150 acres of this area is estimated to have a transmissivity rate greater than 6,000ft^2/day.

Table 3. Summary of aquifer transmissivity rates in Alexandria.

Aquifer Transmissivity	Size
less than 3,000 sq. ft. per day	2,377.3 acres
4,000-6,000 sq. ft. per day	179.5 acres
greater than 6,000 sq. ft. per day	147.3 acres

Source: USGS stratified drift aquifers (GRANIT 2000).

Wetlands, such as this shrub swamp, found along roadways can help trap excessive sediments, nutrients, and other harmful runoff that can be detrimental for water quality, both surface and groundwater resources. Wetlands in these areas are even more important if they function to recharge aquifers beneath the wetland.

Wellhead Protection Areas

The NH Department of Environmental Services has mapped wellhead protection areas throughout the state. This assists the agency with setting drinking water protection priorities within these areas to prevent the contamination of the groundwater source. A wellhead protection area delineates the area that supplies groundwater to a productive public well supply. The size of the area generally depends on the maximum daily withdrawal of water from the well, as well as existing data on the groundwater resource. Wellhead protection areas in Alexandria include the Village and areas to the north and east extending into Bristol to Newfound Lake. This occupies about 3,250 acres and

includes the zone associated with the highest yield aquifer in Alexandria (Map 2, Page 18).

Threats to Water Quality

In an effort to better understand potential threats to water quality, and particularly threats to groundwater resources within wellhead protection areas, the NH Department of Environmental Services documents known and potential contamination sources. These include both above and below ground storage tanks.

There are 17 sites that have been identified as known or potential threats to water quality (Map 2, page 18). These include areas associated with faulty septic systems, non-petroleum hazardous waste, non-hazardous holding tank, hazardous spill, wastewater lagoons, leaking oil tanks, wastewater discharge sites, gravel pits, and a junkyard. Many of the sites are no longer considered a threat. Eleven of the 17 sites have been closed by the NH Department of Environmental Services. This means protective measures have been put in place and no further action is required.

Water Protection Buffers

Water protection buffers extend 250 feet on either side of surface waters, streams, and wetlands. This accounts for approximately 4,940 acres in Alexandria (Map 2, Page 18). Water protection buffers include riparian zones[4] and their adjacent vegetative buffers, which provide a range of natural services that are essential in maintaining biodiversity and proper ecological functions.

Maintaining appropriate buffers along water features can help to ensure healthy, intact wildlife habitats. They provide space for safe wildlife movement as they move from one habitat to another. They also provide habitat for more localized species such as small mammals, birds, amphibians, and some reptiles. Forested buffers help to keep stream temperatures cool, a necessity for brook trout and the food supply they depend upon. They also support a thriving soil community, providing food web support and nutrients for plant growth.

[4] A riparian zone forms the area between the land and water. This includes areas adjacent to ponds, streams, rivers and wetlands.

Water protection buffers help to maintain clean water for swimming and drinking. Intact upland forests help to slow water in rain events as it moves across the surface of the land. The various parts of the groundcover (leaves, stems, downed trees, and plants) help to trap harmful runoff that may otherwise enter a stream or pond, and potentially an aquifer system. They also help to reduce the effects of downstream flooding by storing rising water levels in floodplains.

This forested buffer along the Smith River acts as a buffer for road salts and other toxicants that are washed off the adjacent state highway during rain events. This helps to maintain good, clean water. The forested buffer also affords the opportunity for wildlife to travel safely along the river as they move from one habitat to another.

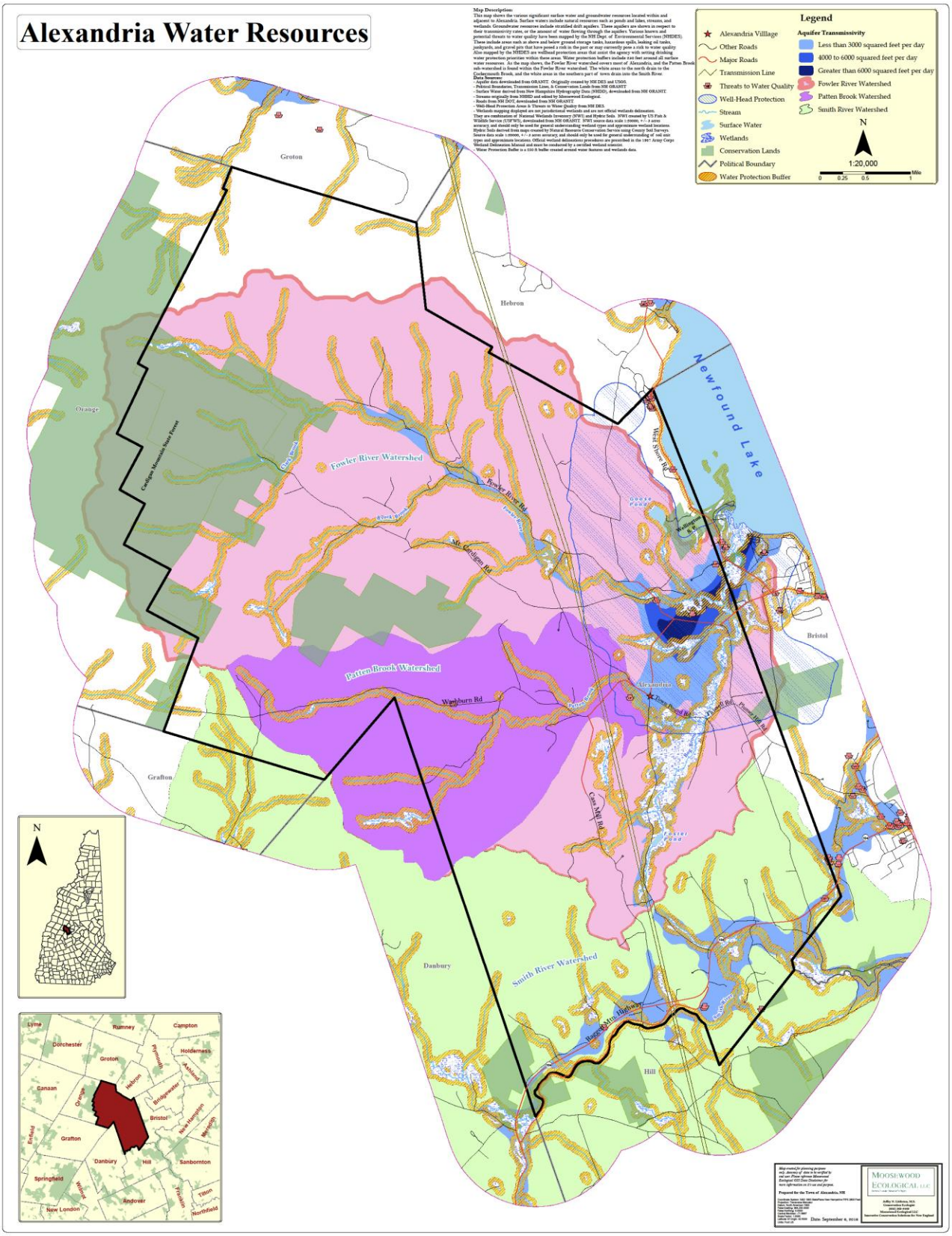
Watersheds

All of the previously discussed water resources reside in a watershed. A watershed is the area that drains to a common water resource. This may be a wetland, stream, or lake. The land use within a particular watershed can have a direct effect on the quality and quantity of surface waters and the underlying aquifers. Land use planning that uses a watershed approach can have a great impact on a town's water resources. This is important since we all depend upon clean water to help sustain life.

The Fowler River watershed is the largest in Alexandria (Map 2, Page 18). At 23,023 acres, it covers over 75% of the town. Part of the Cardigan Mountain State Forest is located within the upper reaches of the watershed, as well as the large, privately-owned conserved tract on Hutchins Hill. One of the main sub-watersheds is Patten Brook (4,156 acres), which eventually flows into Alexandria Bog and Bog Brook before entering Fowler River just north of Fowler River Road. In general, water quality within these

watersheds is expected to be good due to relatively little development and expansive forest cover. Northern parts of town drain into the Cockermouth River watershed. Southern parts drain into the Smith River watershed.

Signs of black bear were very common throughout Alexandria. This bear scat was observed on top of a *Sphagnum* peat mat. Peatlands are unique types of wetlands that provide habitat for a variety of plants not found in other wetlands.


Alexandria Water Resources
Legend
Alexandria Villlage
Other Roads
Major Roads
Transmission Line
Threats to Water Quality
Well-Head Protection
Stream
Surface Water
Wetlands
Conservation Lands
Political Boundary
Water Protection Buffer
Aquifer Transmissivity
Less than 3000 squared feet per day
4000 to 6000 squared feet per day
Greater than 6000 squared feet per day
Fowler River Watershed
Patten Brook Watershed
Smith River Watershed
N
1:20,000
Mile
0 0.25 0.5 1
Groton
Hebron
Orange
Grafton
Danbury
Hill
Bristol
Alexandria
Newfound Lake
Fowler River Watershed
Patten Brook Watershed
Smith River Watershed
Cardigan Mountain State Forest
Mt. Cardigan Rd
Fowler River Rd
Wentworth Rd
Washburn Rd
West Shore Rd
Cross Mill Rd
Foster Road
Range Rd
Lyme
Rumney
Campton
Dorchester
Holderness
Plymouth
Ashland
Canaan
Bridgewater
New Hampton
Enfield
Springfield
Wilmot
New London
Andover
Franklin
Tilton
Northfield
Sanbornton
Moosewood Ecological, LLC
Prepared for the Town of Alexandria, NH
Date: September 6, 2018

BIOLOGICAL RESOURCES

Wildlife Habitats

The NH Fish and Game Department, in cooperation with other agencies, organizations, and individuals, produced the first edition of the NH Wildlife Action Plan (WAP) in 2005. The Plan was revised in 2015. This document was designed as a planning and educational tool for federal, state, and municipal governing bodies, conservation commissions, land trusts and other conservation organizations, and private landowners, as well as the general public, to promote the conservation and management of NH's biological diversity. The WAP provides a resource for developing informed land use decisions and land management planning. The intent was to ensure an adequate representation of various wildlife habitats are maintained across our landscape, keeping common species common in NH and working to prevent the loss of our rare and endangered species. Each of the WAP habitats is considered to be critical for the long term survival of various species.

The WAP identified approximately 12 different types of large and medium-scale wildlife habitats for Alexandria in their revised habitat mapping in 2015. However, since these habitats were based on computer models, they only *predict* where these habitat types may be present. Ground-truthing is essential to better understand the extent of habitats. Limited site visits and roadside observations were made to better understand the types and extent of the WAP habitats. This resulted in the addition of the lowland spruce-fir forested habitat. It also provides a more representative understanding of the true extent of wildlife habitats in Alexandria.

A total of 12 wildlife habitats as recognized by the WAP were mapped for Alexandria (Table 4, Page 20 and Map 3, Page 23). All 12 habitats were confirmed to exist in Alexandria. The lowland spruce-fir forest was also observed. However, the WAP did not map this habitat type in Alexandria. It occurs in small, discrete patches scattered throughout the town.

