Wildlife Habitat and Land Stewardship Plan
for the
Spruce Hole Conservation Area

Durham, New Hampshire

Prepared for the:
Durham Conservation Commission
Durham, New Hampshire

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Purpose of this Plan

The goal of this Stewardship Plan was to assess the current condition of the property and to guide the implementation of stewardship activities to protect the Spruce Hole Bog and Spruce Hole Aquifer and associated water supply, to benefit, and enhance recreational opportunities where feasible on the Spruce Hole Conservation Area. This was achieved by identifying and evaluating the soils, topography, plants, animals, habitats, trails and other cultural features, and landscape setting of the property. This Plan was funded by an an anonymous donor.

This Wildlife Habitat and Land Stewardship Plan includes the following chapters and materials:

- **Chapter 1 – Property Description** describes the location and property history.
- **Chapter 2 -- Ecological Features** describes the landscape setting, topography, soils, Spruce Hole Bog, oak-pine forest, plant and wildlife observations, and cultural features of the property.
- **Chapter 3 – Stewardship Recommendations** presents management actions to protect the bog and aquifer, enhance wildlife habitat, and enhance recreational opportunities.
- **A set of maps is included as Appendix 1** to further illustrate the property features.
- **Appendices 2-8** provide additional background material and property documents.

Chapter 1 Property Description

Location and General Description

The Town of Durham owns the 42-acre Spruce Hole Conservation Area. The property is located on the Town's western boundary with the Town of Lee. It is about 3 miles from downtown Durham and is bounded by Packers Falls Road to the south, a private landowner and Durham's Packers Falls gravel pit/new Spruce Hole well site to the west, a private landowner to the north, and the Oyster River Forest to the east (Map 1—Appendix 1). Public access to the property is from a parking area off Packers Falls Road on the adjacent Oyster River Forest.

Spruce Hole Conservation Area protects the Spruce Hole Bog and the Spruce Hole Aquifer. It is entirely upland woods, except for the 2.5-acre kettle hole bog, which is recognized as a National Natural Landmark by the National Park Service. A trail network leads from the abutting 172-acre Oyster River Forest to the bog. In 2010, a portion of the Spruce Hole Conservation Area was logged under the supervision of forester Charlie Moreno on behalf of the Town of Durham. A water supply line was laid in 2014, extending from Durham's Packers Falls gravel pit (site of the new Spruce Hole well) through the Spruce Hole Conservation Area to an existing water line on the Oyster River Forest (Map 5—Appendix 1).

The property appears to be in good ecological health. I found no invasive plant species and there is no detectable erosion, debris, or other related issues. Given that invasive plants are prevalent on the abutting Oyster River Forest and soils were disturbed during the laying of a new water line, it will be important to regularly monitor for invasive plants.

History of the Property

The National Park Service designated Spruce Hole Bog as a National Natural Landmark in 1972. According to the National Register of Natural Landmarks: "It illustrates characteristics of a typical sphagnum-heath bog, localized in a specialized geologic setting." Spruce Hole Bog was said to be the last of six kettle hole bogs in southern New Hampshire. The other five were presumably destroyed by development (from Miller 1996).

The Durham Conservation Commission pursued preservation of the unique Spruce Hole Bog beginning in the early 1970s when the landowner (Morgan) and developers were considering a large residential subdivision of the land that included the bog. After several years of discussion and negotiations, the Town of Durham acquired a 14.5-acre parcel of land that included the bog from Norman and Nada Morgan in 1974. The land was described on a plan titled, "Boundary Plan of the Spruce Hole Tract for the Durham Conservation Commission," and drawn by H. Berquist (Appendix 3). The conveyance was subject to the following (see Appendix 4 for the full warranty deed):

- The said Town of Durham shall, within reasonable time, from and after the date hereof, erect and maintain an appropriate fence on that portion of the premises beginning at the Phair property, so-

called, and that portion of the Morgan property adjoining the gravel pit; and thereafter maintained by the said town of Durham.

- The said Morgan and Morgan, their heirs, successors, and assigns, retain the right to the use of the premises herein above conveyed for the purpose of satisfying density requirements of the Planning Board of the Town of Durham with respect to the development of the adjoining premises.

- The above-described premises are to be used by the Town of Durham Conservation Commission in accordance with New Hampshire Revised Statutes Annotated 36-A, as amended or hereinafter amended.

The Phair property referred to in the first statement above is now the Oyster River Forest and the Morgan property referred to as adjoining the gravel pit is now part of the Spruce Hole Conservation Area. Conservation Commission notes from October 2, 1974 as compiled by Robin Mower (2014) mentions that, "The agreement requires fencing 1100 feet of one side of the tract." The town erected a barbed wire fence along that boundary to be in compliance with the deed, and it is still evident today. However, the town now owns both sides of this fence, so whatever the original purpose of the fence, it now seems moot.

The Town of Durham acquired the 27.7 acres that lies to the south of the 14.5-acre Spruce Hole Bog tract In 1989. Collectively these two tracts make up the 42-acre Spruce Hole Conservation Area. This second parcel was acquired through Eminent Domain (See Appendix 4). The Town determined that this property was required for the purpose of protecting the fragile ecological system surrounding Spruce Hole; to expand the municipal water system; eliminate potential pollution; and protect a water supply. The three owners at the time (known as Spruce Hole Associates) were proposing a development that would have harmed these values.

Table 1. Documents related to the Spruce Hole Conservation Area.