Table 4. Summary of wildlife habitats in Alexandria.

Wildife Habitat Type	Size
Marsh and Shrub Wetlands	386.2 acres
Peatlands	67.9 acres
Northern Swamps	47.1 acres
Temperate Swamps	216.7 acres
Ponds and Lakes	81.3 acres
Rivers and Streams	89.4 miles
Floodplain Forests	31.6 acres
High Elevation Spruce-Fir Forest	98.8 acres
Northern Hardwood-Conifer Forest	8,560.7 acres
Appalachian Oak-Pine Forest	709.9 acres
Hemlock-Hardwood-Pine Forests	15,420.4 acres
Rocky Ridge	342.6 acres
Cliffs and Talus Slopes	252.4 acres
South-facing Slopes	15,419.4 acres
Grasslands	1,155.5 acres

Source: GIS Slope Analysis by Moosewood Ecological; NH Fish and Game Department Wildlife Action Plan (2015) and NH hydrography datasets from GRANIT.

Rocky ridges and talus slopes can be found on Mowglis Mountain and Oregon Mountain, as well as Mt. Cardigan. In fact, this habitat is considered as an exemplary example, which further recognizes its ecological significance. Smaller examples of this habitat type were also observed on Hutchins Hill, and most likely exist in other highlands, especially with steep slopes. High elevation spruce-fir forests appear only to exist on Mount Cardigan. This forest type is generally found at elevations from 2,500 feet to 3,500 feet. Other forests that characterize Alexandria's highlands include lowland spruce-fir forests and northern hardwood-conifer forests. Examples of these can be found on Hutchins Hill, as well as other highlands in the western and northern parts of town, including Brown Mountain, Braley Hill, and Pine Hill among others. Other features found in association with higher elevations include cliffs. The WAP has mapped the cliff habitat for Sugarloaf, which can be viewed from West Shore Road. Cliff habitat is also present on Mount Cardigan and Bear Mountain.

As one begins to move into to the lower elevations and along waterways such as Smith River, Fowler River, Patten Brook, Alexandria Bog, and Bog Brook hemlock-hardwood-pine forest communities tend to dominate. In fact, this forest type occupies

almost 60% of Alexandria. Occasionally lowland spruce-fir swamps are found in association with the hemlock-hardwood-pine forest.

As discussed above, wetlands, mostly small in nature, can be found scattered throughout the town. Alexandria contains about 386 acres of wet meadows/shrub wetlands. Forested swamps make up nearly 264 acres. Peatlands are another type of wetland habitat. These are generally found where water moves slowly or becomes stagnant. In Alexandria, there are approximately 68 acres of peatlands. These are mainly located in the lowlands near Alexandria Bog and Foster Pond. In fact, the Alexandria Bog contains an exemplary example of a peatland.

Floodplains are probably slightly more prevalent along Smith River than what is predicted by the WAP. A red maple floodplain forest was observed along the river. The floodplains within the Village area are most likely more prevalent and include grasslands, as well as forests. Grasslands are a human-modified habitat and mostly exist as active farmlands. Many of these can be viewed in the Village and along Smith River.

For a more detailed description on the various wildlife habitats observed during the site assessments see Appendix A. This summary addresses on-site assessments within the Smith River, Fowler River, and Patten Brook watersheds and greater Alexandria Bog area, as well as from roadside observations throughout Alexandria.

This wetland is arguably another significant wetland ecosystem. It contains a variety of wildlife habitats, including open water and a peatland characterized by interesting natural communities. Pitcher plants can be found scattered throughout, and river otter and bear scat was observed as well.

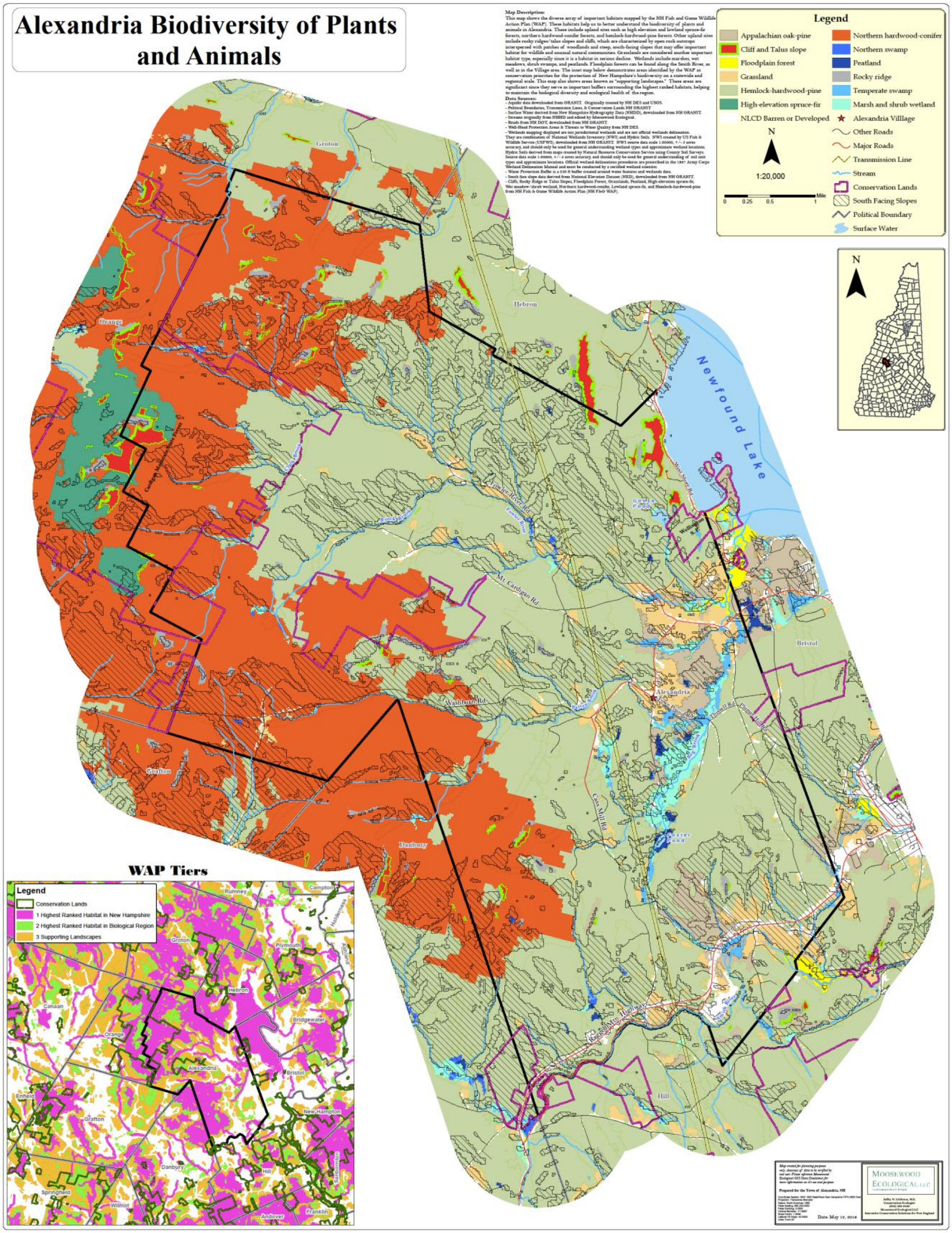
Additional habitats recognized but not mapped in the WAP included potential vernal pools, shrublands, and bat hibernacula. Vernal pools and shrublands are predicted to be more widespread throughout Alexandria and are best mapped during ground-truthing exercises. A bat hibernacula is known to occur in Alexandria. This site was not observed in 2012 or 2016 but it was previously reported to the NH Natural Heritage Bureau. These habitats are significant for bats as they overwinter in the state. Mapping of these important wildlife habitats was beyond the scope of the WAP.

One final habitat type was created and mapped for the Alexandria NRI. This habitat type is not recognized by the WAP. This includes steep, south-facing slopes, representing over 15,400 acres in Alexandria (Map 3, Page 23). When associated with talus slopes, especially beneath cliffs, this habitat can serve as important den sites for various mammals, including coyotes, fox, porcupine, and bobcat. These areas can also be important sunning areas for bobcat in the winter months. Snakes will typically overwinter in such rocky areas. Lastly, these sites may also be associated with rare plants and communities due to their southern exposure creating much warmer habitats.

Wildlife Action Plan Habitat Rankings

As part of the WAP, the NH Fish and Game developed habitat rankings based on a variety of biological and human factors. Biological factors included attributes such as the size and condition of habitats, presence of rare species, and overall biological diversity. Human impacts included conditions such as the degree of development and pollution. To assist with conservation planning efforts in the state, each habitat type was ranked by its condition.

As seen in the inset figure in the bottom left corner of the Biodiversity of Plants and Wildlife map, some of these high rankings can be found in Alexandria (Map 3, Page 23). The pink color represents areas that have the highest ranked habitats state-wide. This ranking also considered the various biological regions in the state. The green coloration denotes areas that have high significance in the region. Finally, in order to maintain the health of the highest ranked habitats, it is important to protect the adjacent areas. The orange areas show the supporting landscapes that can help to insure the long term viability of the highest ranked areas.


Alexandria Biodiversity of Plants and Animals
Legend
Appalachian oak-pine
Cliff and Talus slope
Floodplain forest
Grassland
Hemlock-hardwood-pine
High-elevation spruce-fir
NLCD Barren or Developed
Northern hardwood-conifer
Northern swamp
Peatland
Rocky ridge
Temperate swamp
Marsh and shrub wetland
Alexandria Villlage
Other Roads
Major Roads
Transmission Line
Stream
Conservation Lands
South Facing Slopes
Political Boundary
Surface Water
N
1:20,000
Newfound Lake
Groton
Hebron
Orange
Bristol
Alexandria
Grafton
Danbury
Hill
Washburn Rd
Mt Cardigan Rd
WAP Tiers
Legend
Conservation Lands
1 Highest Ranked Habitat in New Hampshire
2 Highest Ranked Habitat in Biological Region
3 Supporting Landscapes
Rumney
Campton
Plymouth
Canaan
Bridgewater
Enfield
New Hampton
Springfield
Wilmot
Andover
Franklin
MOOSEWOOD ECOLOGICAL LLC
Date: May 10, 2019

Wildlife Diversity

The 2012 and 2016 site assessments were used to catalogue the diversity of wildlife throughout Alexandria. These observations were then combined with existing data, including a report on the Alexandria Bog by the Audubon Society of New Hampshire and NH Natural Heritage database. A total of 130 wildlife species have been documented (Appendix A). This includes 95 birds, 18 mammals, 12 amphibians, and 5 reptiles. These lists are not meant to be a comprehensive list rather it should serve as a supplement to existing and future lists for Alexandria.