Document/Reference Information	Date Recorded	Registry of Deeds and/or Prepared By
Durham Tax Map 13 Lots 13-1 and 13-5; 42 acres	------	(Appendix 2)
Warranty Deed-Spruce Hole Bog (Morgan to Town of Durham)	9/25/1974	BK 953 PG 015 (Appendix 4)
Boundary Plan (Morgan-Spruce Hole Bog)	9/30/1974	Plan #54, Pocket 4, Folder 1; Drawn by H. Berquist (Appendix 3)
Plan of Lots, Nada Morgan	4/16/1982	Plan #23A-43 by G.L. Davis and Associates (Appendix 3)
Plan of Lots, Nada Morgan	4/16/1982	Plan #23A-44 by G.L. Davis and Associates (Appendix 3)
Plan of Lots, Nada Morgan	5/17/1986	Plan #024A-036 by G.L. Davis and Associates (Appendix 3)
Eminent Domain document (Spruce Hole Assoc. to Town of Durham)	11/29/1989	BK 1482 PG 0583 (Appendix 4)
Warranty Deed (Morgan to Spruce Hole Assoc.)	06/06/1988	BK 1388 PG 0786
Warranty Deed-Gravel Pit (Morgan to Town of Durham)	5/26/1982	BK 1080 PG 468
Warranty Deed (Kunkle to Colasante)(abuts Spruce Hole)	11/6/1998	BK 2055 PG 0499
Warranty Deed (Fisher to Morgan)	8/12/1958	BK 692 PG 13

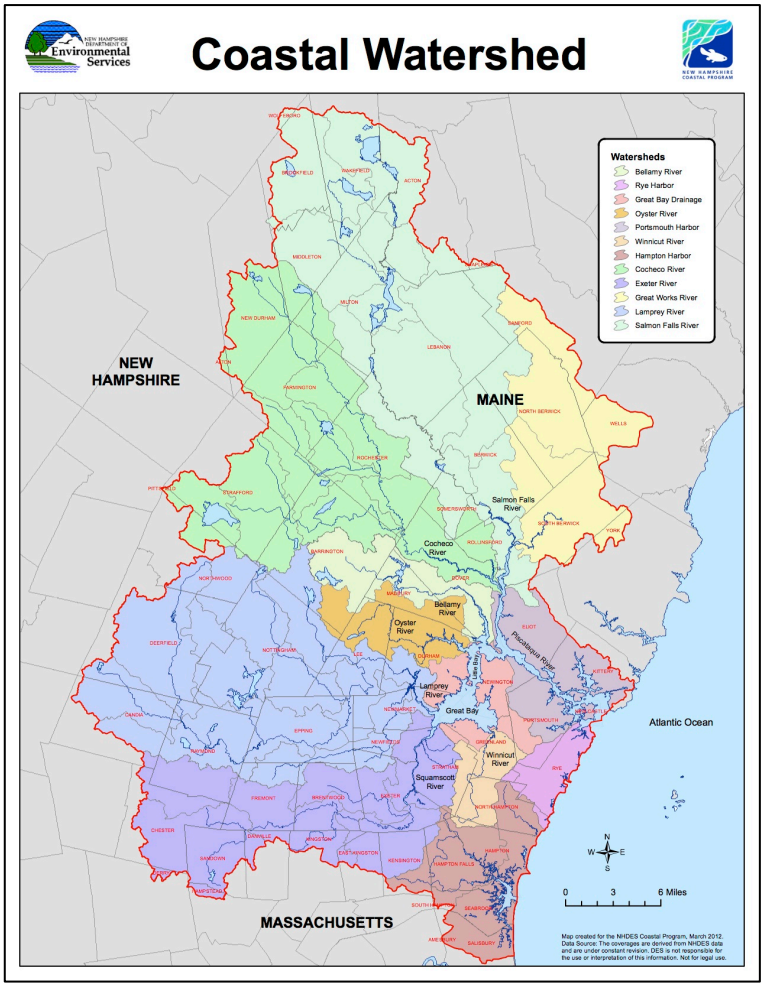
Chapter 2 Ecological and Cultural Features

Landscape Setting

Oyster River Watershed

The Spruce Hole Conservation Area lies entirely within the Oyster River watershed. The Oyster River is one of seven major rivers that flow into the nationally significant Great Bay estuary. At 19,875 acres, the Oyster River watershed is one of the smallest watersheds in the entire coastal region of New Hampshire. Portions of six towns make up the watershed: Durham (38%), Lee (24%), Madbury (17%), Barrington (15%), Dover (5%), and Nottingham (2%). Nearly half of Durham lies within the watershed.

In 2000, local volunteers formed the Oyster River Watershed Association, a 501(c)(3) nonprofit, to protect the ecological integrity and environmental quality of the watershed through community participation and involvement. The group wrote a management plan in 2001 and in 2010 nominated the entire freshwater portion of the river, stretching from the headwaters in Barrington to the Mill Pond dam in Durham, for designation in the NH Rivers Management and Protection Program (ORWA 2001, 2010).



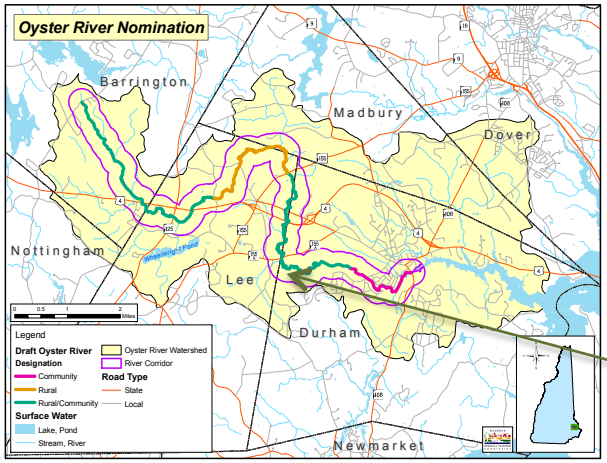


Figure 1.
Above: Location of Oyster River watershed within the Coastal Watershed of New Hampshire (Map from NH DES).

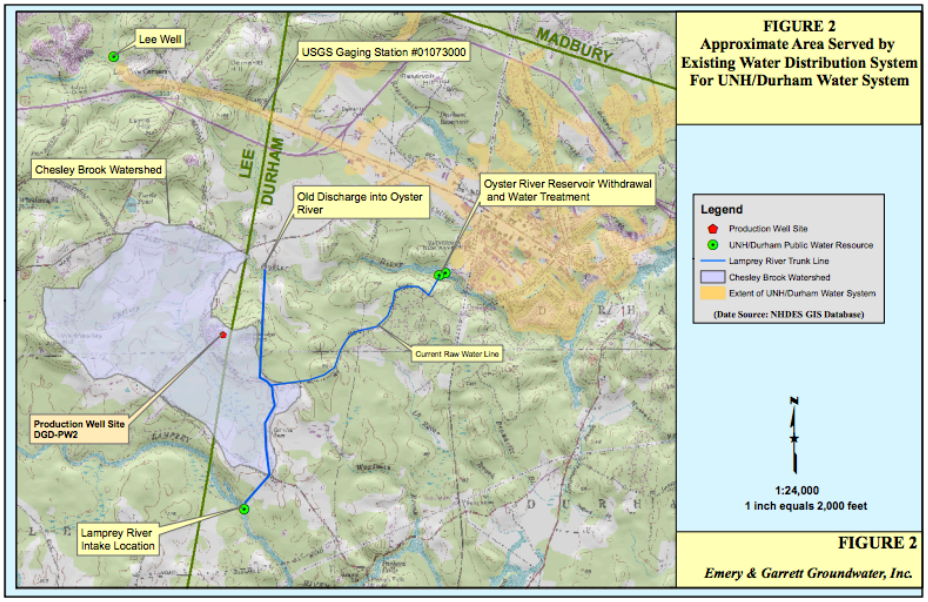
Figure 2.
Left: Location of Spruce Hole Conservation Area within the Oyster River watershed (Map from Oyster River Watershed Association).

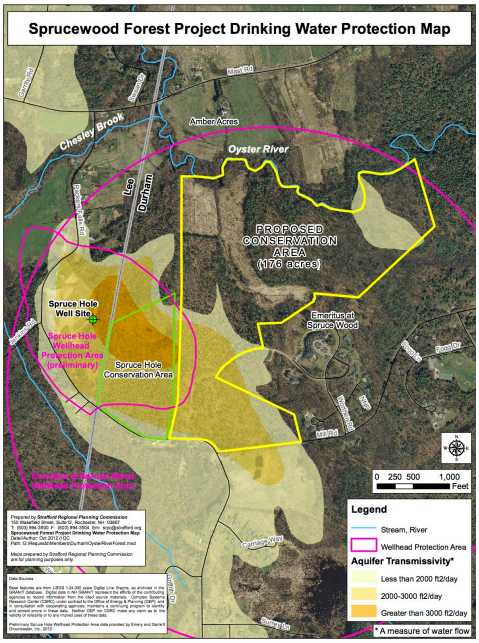
Wellhead Protection Areas and Stratified Drift Aquifer

The Spruce Hole Conservation Area lies entirely within the Emeritus at Sprucewoods wellhead protection area. Most of the property lies within the Spruce Hole wellhead protection area and an important stratified drift aquifer lies beneath the property (See Figure 4).

Historically the Town of Durham pumped water from the Lamprey River to the Oyster River for storage in the downstream Oyster River Reservoir; the water was pumped via a water pipe that is buried beneath the main woods road on the Oyster River Forest (Figure 3). In 2014, the Town laid a new water line from the Packers Falls gravel pit through the Spruce Hole Conservation Area to the existing water line on the Oyster River Forest (Map 5--Appendix 1). The new drinking water well is being installed on the site of Durham's Packers Falls Road gravel pit. When operational the Town will pump water from the Lamprey River during periods of high water to recharge the Spruce Hole Aquifer that underlies this new Spruce Hole Well.

Figure 3. (Left) Location of Durham water lines (from Emery & Garrett, Inc. 2012). Figure 4. (Right) Preliminary wellhead protection area for the Spruce Hole Well (from Strafford Regional Planning Commission (2012).





Stratified drift aquifers are composed of layers of sand and gravel deposited by glacial meltwater coming from glaciers. These layers are partially or fully saturated by groundwater. Several studies identified the aquifer as a potential future public water supply (ORLAC 2014). Most recently, Emery & Garrett, Inc. (2012) completed a final investigation of the potential water supply prior to the Town of Durham's installation of the new production well. Several new monitoring wells were installed as part of the development of a new production well (Figures 5 and 6). In 2000, Tom Ballestero and Tom Lee from the University of New Hampshire prepared a report on the hydrogeological conditions of the Spruce Hole Bog sand and gravel foundation. Their report laid the foundation for development of the Spruce Hole Well.

Figure 5. Monitoring well sites for the new Durham Spruce Hole Well (from Emery and Garrett 2012).

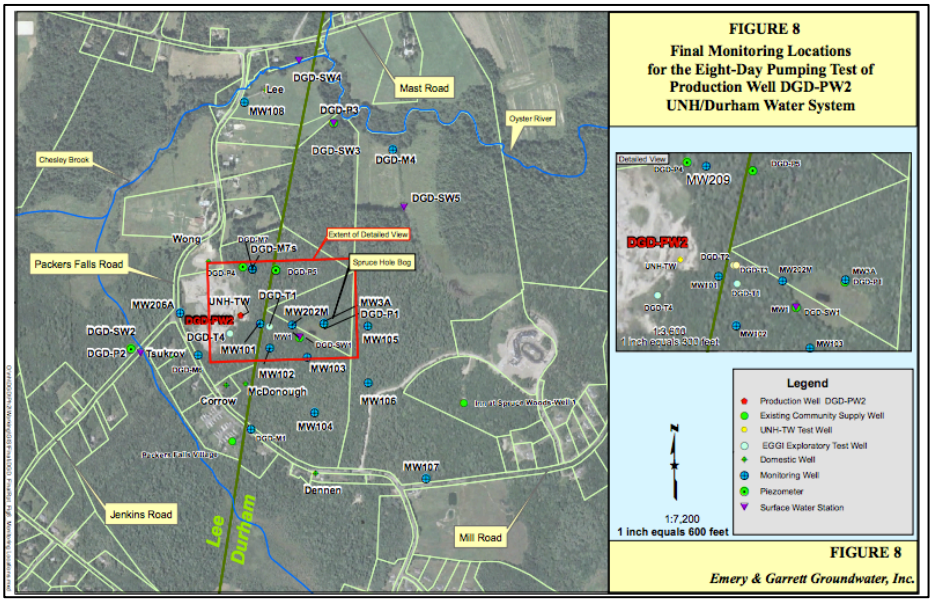
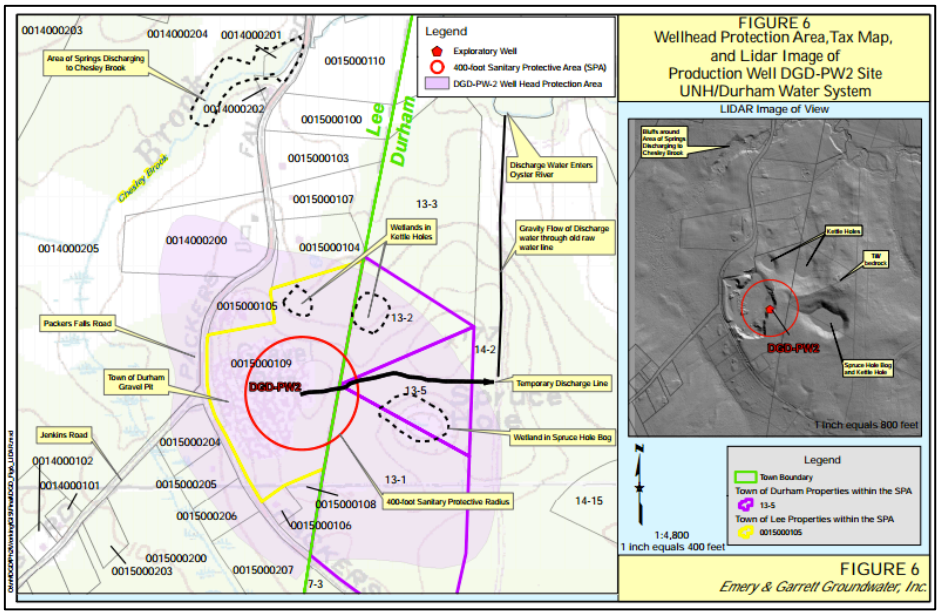