Wildlife observed within the uplands watershed was quite diverse. These included wildlife mostly using forested habitats but were also associated with forest edges, small forest openings, riparian habitats along various brooks, and an abandoned beaver pond. These species included red-tailed hawk, broad-winged hawk, Cooper's hawk, pileated woodpecker, black-capped chickadee, white-breasted nuthatch, hermit thrush, common raven, American crow, blue jay, veery, least flycatcher, eastern wood-pewee, common yellowthroat, indigo bunting, magnolia warbler, red-eyed vireo, blue-headed vireo, wild turkey, northern cardinal, and cedar waxwing. Also reported were American woodcock (a species of conservation concern). Mammals included white-tailed deer, moose, black bear, coyote, weasel, red squirrel, porcupine, and bobcat. In terms of amphibians and reptiles seven species were recorded, including American toad, green frog, red-spotted newt, spring peeper, pickerel frog, gray tree frog and garter snake.

Given the wide range of habitats, wildlife within Alexandria Bog included a variety of species using terrestrial, wetland, and aquatic habitat types. Species observed using open water, emergent marsh and shrub swamp habitats included American bittern, great blue heron, mallard, wood duck, red-winged blackbird, kingfisher, mourning dove, cedar waxwing, American crow, barn swallow, chimney swift, eastern phoebe, eastern kingbird, alder flycatcher, northern parula, common yellowthroat, northern waterthrush, gray catbird, eastern towhee, song sparrow, swamp sparrow, chipping sparrow, vesper sparrow, yellow warbler, American goldfinch, broad-winged hawk, red-tailed hawk, garter snake, spring peeper, green frog, bullfrog, pickerel frog, deer, moose, coyote, bear, raccoon, skunk, mink, and otter, as well as old and new beaver sign. These observations also included those using the edge habitats associated with the adjacent forested areas, as

well as the power line corridor. Species of conservation concern previously documented in Alexandria Bog included ribbon snake, wood turtle, Virginia rail, northern harrier, veery, purple finch, rusty blackbird, and eastern meadowlark.

Species observed within the upland forests surrounding Alexandria Bog included northern goshawk, barred owl, pileated woodpecker, hairy woodpecker, blue jay, American crow, common raven, black-capped chickadee, winter wren, veery, hermit thrush, red-eyed vireo, blue-headed vireo, ovenbird, scarlet tanager, chipmunk, red squirrel, coyote, deer, moose, bear, wood frog, gray tree frog, and red-spotted newt.

Other interesting species included peregrine falcon (state threatened) and a sandhill crane. While not observed this year, peregrine falcons have been documented in undisclosed locations in Alexandria. One very unusual visitor included a sandhill crane that was observed in the Village in May 2012. This species is generally found in Canada and the northern part of the Midwest during the breeding season.

Rare and Invasive Plants

No rare plants were observed during the field assessments. In addition, no rare plants have been reported to the NH Natural Heritage Bureau. However, this NRI does not constitute a comprehensive inventory of plants in Alexandria. Sampling over the various seasons would provide a better snapshot of plants throughout the town.

Invasive plants appear to be not as prevalent as in some other communities in New Hampshire, especially those towns associated with more developed and disturbed areas. The most abundant and widespread invasive plant is Japanese knotweed. This species can be found along sections of Bog Brook/Alexandria Bog, Smith River, and the lower section of Patten Brook where it meets Alexandria Bog. The latter location represents the largest patch of knotweed and can be easily observed along either side of Bog Road at the point where it crosses Patten Brook. Another smaller site was noted on a town-owned site on Bog Road. Autumn olive was also noted in this location. One purple loosestrife plant was noted along Bog Road at the crossing of Bog Brook adjacent to the powerline right-of-way. Japanese knotweed was also observed along Walker Road where it crosses a small brook that leads to Smith River. With its proximity to the Smith River

and the overall general ecology of Japanese knotweed, it is most likely that this species, as well as additional invasive plants, may be found in other areas along the banks and floodplains of the Smith River and other streams.

Japanese knotweed and buckthorn were noted within the powerline right-of-way. It is likely that other invasive species also exists along the right-of-way. Invasive species were not observed within the upland forests of Alexandria. However, this assessment does not represent a comprehensive survey of invasive plants in Alexandria.

Invasive plants can dramatically change habitats, affecting both native plants and wildlife. These invaders have developed a variety of strategies to quickly colonize an area. This site shows an infestation of Japanese knotweed along Patten Brook where it meets Alexandria Bog. Dense patches have formed here, out-competing native plants and altering floodplain habitat for various wildlife.

LAND RESOURCES

Alexandria is rich with important soils for both forest management and agriculture. These areas represent some of the best soils for the production of forest products and food, feed, and fiber from farming. Understanding these natural resources provides insight into the best use of the landscape.

Important Farmland Soils

In response to the Farmland Protection Policy Act of 1981[5], farmland soils were mapped by the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). Based on a variety of physical and chemical properties (i.e., drainage, texture, hydric regime, pH, erodibility factor), these soils have been identified as being among the most productive lands for many types of farming practices. These include prime farmland soils, farmland soils of statewide significance, and farmland soils of local significance. Each is defined below by the USDA NRCS:

Prime Farmland

- Soils that have an aquic or udic moisture regime and sufficient available water capacity within a depth of 40 inches to produce the commonly grown cultivated crops adapted to New Hampshire in 7 or more years out of 10.
- Soils that are in the frigid or mesic temperature regime.
- Soils that have a pH between 4.5 and 8.4 in all horizons within a depth of 40 inches.
- Soils that have either no water table or have a water table that is maintained at a sufficient depth during the cropping season to allow cultivated crops common to New Hampshire to be grown.
- Soils that have a saturation extract less than 4 mmhoc/cm (millimhos per centimeter, which is a measure of electric conductance) and the exchangeable sodium percentage is less than 15 in all horizons within a depth of 40 inches.
- Soils that are not frequently flooded during the growing season (less than a 50% chance in any year or the soil floods less than 50 years out of 100).
- The product of the erodibility factor times the percent slope is less than 2.0 and the product of soil erodibility and the climate factor does not exceed 60.

[5] As defined by the USDA NRCS: "The Farmland Protection Policy Act of 1981 was established to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses, and to assure that Federal programs are administered in a manner that, to the extent practicable, will be compatible with state, unit of local government, and private programs and policies to protect farmland."

- Soils that have a permeability rate of at least 0.06 inches per hour in the upper 20 inches.
- Soils that have less than 10 percent of the upper 6 inches consisting of, rock fragments larger than 3 inches in diameter.

Farmland of Statewide Importance

These soils refer to land that is not prime or unique but is considered farmland of statewide importance for the production of food, feed, fiber, forage and oilseed crops. Criteria for defining and delineating farmland of statewide importance are determined by a state committee chaired by the Commissioner, New Hampshire Department of Agriculture, Markets and Food, with members representing the University of New Hampshire Cooperative Extension, New Hampshire Association of Conservation Districts and the New Hampshire Office of State Planning. The NRCS State Soil Scientist serves on this committee in an advisory capacity. The original criteria were established on June 20, 1983. They were updated on December 7, 2000, as follows.

- Have slopes of less than 15 percent.
- Are not stony, very stony or boulder.
- Are not somewhat poorly, poorly or very poorly drained.
- Includes soil complexes comprised of less than 30 percent shallow soils and rock outcrop and slopes do not exceed 8 percent.
- Are not excessively drained soils developed in stratified glacial drift, generally having low available water holding capacity.

Farmland of Local Importance

Farmland of local importance is farmland that is not prime, unique or of statewide importance, but has local significance for the production of food, feed, fiber and forage. Criteria for the identification and delineation of local farmland are determined on a county-wide basis by the individual County Conservation District Boards. The original criteria were established on June 20, 1983. Updates are noted according to the county

initiating the update. The criteria for soils of local importance in Grafton County are as follows:

- Soils that are poorly drained, have artificial drainage established and are being farmed.
- Specific soil map units identified from the NRCS county soil survey legend, as determined by the Conservation District Board.
- All land that is in active farm use.

Important farmland soils cover approximately 6,110 acres in Alexandria, or roughly 22% (Table 5 and Map 4, Page 35). These soils are widely distributed throughout the town. Prime farmland soils make up about 9% of the total acreage, and generally occur along stream drainages and in the Village. Farmland soils of local and statewide significance make up the bulk of the acreage of these soil types. These are found to be more widespread in Alexandria.

Table 5. Summary of important soils for farm production in Alexandria.

Important Farmland Soil Type	Size
Prime Farmland Soils	542.3 acres
Other Farmland Soils of Signficance	5,567.7 acres

SOURCE: GIS Analysis (Moosewood Ecological 2012) of USDA Natural Resources Conservation Service soils.

Active farmlands promote a sense of place and rural identity. The various products that are produced on these farmlands contribute to the local economy.

Important Forest Soils

Forest resources within New Hampshire are significant for many reasons. They provide sources of employment, a multitude of forest products, promote local economies, recreation and tourism, provide clean air, help sequester carbon, and provide substantial habitats for wildlife and plants, as well as diverse ecological functions (such as nutrient cycling, carbon sequestration, water quality maintenance through sediment trapping). For these reasons, it is important to maintain large tracts of forest lands and to better understand where important forest soils exist in Alexandria.

The USDA Natural Resources Conservation Service has mapped the distribution of important forest soils and has classified them according to their capacity to grow trees. These soils signify areas as providing the most productive lands for timber production. The NRCS has identified three soils groups within this category and have described each as follows:

Forest Soil Class IA

This group consists of the deeper, loamy textured, moderately well, and well-drained soils. Generally, these soils are more fertile and have the most favorable soil moisture relationships. The successional trends on these soils are toward stands of shade tolerant hardwoods, i.e., beech and sugar maple. Successional stands frequently contain a variety of hardwoods such as red oak, beech, sugar maple, red maple, white birch, yellow birch, aspen, and white ash in varying combinations with red spruce, hemlock, and white pine. Hardwood competition is severe on these soils. Softwood regeneration is usually dependent upon persistent hardwood control efforts.

Forest Soil Class IB

The soils in this group are generally sandy or loamy over sandy textures and slightly less fertile than those in group IA. These soils are moderately well and well drained. Soil moisture is adequate for good tree growth, but may not be quite as abundant as in group IA soils. Soils in this group have successional trends toward a climax of tolerant hardwoods, predominantly beech. Successional stands, especially those which are heavily cut over, are commonly composed of a variety of hardwood

species such as red oak, red maple, aspen, paper birch, yellow birch, sugar maple, and beech, in combinations with white pine, red spruce, balsam fir, and hemlock. Hardwood competition is moderate to severe on these soils. Successful softwood regeneration is dependent upon hardwood control.

Forest Soil Class IC

The soils in this group are outwash sands and gravels. Soil drainage is somewhat excessively to excessively drained and moderately well drained. Soil moisture is adequate for good softwood growth, but is limited for hardwoods. White pine, red maple, aspen, and paper birch are common in early and mid-successional stands. Successional trends on these coarse textured, somewhat droughty and less fertile soils are toward stands of shade tolerant softwoods, i.e., hemlock and red spruce. Hardwood competition is moderate to slight on these soils. Due to less hardwood competition, these soils are ideally suited for softwood production. With modest levels of management, white pine can be maintained and reproduced on these soils. Because these soils are highly responsive to softwood production, especially white pine, they are ideally suited for forest management.

Important forest soils represent nearly 17,900 acres, or approximately 64% of Alexandria (Table 6 and Map 4, Page 35). Forest soil groups IA and IB make up the majority of this resource and are most ideally suited for hardwood production. Soil group IC appears to be more restricted to stream drainages where outwash sands and gravels were deposited by glacial activity about 11,000 years ago. These soils tend to be well-drained, a characteristic that ideally suits white pine and other softwoods. These areas include sites along Smith River and Fowler River.

Table 6. Summary of important forest soils for timber production in Alexandria.

Important Forest Soil Type	Size
Hardwood Production (IA and IB)	16,678.7 acres
Softwood Production IC)	1,193.0 acres

SOURCE: GIS Analysis (Moosewood Ecological 2012) of USDA Natural Resources Conservation Service soils.

This enriched northern hardwood forest was observed along a north-facing slope near Washburn Road in the upper parts of the Patten Brook watershed. This site has been identified to have important soils for a productive hardwood forest. Areas identified as such have the capabilities of producing good quality timber products that contribute to the local economy.

Unfragmented Landscape

The inset figure found in the lower left corner on the Land Resources Map shows the unfragmented landscape in Alexandria (Map 4, Page 35). These data were developed as part of the WAP. For the purposes of this project, fragmenting features were defined as 500 feet on either side of existing roadways, including all state and town roads but excluding Class VI roads and trails, as well as private driveways. This is the area where most developments are predicted to occur in relation to roadways. Unfragmented blocks of land includes a variety of natural habitats such as forests, wetlands, streams, and ponds but also can include human-modified areas such as farmlands and shrublands.

The fragmentation of land can negatively affect species survival rates, including mortality, lowered rates of breeding success, or species loss altogether. The degree of fragmentation depends upon many aspects, such as the size and shape of unfragmented block, the species in question, the extent of loss of natural habitats, intensity of human use, and colonization of invasive species.

Large blocks of unfragmented areas are widely known to support greater biodiversity than smaller blocks. As forest blocks become smaller due to the construction of roadways and developments their biodiversity will generally be reduced. This fragmentation affect has less immediate impact on generalist species or those with small home ranges (such as gray squirrels, raccoon, many amphibians, and small rodents) while affecting and potentially eliminating area-sensitive specialists that need large forested

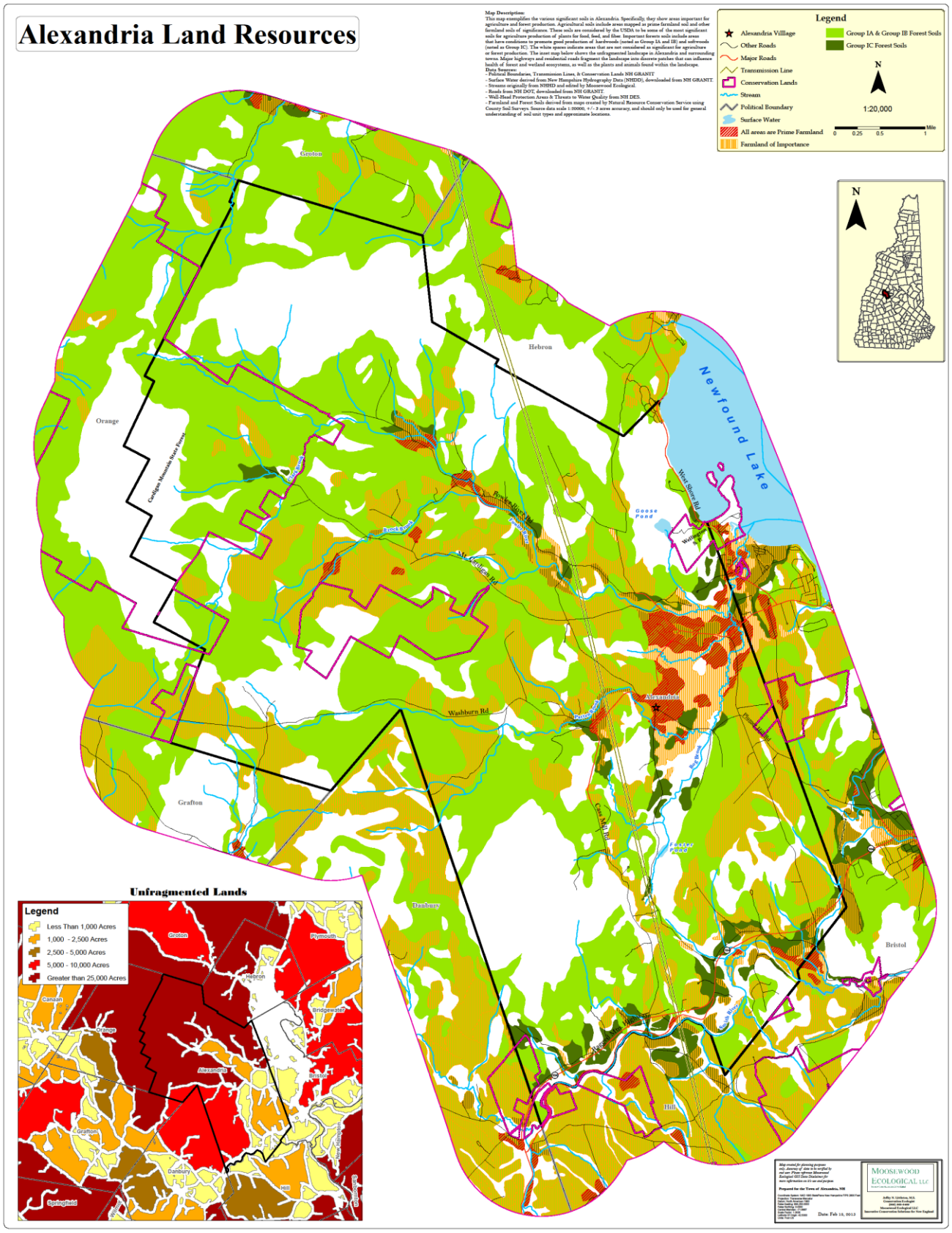
blocks in order to maintain their home ranges and for long-term survival (such as bear, bobcat, moose, some reptiles, wood thrush, and goshawk). Table 7 (Page 34) provides a general list for habitat block size requirements for wildlife to help illustrate this point.

Another function of large landscapes is to allow wildlife movement and habitat connectivity. By maintaining connectivity between critical habitats it may be possible to provide permanent wildlife corridors within the built environment. Wildlife travel corridors function as areas that one or many species may use to move from one habitat to another. This movement can be based on traveling to various areas for feeding, breeding, nesting, or shelter. Wildlife must be able to travel safely throughout the landscape in order to meet their biological needs. Many depend upon a variety of habitats for their survival and may utilize many natural features for travel. These may include features such as riparian zones of wetlands, ponds, and streams, ridgelines, utility rights-of-way, and forest patches acting as a safe route between two or more habitats. A variety of wildlife can be associated with these corridors, including otter, muskrat, fox, coyote, bobcat, deer, moose, fisher, mink, and bear.

Wildlife corridors are not only significant for mammals but are equally important for amphibians, reptiles and migratory birds. Both amphibians and reptiles begin to move from their wintering habitats to their respective breeding and nesting grounds in the spring. This is the time of year that most mortality can be noticed as these species travel across roadways in search of suitable habitats. This effect can often be exacerbated as the same individuals must return back to their wintering habitats. Thus, there is a great significance in maintaining habitat connectivity, as well as understanding where these patterns of movement are taking place. This latter point can be a very important educational tool for community awareness about corridors across roadways. It can provide a means to adjust transportation patterns to help eliminate potential road mortality.

Table 7. Habitat block size requirements for wildlife.

1-19 Acres	20-99 Acres	100-499 Acres	500-2,500 Acres	>2,500 Acres
raccoon	raccoon	raccoon	raccoon	raccoon
	hare	hare	hare	hare
				coyote
small rodent	small rodent	small rodent	small rodent	small rodent
	porcupine	porcupine	porcupine	porcupine
				bobcat
cottontail	cottontail	cottontail	cottontail	cottontail
	beaver	beaver	beaver	beaver
				black bear
squirrel	squirrel	squirrel	squirrel	squirrel
	weasel	weasel	weasel	weasel
		mink	mink	mink
				fisher
	woodchuck	woodchuck	woodchuck	woodchuck
		deer	deer	deer
muskrat	muskrat	muskrat	muskrat	muskrat
			moose	moose
red fox	red fox	red fox	red fox	red fox
songbirds	songbirds	songbirds	songbirds	songbirds
		sharp-shinned hawk	sharp-shinned hawk	sharp-shinned hawk
			bald eagle	bald eagle
skunk	skunk	skunk	skunk	skunk
		Cooper's hawk	Cooper's hawk	Cooper's hawk
		harrier	harrier	harrier
		broad-winged hawk	broad-winged hawk	broad-winged hawk
			goshawk	goshawk
		kestrel	kestrel	kestrel
			red-tailed hawk	red-tailed hawk
		great-horned owl	great-horned owl	great-horned owl
			raven	raven
		barred owl	barred owl	barred owl
		osprey	osprey	osprey
		turkey vulture	turkey vulture	turkey vulture
		turkey	turkey	turkey
most reptiles	most reptiles	reptiles	reptiles	reptiles
	garter snake	garter snake	garter snake	garter snake
	ring-necked snake	ring-necked snake	ring-necked snake	ring-necked snake
most amphibians	most amphibians	most amphibians	amphibians	amphibians
		wood frog	wood frog	wood frog


Alexandria Land Resources
Map Description:
This map exemplifies the various significant soils in Alexandria. Specifically, they show areas important for agriculture and forest production. Agricultural soils include areas mapped as prime farmland soil and other farmland soils of significance. These soils are considered by the USDA to be some of the most significant soils for agriculture production of plants for food, feed, and fiber. Important forests soils include areas that have conditions to promote good production of hardwoods (noted as Group IA and IB) and softwoods (noted as Group IC). The white spaces indicate areas that are not considered as significant for agriculture or forest production. The inset map below shows the unfragmented landscape in Alexandria and surrounding towns. Major highways and residential roads fragment the landscape into discrete patches that can influence health of forest and wetland ecosystems, as well as the plants and animals found within the landscape.
Data Sources:
- Political Boundaries, Transmission Lines, & Conservation Lands: NH GRANIT
- Surface Water derived from New Hampshire Hydrography Data (NHDD), downloaded from NH GRANIT.
- Streams originally from NHHD and edited by Moosewood Ecological.
- Roads from NH DOT, downloaded from NH GRANIT.
- Well-Head Protection Areas & Threats to Water Quality from NH DES.
- Farmland and Forest Soils derived from maps created by Natural Resource Conservation Service using County Soil Surveys. Source data scale 1:20000, +/- 3 acres accuracy, and should only be used for general understanding of soil unit types and approximate locations.
Legend
Alexandria Villlage
Other Roads
Major Roads
Transmission Line
Conservation Lands
Stream
Political Boundary
Surface Water
All areas are Prime Farmland
Farmland of Importance
Group IA & Group IB Forest Soils
Group IC Forest Soils
N
1:20,000
Mile
0 0.25 0.5 1
N
Groton
Hebron
Orange
Newfound Lake
Goose Pond
Washburn Rd
Grafton
Danbury
Alexandria
Bristol
Hill
Unfragmented Lands
Legend
Less Than 1,000 Acres
1,000 - 2,500 Acres
2,500 - 5,000 Acres
5,000 - 10,000 Acres
Greater than 25,000 Acres
Groton
Plymouth
Hebron
Canaan
Bridgewater
Orange
Alexandria
Bristol
Grafton
Danbury
Springfield
Hill
MOOSEWOOD ECOLOGICAL LLC
Date: Feb 18, 2013

LAND CHARACTERISTICS

A variety of land characteristics can create challenges or constraints for various types of land use activities (Table 8, Page 37 and Map 5, Page 38). This can include various land uses from residential subdivisions and industrial developments to forestry and farming. Major challenges include water resources such as streams, lakes, ponds, and wetlands, especially as they are governed by state and/or town regulations. Other challenges include the steep slopes characteristic of much of Alexandria's landscape.