Figure 6. Wellhead protection area and lidar image (from Emery and Garrett 2012).



Conservation Focus Areas and Important Habitat

Oyster River Forest Conservation Focus Area

In 2006, The Nature Conservancy, Society for the Protection of New Hampshire Forests, and the Rockingham and Strafford Regional Planning Commissions published *The Land Conservation Plan for New Hampshire's Coastal Watersheds* ("The Coastal Plan") (Zankel et al. 2006). The authors identified 75 Conservation Focus Areas that comprise over 190,000 acres or 36% of the coastal watersheds that are of

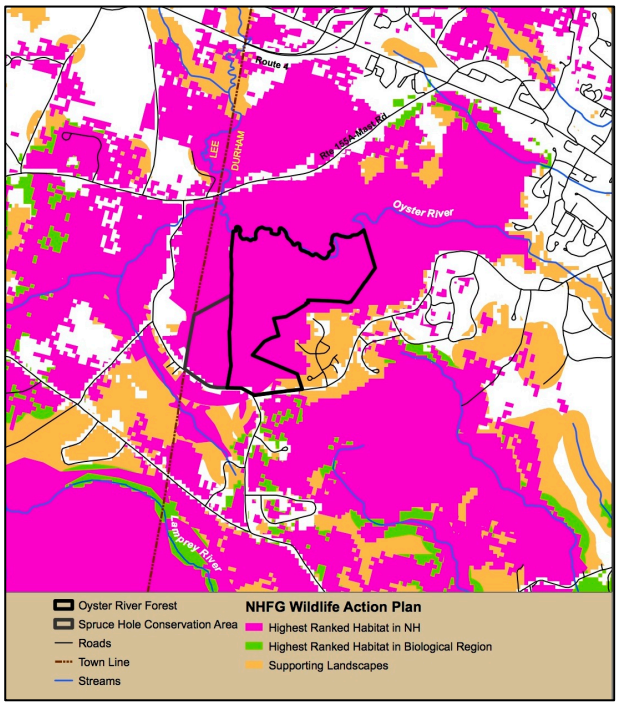
exceptional significance for living resources and water quality. The Spruce Hole Conservation Area is core area within the Oyster River Conservation Focus Area (Figure 8).

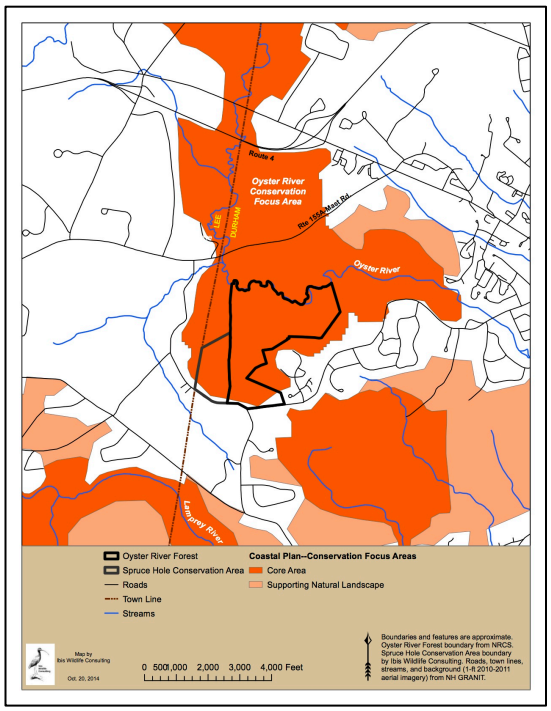
Highest Ranked Wildlife Habitat in New Hampshire

Since wildlife don't recognize ownership or political boundaries it is useful to see how a particular property fits into the larger landscape of wildlife habitats. To identify areas of statewide importance for wildlife, the NH Fish and Game Department (NHFG) analyzed the condition of broad habitat types, based on biological, landscape, and human factors that were impacting the habitat. Biological factors included rare plant and animal species and overall biological diversity. Landscape factors included size of habitat and how close it was to other patches of that habitat. Human impact factors included density of roads around the habitat, dams, recreational use, and pollution. Different factors were used to evaluate a particular habitat. For example, hiking trails may reduce the habitat quality in alpine areas, but are likely less damaging to oak-pine forests such as on the Spruce Hole Conservation Area.

The Spruce Hole Conservation Area falls within what the New Hampshire Fish and Game Department (NHFG) Wildlife Habitat Action Plan (NHFG 2006) identified as 'highest ranked habitat in the state." (NHFG 2010; Figure 7).