As previously mentioned, certain water bodies and rivers are protected under the Shoreland Water Quality Protection Act (RSA 483-B). These include Newfound Lake, Goose Pond, Fowler River and Smith River. The Act establishes minimum standards for various setbacks from the reference line based on land use within the designated 250-foot buffer. Wetlands, including rivers and water bodies, are also protected by state statutes (RSA 482-A: Fill and Dredge in Wetlands). Water resources in the state were "found to be for the public good and welfare of this state to protect and preserve its submerged lands under tidal and fresh waters and its wetlands… from despoliation and unregulated alteration." This includes the adverse affects on wildlife and habitats, commerce, recreation, aesthetic enjoyment, flood storage capabilities, and water quality.

In recognition of the significance of water resources, Alexandria has enacted regulations that define a minimum of 250 feet setback for buildings in a subdivision. This is the area defined as orange hatching adjacent to surface water resources. It states that "this area must be left as green/open space and conform to conservation efforts."

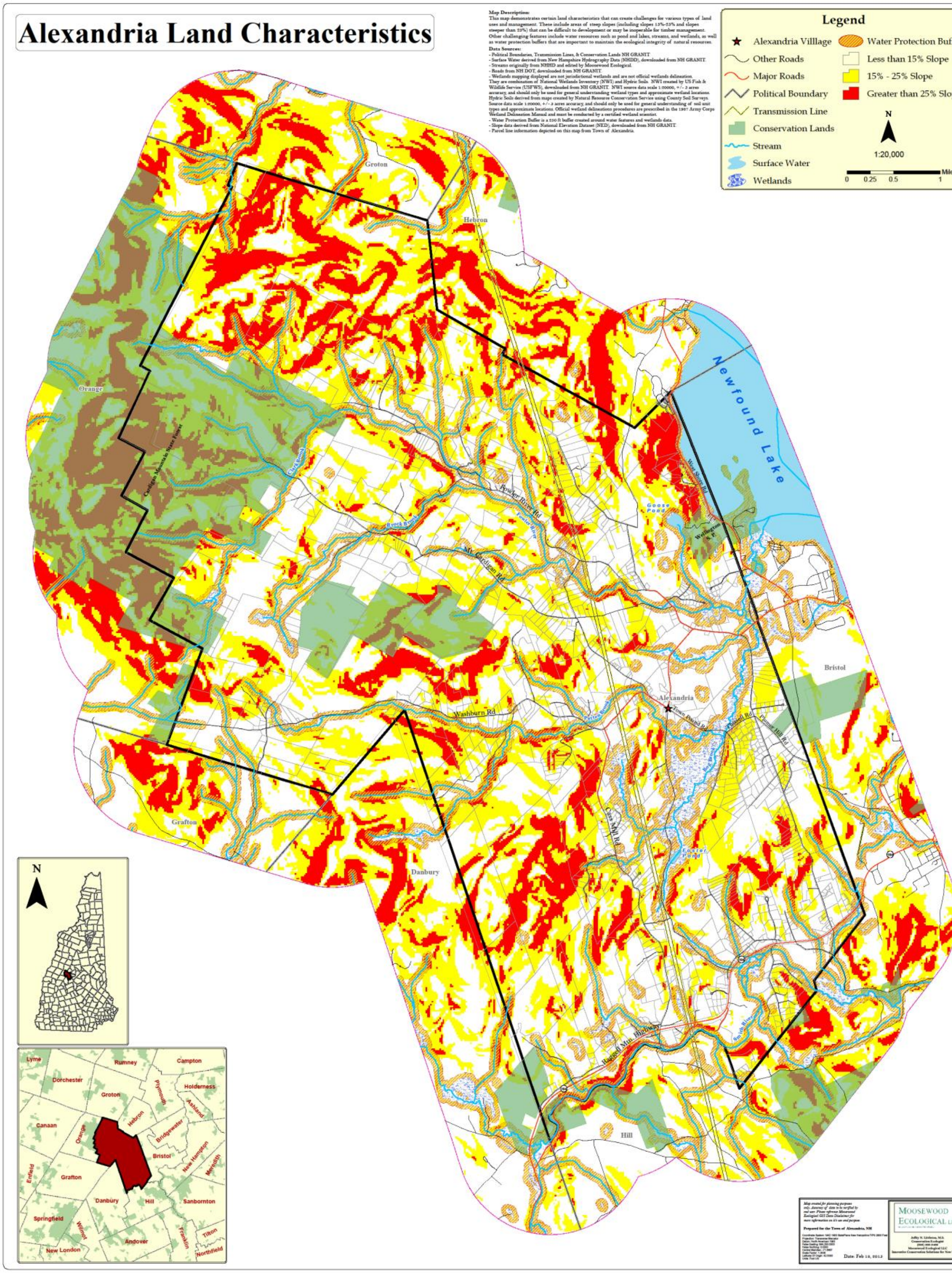
Finally, steep slopes can present a variety of challenges for certain types of land uses. These include the development of buildings, roads, and septic systems, increased potential for erosion, and inoperability for timber management. Many of Alexandria's steep slopes have a very thin layer of soil (or may even be exposed bedrock), making these areas vulnerable to increased runoff and erosion, which contributes to lower water quality. Almost half of Alexandria has slopes that are greater than 15%. Of this area 4,406 acres are greater than 25%, presenting some of the most challenging terrain in town.

Table 8. Summary of land characteristics that may present challenges on various types of land use.

Land Characteristics Description	Size (acres)
Wetlands	702.3 acres
Surface Waters	
Newfound Lake	4,450.7 acres*
Goose Pond	15.5 acres
Foster Pond	5.9 acres
Streams	
Fowler River	3.9 miles
Smith River	12.5 miles
Patten Brook	6.9 miles
Bog Brook	5.1 miles
Brock Brook	3.3 miles
Clark Brook	5.7 miles
Other Streams	52.1 miles
Water Protection Buffer	4,93.93 acres
Steep Slopes	
15% - 25% Slope	9,144.1 acres
Greater than 25% Slope	4,406.4 acres

SOURCES: USDA Natural Resources Conservation Service soils, US Fish and Wildife Service National Wetlands Inventory, USGS topography, digital elevation models, and NH hydrography datasets

* This is the total acreage of Newfound Lake, most of which does not reside in Alexandria.


Alexandria Land Characteristics
Map Description:
This map demonstrates certain land characteristics that can create challenges for various types of land uses and management. These include areas of steep slopes (including slopes 15%-25% and slopes steeper than 25%) that can be difficult to development or may be inoperable for timber management. Other challenging features include water resources such as pond and lakes, streams, and wetlands, as well as water protection buffers that are important to maintain the ecological integrity of natural resources.
Data Sources:
- Political Boundaries, Transmission Lines, & Conservation Lands NH GRANIT
- Surface Water derived from New Hampshire Hydrography Data (NHDD), downloaded from NH GRANIT.
- Streams originally from NHHD and edited by Moosewood Ecological.
- Roads from NH DOT, downloaded from NH GRANIT.
- Wetlands mapping displayed are not jurisdictional wetlands and are not official wetlands delineation. They are combination of National Wetlands Inventory (NWI) and Hydric Soils. NWI created by US Fish & Wildlife Service (USFWS), downloaded from NH GRANIT. NWI source data scale 1:20000, +/- 3 acres accuracy, and should only be used for general understanding wetland types and approximate wetland locations. Hydric Soils derived from maps created by Natural Resource Conservation Service using County Soil Surveys. Source data scale 1:20000, +/- 3 acres accuracy, and should only be used for general understanding of soil unit types and approximate locations. Official wetland delineations procedures are prescribed in the 1987 Army Corps Wetland Delineation Manual and must be conducted by a certified wetland scientist.
- Water Protection Buffer is a 250 ft buffer created around water features and wetlands data.
- Slope data derived from National Elevation Dataset (NED), downloaded from NH GRANIT.
- Parcel line information depicted on this map from Town of Alexandria.
Legend
Alexandria Villlage
Other Roads
Major Roads
Political Boundary
Transmission Line
Conservation Lands
Stream
Surface Water
Wetlands
Water Protection Buffer
Less than 15% Slope
15% - 25% Slope
Greater than 25% Slope
N
1:20,000
0 0.25 0.5 1 Mile
Groton
Hebron
Orange
Newfound Lake
Goose Pond
Bristol
Alexandria
Washburn Rd
Grafton
Danbury
Hill
MOOSEWOOD ECOLOGICAL LLC
Date: Feb 16, 2012
Lyme
Rumney
Campton
Dorchester
Holderness
Groton
Canaan
Hebron
Orange
Bristol
Grafton
Enfield
Danbury
Hill
Sanbornton
Springfield
Andover
Tilton
New London
Northfield

CONCLUSION

Alexandria has a wide range of natural resources that host a diversity of species, including some of conservation concern. These include rivers and water bodies, wetlands, high quality and unique examples of wildlife habitats, rare and endangered species habitats, and Alexandria's large unfragmented forests. Alexandria also boasts significant natural resources that are vital for the working landscape. These include active farmlands and important soils, which signify specific areas as providing the most productive lands for agriculture and timber production. The Alexandria NRI was created to better understand where these significant natural resources are located and why they are important.

Planning for the protection of the rural landscape and biological diversity is an ongoing process as more is learned from research and the effects of land use. Fortunately, today we are better equipped with various tools to assist with informed decision making. One such tool is the Alexandria NRI. This report should be viewed as a work in progress. It should be reviewed and updated regularly to reflect new data, including on-site assessments, additional conservation lands, new regulatory policies, and regional conservation priorities.

Driving along many of the roads in Alexandria will certainly reveal sign that bears have been moving through the area. This utility pole has been bitten several times by a black bear. By examining the number of poles and intensity of bites it is possible to understand areas that are heavily used by bears. Based on "hit" utility poles, it appears that bear are crossing the northern section of Bog Road just south of Patten Brook to and from Alexandria Bog. Additional sign along the edge of the Bog in this area helps to confirm this statement.

LITERATURE RESOURCES

Audubon Society of NH. 1993. Inventory of the Alexandria Bog. Concord, NH.

Bowman, P.J. 2007. Ecological Inventory of Cardigan Mountain State Forest. New Hampshire Natural Heritage Bureau, Concord, New Hampshire.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. US Dept. of Interior, Fish and Wildlife Service, Washington D.C. 131 pp.

Dahl, T.E. 1990. Wetlands losses in the United States 1780s to 1980s. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C. 21 p.

New Hampshire Department of Environmental Services. 2008. Innovative Land Use Planning Techniques: A Handbook for Sustainable Development. New Hampshire Department of Environmental Services, Concord, New Hampshire.

New Hampshire Fish and Game Department. 2015 (second edition). New Hampshire Wildlife Action Plan. New Hampshire Fish and Game Department, Concord, New Hampshire.

New Hampshire Natural Heritage Bureau. 2013. Rare Plants, Rare Animals, and Exemplary Natural Communities in New Hampshire Towns. Concord, NH.

New Hampshire Office of Energy and Planning. 1998. Population Estimates and Projections database. Concord, NH.

New Hampshire State Statutes. 1989. RSA 482-A: Fill and Dredge in Wetlands. http://www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-L-482-A.htm

Newfound Lake Region Association. 2009. Every Acres Counts: The Newfound Master Plan. http://www.newfoundlake.org/watershedmasterplan/themasterplan.html

Society for the Protection of New Hampshire Forests. 2005. New Hampshire's Changing Landscape - Population Growth and Land Use Changes: What They Mean for the Granite State. SPNHF, Concord, NH.

Sperduto, D.D. 2005. Natural Community Systems of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire.

Sperduto, D.D. and W.F. Nichols. 2011 (second edition). Natural Communities of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, NH. Pub. UNH Cooperative Extension, Durham, NH.

Stone, A.J.L. 2001. Natural Resources Inventory – A Guide for New Hampshire Communities and Conservation Groups. UNH Cooperative Extension, Durham, New Hampshire.

Town of Alexandria. 2008. Subdivision Regulations.

Town of Alexandria. 2010. Community Master Plan. Town of Alexandria Planning Board.

GLOSSARY

Alluvial – pertaining to soils deposited a stream.

Aquic Moisture – pertaining to soils that are free of dissolved oxygen because the soil is saturated by water.

Aquifer – an underground area containing water in either bedrock or sand and gravel that can be used as a source for drinking water.

Biodiversity – the amount of variation of life forms, including plants and animals.

Bog – a type of peatland that only receives water through rain and snow and is typically colonized by acid-loving plants; bogs typically do not have an inlet or outlet stream (compare to fen).

Degradation – the process of deterioration over time, such as the decline of water quality over time due to increased pollution.

Ecosystem – a community of living organisms (plants and animals) within the non-living environment (soil and water).

Ecological Community – a group of two or more populations of different species found in the same place.

Emergent Marsh-Shrub System – a type of wetland ecosystem that includes marsh and shrub habitats.

Erodibility Factor – a description of the inherent erodibility of a particular soil type.

Exemplary Communities – includes all rare types of natural communities as well as common types that are in excellent condition.

Fen – a type of peatland that receives water through multiple sources, including streams, ponds, and rain, and is less acidic than bogs; fens typically have an inlet and/or outlet stream (compare to bog).

Genes – a unit of heredity found in living organisms (plants and animals) that can be passed from one generation to the next

Hibernacula – the location chosen by an animal for hibernation.

Hydric – pertaining to a wet or moist environment.

Hydrology – pertaining to the science of water.

Impoundments – an area enclosed to contain something, such as a beaver pond.

Natural Communities – combinations of distinct plant assemblages, their physical environments, and the ecological processes that affect them; includes both uplands and wetlands such as forests and woodlands, talus slopes, shorelines, marshes, forested swamps, peatlands, and floodplains.

Nutrient Cycling – process by which living (plants and animals) and non-living (soil and water) elements of the environment return to help produce and/or feed living organisms.

Peatland – a type of wetland that produces peat from decaying plants; Sphagnum mosses are typically found in peatlands.

Riparian – the area where land and water meet along the edge of a river, stream, lake, pond, or wetland.

Sedge Meadow – a type of wetland that typically forms in abandoned beaver impoundments, is noted by a lack of surface water, and includes various kinds of sedges and grasses.

Sequester Carbon – the act of capturing and storing carbon dioxide.

Species of Concern – includes all rare species as well as species that are in decline.

Stratified Glacial Drift – sediments (sand, clay, silt, and rock) that have been sorted and layered by size as a result of melting glaciers.

Successional Trend – the direction in which a forest changes over time; these are in response to disturbances such as logging, fire, and wind events (such as hurricanes), which can set the trend back to an earlier state.

Temperate Minerotrophic Swamp System – a type of wetland ecosystem that is dominated by trees and has some mineral enrichment important for plant growth; includes red maple swamps.

Terrestrial – pertaining to things associated with land (as opposed to air or wetlands).

Transmissivity – the rate at which water moves through an aquifer and is measured in square feet per day (ft^2/day).

Udic Moisture – a type of soil moisture regime that is found in humid climates but are not saturated by water long enough to deplete oxygen (compare to aquic moisture).

Unfragmented Blocks – undeveloped areas of land and water that are not broken up by Roadways, serving as critical habitat for a variety of species.

Vernal Pools – temporary pools of water associated with periodic drying that are free of fish, serving as critical habitats for many species, particularly amphibians that need this habitat for long-term survival.

Wetlands – defined by the NH Dept. of Environmental Services Wetlands Bureau as "an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soils conditions."

Spring beauty is a spring ephemeral observed along the Bog Brook floodplain. Trout lilies were also abundant in the area.

APPENDIX A
2012 & 2016 FIELD ASSESSMENT SUMMARY

Field Notes from Site Assessments during 2012 and 2016 in Alexandria, NH

The following field notes have been separated into four distinct sections: *Fowler River and Patten Brook Watersheds*, *Smith River Watershed*, *Alexandria Bog and Vicinity*, and *Town-wide Windshield Surveys*. In 2012, field surveys focused on the Patten Brook watershed, Alexandria Bog and surrounding area, and windshield surveys. In 2016, we expanded our field surveys to include the greater Fowler River watershed and the Smith River watershed.

A total of 10 days of field work were allocated to ground-truth various natural resources in 2012 and 2016. Roadside surveys and on-site assessments were used to collect data on wildlife, plants, habitats, and natural communities. All observations of wildlife were noted, including visual and auditory observations as well as other signs such as feeding, browsing, tracks, scat, and scent stations. Invasive plants were also noted. A GPS unit and digital camera was used to record significant ecological attributes.

Fowler River & Patten Brook Watersheds

Fowler River Watershed

Habitats and Natural Communities:

The Fowler River watershed contains a vast amount of wildlife habitat and natural communities. Notable features observed during field visits included Bog Brook, Town Brook, Brock Brook, Bear Mountain, and Wellington State Park.

The lower elevations within the Fowler River watershed are comprised of a hemlock-hardwood-pine forest ecosystem. The various brooks within the watershed vary slightly in substrate composition and associated forest community types. This can be due to a number of factors including stream order, geology, topography, and human influence. Bog Brook is a mostly sandy bottom stream with some large rocks and a sinuous channel. A small red maple floodplain forest can be found along Bog Brook between Bailey Road and Thissell Road. This floodplain forest also contains a vernal pool that is especially important for amphibians and other pool-breeding organisms.

Town Brook, which runs along Hodgdon Road, is about 6ft wide and is characterized as rocky/boulder with a repetition of riffles and falls followed by small pools. The forest community here is a semi-rich mesic sugar maple forest. The section of Brock Brook running along Brook Road is also lined with semi-rich mesic sugar maple forest, while the uplands to the east and west are characteristic of hemlock-beech-oak-pine forest. Small areas of beech forest are present on the slopes northeast of the brook while areas of pure hemlock forest were observed on the slopes to the southwest of the brook.

The upland communities in Wellington State Park and on the west side of Bear Mountain were also characteristic of a hemlock-hardwood-pine forest ecosystem. The main natural community is represented by hemlock-beech-oak-pine forest. Signs of current logging were observed to the east of the power line on Bear Mountain, as well as to the northeast of Brock Brook. It is likely that the majority of the slopes in the northern part of the Fowler River watershed are very similar to those of Bear Mountain and Wellington State Park. As one gains in elevation the northern hardwood-conifer forest ecosystem begins to dominate the landscape, which includes communities such as hemlock-oak-northern hardwood forest and sugar maple-beech-yellow birch forest.

In elevations below 2,400 feet sugar maple-beech-yellow birch forest was observed by Peter J. Bowman on the slopes of Cardigan Mountain in his 2007 report "Ecological Inventory of Cardigan Mountain State Forest." As elevation increased above 2,400 feet, the high-elevation spruce-fir forest ecosystem dominates this landscape. High-elevation spruce-fir forest community is the typical forest type. However, two other ecosystems with their associated communities were also observed at the higher elevations of Cardigan Mountain. The montane rocky ridge system containing red spruce-heath-cinquefoil rocky ridge and montane heath woodland communities were present on the summit and upper slopes of Firescrew, Broad Ridge between Firescrew and Cardigan Mountain, as well as the eastern and southern slopes of Cardigan Mountain between 2,500 and 2,800 feet (Bowman 2007). Subalpine heath-krummholz/rocky bald system containing sheep laurel-labrador tea heath-krummholz and subalpine rocky bald communities were also present on the summit and directly south of the summit on Cardigan Mountain (Bowman 2007). These communities are only found at high elevations and unlikely to be observed anywhere else in Alexandria.

Patten Brook Watershed

Habitats and Natural Communities

The Patten Brook watershed falls within the greater Fowler River watershed (see Map 2, p.18). This section has been separated since this was a major focus during the 2012 natural resources inventory. Most of the ecological attributes of the Patten Brook watershed mirror that of the greater Fowler River watershed.

The Patten Brook watershed contains a variety of important wildlife habitats and natural communities. The upper slopes of Hutchins Hill and Braley Hill support a northern hardwood-conifer forest ecosystem, comprising various natural communities, including northern hardwood spruce-fir-forest, sugar maple-beech-yellow birch forest, and hemlock-spruce-northern hardwood forest. The semi-rich mesic sugar maple forest community occurs in smaller patches within the larger forested ecosystem, particularly where the soil increases in moisture and nutrient enrichment. Rich mesic forests may also be present. It is suspected that the same forest communities may also occur on Brown Mountain and Pine Hill, as well as the north side of Alexander Hill. The top of Hutchins Hill supports a mature stand of a lowland spruce-fir forest community, and through aerial photography interpretation it appears that this spruce-fir forest also exists on top of Braley Hill and Pine Hill. The south-facing slope of Hutchins Hill also supports rocky outcrops and small cliffs. This area provides habitat for snake hibernacula, as well as winter sunning areas for bobcat and denning sites for other mammals such as porcupine.

As one begins to move into the lower elevations and along Patten Brook hemlock-hardwood-pine forest communities tend to dominate with the occasional lowland spruce-fir swamp. Areas lower in the watershed dominated by hemlock may be serving as deer wintering areas (or deeryards). In addition, a few older trees were observed scattered throughout the watershed, including a few 2.5-3 feet yellow birches, 2.5 feet white ash, and a 3.5 feet sugar maple, as well as some older hemlocks. These trees are estimated to be about 150-250+ years old.