Figures 7 and 8. The Spruce Hole Conservation Area in relation to "highest ranked habitat in the state" from the NH Fish and Game Department based on the Wildlife Action Plan (NHFG 2006, 2010) and in relation to the Coastal Plan's Oyster River Conservation Focus Area.





Topography and Soils

The Spruce Hole Conservation Area is relatively flat, except for the kettle hole bog depression and the hill to the north of the bog, which rises to 177 feet, the highest point on the property. The steepest parts of the property are the slopes of the kettlehole bog. Except for water that flows into the kettlehole bog, surface water flows generally south and under Packers Falls and into Chesley Brook, which then flows into the Oyster River.

Table 2 lists the individual soil types found on the Spruce Hole Conservation Area. Except for the muck and peat soils in the bog (~3%), the property is well or excessively drained. The upland soil types include Windsor (55%), Hinckleys (34%), and Hollis-Charlton (7%). The very deep, excessively drained Windsor soils underlie the entire southern half of the property. These soils were well suited for growing white pine. The Hollis-Charlton soils are found on the hill north of the bog, where exposed rock is prevalent, whereas rocky outcrops or stones are absent from the rest of the Spruce Hole Conservation Area.

Besides the bog and associated muck and peat soils there are no other wetlands or poorly drained soils on the Spruce Hole Conservation Area.

Table 2. Soils for the Spruce Hole Conservation Area (USDA 2001).

Soil Symbol	Soil Name	Slope	Parent Material	Drainage	Forest Soils	Farm Soils	Total Acres
WdA/26A	Windsor loamy sand	0-3%	Outwash	Excessively drained	IC	Local importance	23.1
HaB/12B	Hinckley loamy sand	3-8%	Outwash	Excessively drained	IC	------	8.4
HbE/212E	Hinckley gravelly loamy sand	15-60%	Outwash	Excessively drained	IIA	------	5.6
HdC/185C	Hollis-Charlton very rocky fine sandy loams	8-15%	Till	Well drained	IB	------	2.8
Mp/295	Muck and peat	0%	Organic material	Very poorly drained	---	------	1.2
HaC/12C	Hinckley loamy sand	8-15%	Outwash	Excessively drained	IC	------	0.1

Spruce Hole Bog

The Spruce Hole Bog is a type of peatland--a saturated wetland with layers of partially decayed vegetation called peat. It is also a kettlehole bog. These occur in depressions formed during glaciation when massive blocks of ice broke off and were buried by glacial sediments. Over time the ice melted to form the depression. The low-nutrient, acidic, waterlogged environment in these holes then leads to an accumulation of peat, and, in kettlehole bogs, the formation of concentric zones of vegetation (Miller

1996). Ballestero and Lee (2000) noted that the Spruce Hole Bog is a perched wetland system fed by precipitation only and is hydraulically independent of the underlying aquifer.

Dr. Albion Hodgdon collected vascular plants at Spruce Hole Bog from 1930 to 1969; his voucher specimens are in the Hodgdon Herbarium at the University of New Hampshire (Ballestero and Lee 2000). In 1996, Scott Miller completed a vegetation analysis of Spruce Hole Bog for his Master's Thesis at the University of New Hampshire. Miller (1996) described the Spruce Hole Bog as follows:

"The bog occupies a kettlehole basin with sloping sides approximately 45 degrees on either side. There is a hill to the north and a gravel pit approximately half a kilometer to the west. The bog is in a closed basin and most likely receives nutrients primarily from precipitation, runoff from the slopes of the basin, or from groundwater flow. The water table of the peatland appears to be decoupled from that of the surrounding water table due to the presence of an impermeable layer (Ballestero et al. 1995) and can be described as a perched water-peatland system."

Through his fieldwork, Miller (1996) measured the roughly oval-shaped bog as approximately 152 meters (~500 feet) long, 80 meters (~260 feet) wide and one hectare (~2.5 acres) in size. He described five plant communities: lagg, low shrub, Sphagnum/sedge lawn, tall shrub, and bog forest (Figures 9 and 10). The lagg community is the wet margin (the transition zone) between the bog and the surrounding upland. It is typically wet and is where the floating mat of sphagnum is not consolidated enough to support human weight.

Figures 9 and 10. Vegetation of Spruce Hole Bog and bog basin profile (from Miller 1996).

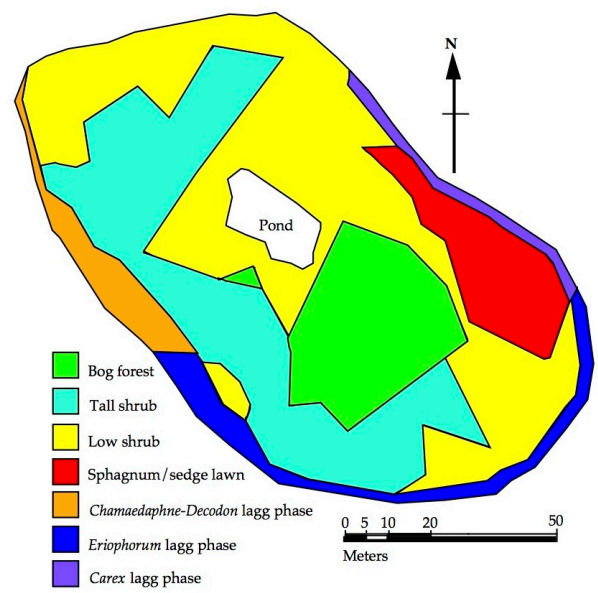


Figure 1.1. Vegetation map of Spruce Hole Bog. The five communities and three phases of the lagg community were delineated by mapping plots classified by the program TWINSPAN (Hill 1979) based on species composition and abundance.

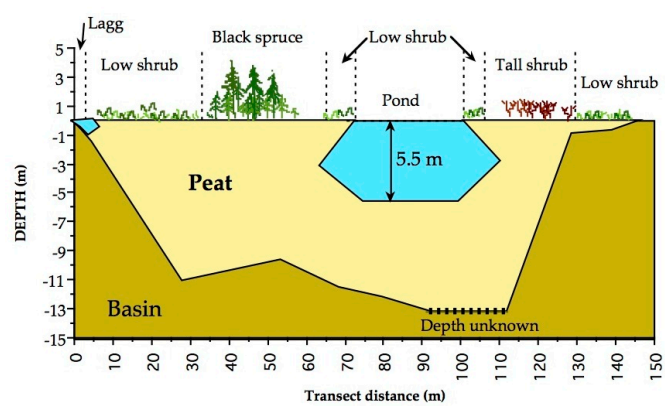


Figure 1.2. Basin profile of Spruce Hole Bog along a southeast to northwest transect. Depth to bedrock in the deepest portion of the basin remains unknown.