Patten Brook appears to be a fairly healthy, intact brook. Throughout its stretch from high in the watershed until it meets its confluence with the Alexandria Bog and Bog Brook, Patten Brook remains mostly a forested stream. An old beaver impoundment was

observed along Washburn Road just east of the brook's origin. Approximately five road crossings occur along its length, as well as various driveways. In the upper portion of the watershed Patten Brook is fairly narrow with a variety of in-stream habitats, including small cascades, riffles, and pools. These varied habitats create for a biologically diverse aquatic ecosystem. As one moves into the lower portion of the watershed Patten Brook becomes much broader and is mainly characterized by riffle habitat. This habitat can be observed from the bridge on Washburn Road along the flats west of the Village.

Wetlands within the watershed are quite limited. The abandoned beaver impoundment noted above most closely resembles a small sedge meadow marsh community. This meadow marsh is the result of a breached dam that drained an abandoned beaver pond. Prior to the development of the beaver dam it appears that the wetland was most likely a peatland (fen). Along the margins of the current wetland one can observe species associated with peatlands, including sphagnum moss, sundews, and marsh St. John's-wort. As beavers move into peatland ecosystems and build dams they strongly influence plant composition and structure by changing the hydrology of the wetland. The result includes a mix of species associated with both peatlands and marsh ecosystems.

Wildlife:

The Fowler River watershed is home to a diverse array of wildlife species. Forest and edge habitat bird species using the habitats found along the brooks and hills include: black-capped chickadee, chipping sparrow, song sparrow, northern cardinal, broad-winged hawk, blue jay, eastern phoebe, red-eyed vireo, black throated-blue warbler, black-throated green warbler, hermit thrush, common yellowthroat, white-throated sparrow, and eastern towhee. Multiple species of amphibians were observed, including the northern two-lined salamander and dusky salamander that rely on the rocky beds of Town Brook and Brock Brook for cover and feeding. Other amphibian species documented using the stream and forest habitats were green frog, American toad, and eastern red-spotted newt. It is expected there are wood turtles using streams and books in the Fowler River watershed. Bog Brook is especially suspect due to its sinuous nature providing sandy point bars for nesting and dark cut banks for hiding. In addition to amphibians and reptiles, mammals are also well-represented. The large, undivided tracts of forest proved to be good habitat for black bear and moose, whose scat and other sign were seen in abundance throughout the watershed. Smaller mammals including raccoon, gray squirrel, and chipmunk were also documented along brooks and in forests of the Fowler River watershed.

Wildlife observed within the Patten Brook watershed was also quite diverse. These included wildlife mostly using forested habitats but were also associated with forest edges, small forest openings, riparian habitats along Patten Brook, and an abandoned beaver pond. These species included red-tailed hawk, broad-winged hawk, Cooper's hawk, pileated woodpecker, black-capped chickadee, white-breasted nuthatch, hermit thrush, common raven, American crow, blue jay, veery, least flycatcher, eastern wood-pewee, common yellowthroat, indigo bunting, magnolia warbler, red-eyed vireo, blue-headed vireo, wild turkey, and cedar waxwing. Also reported were American woodcock (a species of conservation concern). Mammals included white-tailed deer, moose, black bear, coyote, weasel, red squirrel, porcupine, and bobcat. In terms of

amphibians and reptiles seven species were recorded, including American toad, green frog, red-spotted newt, spring peeper, pickerel frog, gray tree frog and garter snake.

Unique/Rare and Invasive Plants:

This assessment does not represent a comprehensive survey of rare and invasive species within the Fowler River watershed. However, it does represent an assessment of the portions of the watershed visited.

No rare species were observed within the Patten Brook watershed. Invasive species included Japanese knotweed, which was prevalent near the confluence with Bog Brook on either side of Bog Road. Invasive species were not observed within the upland forests of the Patten Brook watershed.

No rare plant species were observed during the field visits in 2016 conducted by Moosewood Ecological in the other portions of the Fowler River watershed. However, Bigelow's sedge (*Carex bigelowii)* was found on summit of Mount Cardigan; head-like sedge (*Carex capitata ssp. Arctogena)* was found just west of the summit of Cardigan Mountain; and mountain firmoss (*Huperzia appalachiana)* was found on the northern slope of the main peak of Cardigan Mountain (Bowman 2007). Although no invasive species were observed in the Fowler River watershed during the 2016 visit this does not mean they are not present in other locations not visited. They are likely to occur in the utility right-of-way that cuts through Alexandria.

Natural Communities*

Ecosystem Type	Natural Community Type(s)
Lowland Spruce-Fir/Swamp System	Lowland Spruce-Fir Forest
	Red Spruce-Heath-Cinquefoil Rocky Ridge
	Red Spruce Swamp
	Acidic *Sphagnum* Forest Seep
Northern Hardwood-Conifer System	Northern Hardwood Spruce-Fir Forest
	Sugar Maple-Beech-Yellow Birch Forest
	Hemlock-Spruce-Northern Hardwood Forest
	Hemlock-Oak-Northern Hardwood Forest
	Semi-rich Mesic Sugar Maple Forest
	Rich Mesic Forest
Hemlock-Hardwood-Pine System	Hemlock Forest
	Beech Forest
	Hemlock-Beech-Oak-Pine Forest
	Hemlock-White Pine Forest
	Red Oak-Pine Rocky Ridge
	Semi-rich Mesic Sugar Maple Forest
	Rich Mesic Forest
Emergent Marsh/Shrub Swamp System	Sedge Meadow Marsh
	Highbush Blueberry-Winterberry Shrub Thicket

Montane Rocky Ridge System	Red Spruce-Heath-Cinquefoil Rocky Ridge Montane Heath Woodland
Subalpine Heath-Krummholz/Rocky	Sheep Laurel-Labrador Tea Heath Bald System Krummholz Subalpine Rocky Bald
High-elevation Spruce-fir Forest System	High-elevation Spruce-fir Forest

* = This list represents the suite of natural communities that were observed or may be present within this study area.

Smith River Watershed

Habitats and Natural Communities:

The Smith River watershed contains a variety of natural communities and wildlife habitats. The majority of the Smith River watershed is characterized by the hemlock-hardwood-pine forest ecosystem with elements of the northern hardwood-conifer forest ecosystem. Communities observed include hemlock-beech-oak-pine forest and hemlock-spruce-northern hardwood forest, as well as northern hardwood spruce-fir forest. These communities occupy the majority of the northern bank and south facing slope of Forbes Mountain. Also present on the southern slope of Forbes Mountain is a lowland spruce-fir/swamp forest ecosystem containing red spruce swamp and lowland spruce-fir forest communities. In the southeastern corner of the Smith River watershed there is an enriched red maple floodplain forest. A few vernal pools were observed on the northern side of the Smith River throughout the watershed.

Wildlife:

A diverse assemblage of wildlife was observed using the habitats and communities within the Smith River watershed. Birds associated with wetland systems and forest edges were observed along the edges of the Smith River. Species included black-throated green warbler, black-capped chickadee, white-breasted nuthatch, pileated woodpecker, yellow-throated vireo, wood duck, belted kingfisher, American robin, song sparrow, American crow, yellow-bellied sapsucker, northern flicker, eastern phoebe, chipping sparrow, northern cardinal, broad-winged hawk, blue jay, indigo bunting, red-eyed vireo, and great blue heron. Wood ducks were observed in a beaver impoundment in the central area of the Smith River watershed. An active beaver lodge was present, as well as multiple signs of fresh beaver activity.

Upland communities were also rich in wildlife. Bird species in the upland forest on the slopes of Forbes Mountain included blue jay, great-crested flycatcher, yellow-bellied sapsucker, chipping sparrow, red-breasted nuthatch, black-throated blue warbler, tufted titmouse, yellow-rumped warbler, and ovenbird. Moose tracks and scat were also observed in this area. Reptiles and amphibians were well-represented especially along the banks of the Smith River. Spring peeper, American toad, spotted salamander eggs, and wood frog eggs were observed along the river and within vernal pools. Sign of turtle

nesting was observed in the central part of the Smith River watershed where an abundance of sandy substrate was present. The nesting sign was most likely snapping turtle based on the size of the nests and the type of riverine habitat.

Unique/Rare and Invasive Plants:

There were no rare or unique plants observed within the Smith River watershed. Invasive species documented include Japanese knotweed along the banks of the Smith River in the southeastern and south central parts of the watershed. Multi-flora rose and Japanese barberry was also present in the southeastern part of the watershed close to the Smith River.

Natural Communities*

Ecosystem Type	Natural Community Type(s)
Lowland Spruce-Fir/Swamp System	Lowland Spruce-Fir Forest
	Red Spruce Swamp
	Acidic *Sphagnum* Forest Seep
Northern Hardwood-Conifer System	Northern Hardwood Spruce-Fir Forest
	Sugar Maple-Beech-Yellow Birch Forest
	Hemlock-Spruce-Northern Hardwood Forest
	Hemlock-Oak-Northern Hardwood Forest
	Semi-rich Mesic Sugar Maple Forest
Hemlock-Hardwood-Pine System	Hemlock Forest
	Beech Forest
	Hemlock-Beech-Oak-Pine Forest
	Hemlock-White Pine Forest
	Semi-rich Mesic Sugar Maple Forest
Emergent Marsh/Shrub Swamp System	Sedge Meadow Marsh
	Highbush Blueberry-Winterberry Shrub Thicket
Temperate minor river floodplain system	Red maple floodplain forest

* = This list represents the suite of natural communities that were observed or may be present within this study area.

Alexandria Bog and Vicinity

Habitats and Natural Communities:

The Alexandria Bog wetland is a large complex of marsh, shrub swamp, forested swamp, and peatland communities. Due to its size and array of habitats wildlife within the wetland is expected to be highly diverse. Based on landowner permissions, limited access to the wetland was provided. Access mainly included fringe areas of the wetland in a few locations and viewing the wetland from the roadside. As such, additional

sampling would be needed to more accurately classify and map the natural communities associated within this wetland complex.

Most of Alexandria Bog is characterized as an emergent marsh-shrub swamp ecosystem with small pockets of the medium level fen ecosystem (a type of peatland). The emergent marsh-shrub swamp ecosystem consisted of large patches of wet meadow and emergent marsh, transitioning to open to dense shrub swamps. A few small patches of peatlands exist as well. The best example of the medium level fen ecosystem can be found along the edge of Foster Pond. This ecosystem comprised many types of natural communities, including a leather-leaf – sweet gale shrub bog and a floating marshy peat mat communities.

Along various edges of Alexandria Bog the wetland graded into forested swamps. These swamps included the hemlock-cinnamon fern forest and seasonally flooded red maple swamp. Some of these swamps may be functioning as vernal pools. In addition, two vernal pools were observed within the upland forest adjacent to Alexandria Bog.

An additional wetland complex was observed west of the Alexandria Bog. This wetland appears to be in excellent condition, consisting of peatland and emergent marsh-shrub swamp ecosystems. The upper portion of the wetland complex most likely contains a combination of a medium level fen ecosystem and poor level fen/bog ecosystem, comprising various natural communities. Among these included highbush blueberry-mountain holly wooded fen, mountain holly-black spruce wooded fen, leather-leaf - sheep laurel dwarf shrub bog, and large cranberry-short sedge moss lawn. Additional sampling would be needed to more accurately classify and map the natural communities associated within this wetland complex. Lastly, the middle of this wetland complex included an open water pond and its associated aquatic bed of pond lilies.