Miller also documented 37 vascular plants and 16 bryophytes (mosses and liverworts) in the Spruce Hole Bog (see Appendix 8). The lagg community was dominated by feathery moss (*Spaghnum cuspidatum*) accompanied by leatherleaf (*Chamaedaphne calyculata*) and swamp loosestrife (*Decodon verticillatus*), cottongrass (*Eriophorum* spp.), or sedges (*Carex* spp.) depending on the location around the bog. The low shrub community was dominated by leatherleaf and swamp loosestrife and two other species of *Sphagnum* moss (*S. recurvum* and *S. magellanicum*). The plants were less than two feet tall and the peat mat still too wet to support a person.

Miller (1996) mapped a small patch of *Sphagnum*/sedge lawn in the northeast corner of the bog. It was dominated by *Sphagnum recurvum* and leatherleaf along with a mix of other plants including hoary sedge (*Carex canescens*). The tall shrub community supported highbush blueberry (*Vaccinium corymbosum*), black huckleberry (*Gaylussacia baccata*), and several species of *Sphagnum*, and it had the most well developed hummock-hollow peat formations. Miller (1996) documented several dozen standing dead snags of white pine, thought to be a remnant of a drier period.

According to Miller (1996), the bog forest community had a high diversity of bryophytes—mosses and liverworts—among the dense stand of black spruce (*Pinus mariana*). Highbush blueberry, black huckleberry, and mountain holly (*Nemopanthus mucronatus*) were also abundant, especially around the edges of the spruce forest.

Miller (1996) concluded that the plant community within the Spruce Hole Bog has changed over time, likely in response to changes in water level, plant dynamics, past logging, and defoliation of oak and pine due to gypsy moths in the early 1980s, among other factors.

Oak-Pine Forest

The Spruce Hole Conservation Area is 94% upland Appalachian oak–pine forest. This broad forest type covers less than 10% of the state and is found mostly below 1000 feet in elevation in southern NH and along the Connecticut River in western NH. Intense development has dramatically reduced the area of this forest type, in which natural disturbance (including fire) is typically needed to create a diverse forest age structure (NHFG 2006).

Appalachian oak-pine forests typically grow on nutrient-poor, dry, sandy soils and in warm, dry climates. Some of the dominant plants in these forests are more abundant south of New England, including white oak, black oak, hickories, and pitch pine. Red oak and white pine are common in these forests, as they are in another broad forest type in this region: hemlock–beech–oak-pine forest. Oaks are more abundant on the dry or dry-mesic (moist) glacial till soils, while pines are more abundant on the dry sand plain (outwash) soils. In the absence of fire, other fire-intolerant species such as red maple, American beech, and birches (black, paper, gray) increase in abundance (Sperduto and Kimball 2011). This describes the forest on the Spruce Hole Conservation Area.

On the Spruce Hole Conservation Area, red oak and white pine dominate the overstory and lowbush blueberry and black huckleberry are the most common understory shrubs. A few large (12-inch plus diameter) pitch pines are growing in an area from the woods road gate east onto the Oyster River Forest. Hemlock is mostly absent and herbaceous plants are sparse. Ground flora includes wintergreen,

partridgeberry, ground cedar, and ground pine. These floristic characteristics classify this forest more specifically as a dry Appalachian oak forest.

At the north end of the property, on the north side of the bog and rising up to the top of the hill, hemlock and beech become a bit more abundant. Given the latitude (in a transition zone between northern and southern forest types), slight variations in elevation and different soils, forest types can vary and be intermixed in some areas. That northerly area leans more toward a hemlock–beech–oak-pine forest (or H-BOP).

In May-June 2010, consulting forester Charlie Moreno implemented a timber sale on behalf of the town on 30 acres of the Spruce Hole Conservation Area. This was a forest improvement thinning with the primary goals of improving forest heath (removal of diseased and declining trees) and regeneration of pine, oak, and hickory to enhance forest structure for wildlife. Moreno marked 150 trees with an average diameter of 12.5 inches for cut, leaving a 100-foot no-cut buffer around the bog. GC Morse Logging of Lebanon, Maine did the logging. The final harvest tally included 13,000 board feet of white pine, 435 tons of whole tree chips, and 6 cords of fuelwood. Since this was an improvement cutting, and not an income generator, but it should yield results in forest health and wildlife habitat.

Wildlife and Plant Observations

A systematic inventory of all plants and animals was not completed as part of this planning effort. However, as a result of my site visits and gleaning a list of species from the NH Natural Heritage Bureau Report (NHNHB 2014), Scott Miller's Thesis and the report by Ballestero and Lee (2000), I've assembled a list of plants and animals documented for the Spruce Hole Conservation Area (See Appendix 8).

Ballestero and Lee (2000) reported on several entomology studies conducted at Spruce Hole Bog, including these on mosquitoes and mites:

- Debboun, M. 1983. An ecological study of early season mosquitoes (Diptera: Culicidae) in a New Hampshire kettle hole bog. M.S. Thesis, University of New Hampshire, Durham, NH.

- Donaldson-Fortier, G.M. 1993. Oribatida (Acari) associated with three species of Sphagnum moss at Spruce Hole Bog, New Hampshire, USA. M.S. Thesis, University of New Hampshire, Durham, NH.

In addition, UNH entomologist Donald Chandler said that the most intensively surveyed site for insects in New Hampshire is the Spruce Hole Bog tract, which has an astounding 1,600 species documented for the bog and periphery. Of these, 450 species are beetles (Chandler 1996 *in* Taylor et al. 1996).

Rare Species

The New Hampshire Natural Heritage Bureau (NHNHB, Heritage Bureau) tracks rare species and exemplary natural community locations throughout the state. Appendix 5 includes a report from the NHNHB (2014) that documents the known rare plants and animals and exemplary natural communities for the Oyster River Forest and the Spruce Hole Conservation Area.

Several of the rare species records for the Spruce Hole Bog are historical with current conditions uncertain or no longer supporting these elements. The bog elfin (*Callophrys lanoraieensis*) was last reported in 1900 and the lyre-tipped spreadwing (*Lestes unguiculatus*) in 1942. More recent records include the ringed boghaunter (*Williamsonia lintneri*) in 2000 and netted chain fern (*Woodwardia areolata*) in 1973; both are listed as endangered species in New Hampshire. The Heritage Bureau considers the kettle hole bog system an exemplary natural community. No rare species or exemplary natural communities are documented for the uplands of the Spruce Hole Conservation Area.

Wildlife Habitat Features

Wildlife need food, water, cover, and space to live and reproduce--collectively known as their *habitat.* Each species has unique habitat requirements, and the presence of a given species in an area varies depending on the availability of the habitat that they depend on. Wildlife *food resources* include aquatic and upland plants, fruits, seeds and nuts, insects and other animals, and nectar. All wildlife require *water*, almost daily, yet aquatic organisms clearly depend on it more than upland species. *Cover* provides protection from weather and predators and sites for nesting, resting, travel, and other activities.

The juxtaposition of food, water, and cover determines the wildlife community that occurs in a given area. The ability of wide-ranging animals to move across the landscape—known as wildlife connectivity—is also important. As part of one of a large unfragmented block of land in coastal New Hampshire, the Spruce Hole Conservation Area and surrounding lands provide opportunities for wide-ranging wildlife to travel across the landscape to forage, to disperse, and to find mates. This includes species that we might not expect to endure in this developing landscape, such as moose, black bear, bobcat, and fisher. These are some of the forest-dependent species that often travel long distances during the course of a year and possibly occur on this property at least sometime during the year.

Some of these habitat features that occur on the Spruce Hole Conservation Area include:

- ***Cavity trees (live and dead and dying) and other nest trees***
  More than two-dozen birds and mammals depend on tree cavities for nesting, roosting, or denning. One species, the brown creeper, nests under the loose bark on standing dead or dying trees and some bats roost beneath loose bark. These species require a range of cavity tree size classes and rely on a mix of dead or partially dead standing trees (called “snags”) as well as live trees with cavities. In addition, a mix of softwood and hardwood cavity trees will benefit more species.

  Woodpeckers, chickadees, and nuthatches are primary excavators (i.e., they make the holes), while others use existing holes. Some species require large trees for nesting. These include broad-winged hawk, red-tailed hawk, and barred owl. Typically these large hawks and owls require large trees with three-pronged branching where they can build a large stick nest. Exposed perches along forest and wetland edges are important to some wildlife species including flycatchers and hawks.

Typical cavity tree sizes (in diameter at breast height or dbh) required by various wildlife species are listed below (Bennett 2010). All of these species do occur or are likely to occur on the Spruce Hole Conservation Area.

6-8”	6-12”	12-18”
black-capped chickadee	brown creeper	great-crested flycatcher
downy woodpecker	hairy woodpecker	northern flicker
Eastern bluebird	red-breasted nuthatch	
tufted titmouse	white-breasted nuthatch	
winter wren	yellow-bellied sapsucker	
	northern flying squirrel	

>18”
barred owl
fisher
gray squirrel
porcupine
long-tailed weasel
pileated woodpecker

- ***Dead and down woody material***
  Dead and down woody material (often called “coarse woody debris”) on the forest floor is important for many reasons. Woody material in various stages of decay includes logs, stumps, branches, upturned roots, and tree falls. These provide wildlife habitat, serve as nurse logs for regenerating plants, and contribute to nutrient cycling. As with cavity trees, the larger the fallen log or stump the greater the biological diversity. Decaying wood supports many insects and other invertebrates, which are food sources for shrews, woodpeckers, and black bears. Snakes, fisher, and weasels hunt among the woody debris. Many species including mice, voles, salamanders, snakes, chipmunks, red squirrels, weasels, and black bear use coarse woody debris for cover, den sites, or escape areas. The winter wren nests in upturned tree roots. Mosses, fungi, and lichens are often associated with decaying wood.

  In places, the Spruce Hole Conservation Area has retained or accumulated coarse woody debris, either left behind as part of a logging job or blown down in a storm. Any future forest management should continue to retain this throughout the property.

- ***Hard and soft mast and other food resources***
  Fruits, nuts, and seeds from woody plants that are food for wildlife are collectively known as “mast.” *Hard mast* includes the array of nuts and seeds, which are typically high in fat, carbohydrates, and protein, a food source that is both high in energy content and available into the winter. *Soft mast* includes fruits and berries such blueberries and huckleberries, which grow on the Spruce Hole Conservation Area. Soft mast is more perishable and is often high in sugar, vitamins, and carbohydrates. These fruits are a source of moisture for wildlife during drought years, and are a crucial energy source for some migrating songbirds.

  A diversity of hard and soft mast producing trees, shrubs, and vines is important. Different mast species are available at different times of year, which is critical to wildlife. Also, some species, such as oak, only produce heavy acorn crops every 3-5 years or more, and this varies among oak species. Seed production varies with age as well. For example, peak acorn production for red oak occurs

when the trees are 19-22 inches in diameter at breast height (dbh), while white oak acorn production peaks when the trees are bigger, about 26 inches in dbh.

The major hard mast sources on the Spruce Hole Conservation Area are: acorns of red, white and black oaks, shagbark hickory nuts, hazelnuts, catkins of birches, and the seeds of white pine, pitch pine, hemlock. The conifer seeds are eaten by squirrels, grouse, chickadees, and grosbeaks. The catkins of birches (paper, black and gray) are eaten by many birds.

Cultural Features

Parking and Access

The main access point into the Spruce Hole Conservation Area is via the main gate on Packers Falls Road, on the abutting Oyster River Forest. A gravel parking area there allows for about 6 cars to be parked without blocking the gate. A kiosk with map is situated just inside the gate; however, the map focuses on the Oyster River Forest. A new map is needed that shows both properties, trails, key features, and allowed uses. The gate is locked to control access; motorized access is limited to vehicles used primarily for management and related activities. A few hundred yards to the west is a gate and woods road that leads onto the Spruce Hole Conservation Area. Parking is not available there.