The upland forests surrounding the Alexandria Bog primarily consists of the hemlock-hardwood-pine ecosystem. Forest communities observed within this ecosystem included hemlock forest, hemlock-beech-oak-pine forest, and hemlock-white pine forest. Some areas within hemlock-dominated forests may be functioning as deer wintering areas (or deeryards). A small floodplain forest was observed along Patten Brook between Cass Mill Road and Bog Road. Adjacent to this area it appears that a hemlock-oak-northern hardwood forest exists on a small, north-facing slope.

Several open areas adjacent to Alexandria Bog and along side of Bog Road provide great turtle nesting habitat. The power line right-of-way was one such place. Another site included the town-owned property along Bog Road.

Wildlife:

Given the wide range of habitats, wildlife within this study area included a variety of species using terrestrial, wetland, and aquatic habitat types. Species observed using open water, emergent marsh and shrub swamp habitats included mallard, wood duck, red-winged blackbird, kingfisher, mourning dove, cedar waxwing, American crow, barn swallow, chimney swift, eastern phoebe, eastern kingbird, alder flycatcher, northern parula, common yellowthroat, northern waterthrush, gray catbird, eastern towhee, song sparrow, swamp sparrow, chipping sparrow, vesper sparrow, yellow warbler, American goldfinch, broad-winged hawk, red-tailed hawk, garter snake, spring peeper, green frog, bullfrog, pickerel frog, deer, moose, coyote, bear, raccoon, skunk, mink, and otter, as

well as old and new beaver sign. These observations also included those using the edge habitats associated with the adjacent forested areas, as well as the power line corridor. Species observed within the upland forests included northern goshawk, barred owl, pileated woodpecker, hairy woodpecker, blue jay, American crow, common raven, black-capped chickadee, winter wren, veery, hermit thrush, red-eyed vireo, blue-headed vireo, ovenbird, scarlet tanager, chipmunk, red squirrel, coyote, deer, moose, bear, wood frog, gray tree frog, and red-spotted newt.

Natural Communities*

Ecosystem Type	Natural Community Type(s)
Hemlock-Hardwood-Pine System	Hemlock Forest Hemlock-Beech-Oak-Pine Forest Hemlock-White Pine Forest
Northern Hardwood-Conifer System	Hemlock-Oak-Northern Hardwood Forest
Emergent Marsh-Shrub Swamp System	Emergent Marsh Cattail Marsh Tall Graminoid Meadow Marsh Mixed Tall Graminoid - Scrub-Shrub Marsh Aquatic Bed Highbush Blueberry-Winterberry Shrub Thicket Alder Alluvial Shrubland
Medium Level Fen System and Poor Level Fen/Bog System	Highbush Blueberry-Mountain Holly Wooded Fen Leather-leaf – Black Spruce Leather-leaf – Sheep Laurel Shrub Bog Large Cranberry-Short Sedge Moss Lawn Speckled Alder Wooded Fen Hairy-fruited Sedge-Sweet Gale Fen Floating Marshy Peat Mat
Temperate Minerotrophic Swamp System	Hemlock-Cinnamon Fern Forest Seasonally Flooded Red Maple Swamp

* = This list represents the suite of natural communities that were observed or may be present within this study area.

Unique/Rare and Invasive Plants:

No rare plants were observed. Japanese knotweed was the most predominant species associated with the Alexandria Bog area. As noted above, a major infestation site was observed at the confluence of Patten Brook and Bog Brook. Another smaller area was noted on the town-owned site on Bog Road. Autumn olive was also noted in this location. One purple loosestrife plant was noted along Bog Road at the crossing of Bog Brook adjacent to the powerline right-of-way. Japanese knotweed and buckthorn were noted within the powerline right-of-way. Burning bush was observed in the Village. It is predicted that other invasive species also exists along the right-of-way. This assessment does not represent a comprehensive survey of rare and invasive species within the Alexandria Bog study area.

Town-wide Windshield Surveys

Habitats and Natural Communities:

Based on roadside windshield surveys in 2012 and 2016 it appears that most of the Wildlife Action Plan (WAP) forested habitats are mapped correctly for Alexandria. These included northern hardwood-conifer and hemlock-hardwood pine forests. More detailed sampling would be needed to confirm the extent of these forests since past land use history (mainly logging) has altered species composition and has created a variety of age classes throughout Alexandria, including early and mid successional forests, which can hinder the identification of natural communities from roadsides. As such, the lowland spruce-fir forest is not currently recognized by the WAP to exist in Alexandria. However, small examples have been observed in the town. Also, based on roadside assessments and aerial photography it is highly likely that the Appalachian oak-pine forest and pine barren habitats do not exist in Alexandria.

The rocky ridge/talus slope and cliff habitats are mostly correct. As noted above, rocky ridge/talus slope habitat was also observed on the south face of Hutchins Hill. It is likely that there are additional small patches on other south facing slopes in Alexandria. Grasslands appear to be over estimated. Grasslands mapped along the roadways are fairly correct. However, after reviewing aerial photography some of the grasslands within the core forested areas (out of view from roadsides) do not exist. These include areas such as the powerline right-of-way near Alexandria Bog, as well as most of the grasslands mapped around the rocky ridge/talus slope habitat on Oregon Mountain to the north.

Forest floodplains are probably slightly more prevalent along Smith River, including red maple floodplains observed during this project. The floodplains in the Village are most likely more prevalent but include grasslands as well as forests. Wet meadow/shrub wetlands and peatland habitats are also mostly correct with two exceptions. As noted above, the relatively large wetland west of Alexandria Bog is actually mostly a peatland as is the southern portion of Alexandria Bog at the powerline right-of-way.

Wildlife:

The following wildlife observations are in addition to the lists developed while conducting on-site visits within the Fowler River and Smith River watersheds and the Alexandria Bog area. Within and adjacent to the many grasslands, hayfields, corn fields,

and pastures the following wildlife were observed: broad-winged hawk, turkey vulture, American robin, American crow, song sparrow, bobolink, chipping sparrow, tree swallow, barn swallow, chestnut-sided warbler, eastern bluebird, red-winged blackbird, Northern cardinal, and mourning dove. Adjacent forest birds observed included: kingfisher, chestnut-sided warbler, least flycatcher, American goldfinch, American robin, blue jay, common yellowthroat, chipping sparrow, northern parula, song sparrow, American redstart, great-crested flycatcher, blue-headed vireo, and red-eyed vireo.

Unique/Rare and Invasive Plants:

No rare plants were observed from roadside windshield assessments. Japanese knotweed was observed on the town owner property adjacent to Bog Road and along Walker Road where it crosses a small brook that drains into the Smith River. With its proximity to the Smith River and the overall general ecology of Japanese knotweed it was not surprising that this species was found in the southeastern part of the watershed along the banks and floodplains of the Smith River and other streams close to the Smith River during our onsite visitation.

This assessment does not represent a comprehensive survey of rare and invasive species within the Town of Alexandria.

Wildlife of Alexandria

The following lists of wildlife were based on the 10 field assessments (Littleton 2012 and Littleton 2016), as well as a report on the Alexandria Bog (Audubon Society of New Hampshire 1993). These lists include 95 birds, 18 mammals, 12 amphibians, and 5 reptiles. This list is not meant to be a comprehensive list rather it should serve as a supplement to existing and future lists for Alexandria. Species listed in bold are considered species of conservation concern by the NH Fish and Game (2015). Species noted with one (1) are listed as threatened in NH. Those noted with two (2) are listed as endangered in NH. One very unusual visitor included a sandhill crane that was observed in the village in May 2012. This species is generally found in Canada and the northern part of the Midwest during the breeding season.

Birds

Great blue heron
Canada goose
Wood duck
Mallard
Sandhill crane
Turkey vulture
Northern harrier[2]
Broad-winged hawk
Red-tailed hawk
Northern goshawk
Cooper's hawk
Sharp-shinned hawk
Peregrine falcon[1]
Ruffed grouse
Wild turkey
Virginia rail
Killdeer
American woodcock
Solitary sandpiper
Mourning dove
Ruby-throated hummingbird
Belted kingfisher
Yellow-bellied sapsucker
Downy woodpecker
Hairy woodpecker
Northern flicker
Pileated woodpecker
Eastern phoebe
Eastern wood-pewee
Great-crested flycatcher
Eastern kingbird
Least flycatcher
Alder flycatcher
Blue jay
Common raven
American crow
Tree swallow
Bank swallow
Barn swallow
Chimney swift
Black-capped chickadee
Tufted titmouse
Red-breasted nuthatch
White-breasted nuthatch
Brown creeper
Winter wren
House wren
Golden-crowned kinglet
Ruby-crowned kinglet
Gray catbird
Hermit thrush
Veery
Eastern bluebird
American robin
Cedar waxwing
Red-eyed vireo
Blue-headed vireo
Warbling vireo
Tennessee warbler
Northern parula
Yellow warbler
Chestnut-sided warbler
American redstart
Magnolia warbler
Black-throated blue warbler
Yellow-rumped warbler
Black-throated green warbler
Prairie warbler
Black-and-white warbler
Ovenbird
Common yellowthroat
Northern waterthrush
Dark-eyed junco
Purple finch
Evening grosbeak
American goldfinch
Scarlet tanager
Indigo bunting
Northern cardinal
Rose-breasted grosbeak
Eastern towhee
Chipping sparrow
Song sparrow
Swamp sparrow
White-throated sparrow
White-crowned sparrow
Fox sparrow
Field sparrow
Vesper sparrow
Red-winged blackbird
Eastern meadowlark
Rusty blackbird
Common grackle
Bobolink
Baltimore oriole

Mammals

Eastern coyote	Mink
Red fox	Weasel
American beaver	Raccoon
Moose	North American porcupine
White-tailed deer	Deer or White-footed mouse
Snowshoe hare	Eastern chipmunk
River otter	Red squirrel
Fisher	Black bear
Ermine (short-tailed weasel)	Shrew

Amphibians

Spotted salamander	Spring peeper
Redback salamander	Bullfrog
Red-spotted newt	Green frog
American toad	Pickerel frog
Gray tree frog	Wood frog
Two-lined salamander	Dusky salamander

Reptiles

Eastern painted turtle
Wood turtle
Eastern ribbon snake
Eastern garter snake
Snapping turtle

References and Citations

Audubon Society of New Hampshire. 1993. Inventory of the Alexandria Bog (South of the Fowler River). Audubon Society of New Hampshire, Concord, NH.

Bowman, P.J. 2007. Ecological Inventory of Cardigan Mountain State Forest. New Hampshire Natural Heritage Bureau, Concord, New Hampshire.

Littleton, J. 2013. Alexandria Natural Resources Inventory. Moosewood Ecological LLC, Chesterfield, NH.

New Hampshire Fish and Game Department. 2015 (second edition). New Hampshire Wildlife Action Plan. New Hampshire Fish and Game Department, Concord, New Hampshire.

Sperduto, D.D. 2005. Natural Community Systems of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire.

Sperduto, D.D. and W.F. Nichols. 2011 (second edition). Natural Communities of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, NH. Pub. UNH Cooperative Extension, Durham, NH.