Woods Roads and Trails

The gated woods road on the Spruce Hole Conservation Area leads from Packers Falls Road, to the new water line which it follows west, then it continues north along the property boundary west of the bog and then out toward Packers Falls Road. (Map 5—Appendix 1). The path cleared for the new water line usurped a segment of the old woods road.

A footpath to the Spruce Hole Bog and the National Natural Landmark monument exits from the water line/woods road. The monument is mounted on a large boulder; a short wooded fence frames the "entrance" to the monument. The relatively level footpath continues counterclockwise around the bog until it meets the woods road in the northwest corner of the Spruce Hole Conservation Area. Another footpath enters from the main north-south woods road on the Oyster River Forest (Map 5—Appendix 1). This entry point needs a small sign indicating the direction to the bog.

Other Features

There are several monitoring wells on the property related to the Spruce Hole Well. In addition, there is other well-related infrastructure on the Spruce Hole Conservation Area including the new buried water and an electrical line to serve the new well.

A barbed wire fence is located approximately along the boundary of the original 14.5-acre Spruce Hole tract (Map 5—Appendix 1). This fence was a provision in the deed from Morgan to the Town of Durham. However, that was at a time (1974) when the Morgans still owned the abutting 27.7 acres to the south. Since the town now owns that parcel as well as the lands on both sides to the east and west, the need

for a fence seems moot. I was not able to ascertain why the Morgans requested that the town build a fence.

The property boundaries are well delineated in places. Packers Falls Road forms the southern boundary. The eastern boundary with the town-owned Oyster River Forest is marked by a stonewall in places and with NRCS easement signs every 50 feet or so. The iron pipe (noted in the deed) marking the southeast corner is clearly visible. The southwest corner is marked by a concrete bound, which forms the Lee-Durham boundary.

The western and northern boundaries have no clear monuments along their lengths. Two deeds and associated surveys (see Appendix 3), one by Berquist (1974) and one by G.L. Davis (1982) show different locations for the northwest corner and a different length along the northern boundary. In 1974, the deed (and associated survey by Berquist) from Morgan to the Town of Durham shows a boundary length from the northwest corner east as 661.54 feet. In the deed (and associated survey by Davis) from Morgan to Kunkle (and then Kunkle to Colasante) that same length is 622.29 feet (see Appendices 3 and 4).

Chapter 3 Stewardship Recommendations

Land Stewardship Objectives

The purpose of this Wildlife Habitat and Land Stewardship Plan was to assess the soils, topography, plants, animals, habitats, cultural features, and landscape setting of the property as a means of guiding the stewardship activities to protect the Spruce Hole Bog and Aquifer and other conservation values.

A review of the documents related to the Spruce Hole Conservation Area provides some guidance on the primary stewardship goals for the property. The most pertinent documents are references to the uniqueness of the Spruce Hole Bog, the deeds, and the eminent domain document for the southern tract. Also, the property's proximity to the Spruce Hole Aquifer and Well highlights the importance of protecting those features.

From these guiding documents the following primary land stewardship objectives were developed:

- To protect the ecological integrity of Spruce Hole Bog
- To protect water quality of Spruce Hole Bog, Spruce Hole Aquifer and associated well, and the surface waters that flow into Chesley Brook.

General Stewardship and Monitoring

The following stewardship recommendations were developed to meet the stewardship objectives listed above based on the site capabilities and existing conditions of the Spruce Hole Conservation Area.

These recommendations are also summarized in Table 3 and shown on Map 6—Appendix 1.

- Erect a fence along or around the abutting Spruce Hole Aquifer and Well to ensure public safety and to protect the water supply and its infrastructure. This includes a fence along the boundary with the Spruce Hole Conservation Area and at the entrance to the gravel pit/well site off Packers Falls Road. In reference to protecting the Spruce Hole aquifer formation, Ballestero and Lee (2000) stated that "The best protection measure is to leave the land that overlies the formation undeveloped and restrict access to it."

- Erect small boundary signs along the property boundaries with private ownerships. This primarily includes the southwest boundary and the northern boundary.

- Periodically walk the property boundaries to maintain boundary signs, to assess stewardship needs such as invasive plant control, and ensure good relations with neighbors.

- Remove the barbed wire fence that lies along the boundary between the northern and southern Spruce Hole tracts. Check with the Town Attorney to make sure that this provision of the 1974 deed no longer needs to be maintained.

- Monitor for invasive plants and, if found, remove immediately through mechanical methods (such as hand-pulling). Especially monitor trails and disturbed areas such as the new water line and other entry points from abutting lands.

- Update the map of the property on the kiosk. Include both the Oyster River Forest (note boundary on existing map is not accurate—missing northwest corner near Oyster River) and Spruce Hole Conservation Area. Show trails, key features (e.g., bog monument), and allowed uses.

- Update information about the Spruce Hole Conservation Area on the town website including copy of Stewardship Plan, maps, and related documents.

- Consider hosting a biothon or "bioblitz" where resource professionals and lay people are invited to spend part of a day scouring the property to record all plants and animals (from spiders to mosses to other organisms, large and small) that are encountered. These are fun, educational, and informative events.

- Engage community members and other volunteers in stewardship of the property that can include trail monitoring, sign maintenance, invasive control (if plants are documented), and other volunteer workdays.

- Contact the Emeritus at Sprucewoods to assess the interest among community members for a universally accessible trail that would lead through the Oyster River Forest to the Spruce Hole Bog trail.

- Add small, appropriate signs that direct visitors to the Spruce Hole Bog.

- Consider additional land conservation if landowners are interested, especially tract abutting the Spruce Hole Conservation Area to the north.

Parking, Trails, and Public Uses

Parking:

These recommendations are included in the Oyster River Forest since the parking is on that property. They are included here as well, since this is also the access onto the Spruce Hole Conservation Area.

- Improve parking area at main gate on Oyster River Forest: add gravel and level the site to allow for angle parking on each side of the gate and to enable universal access (i.e., ADA specifications) if such a trail is developed.

- Consider adding large rocks or more metal posts to reduce opening around the gate; currently some motorized vehicles can get around the gate.

- Consider adding some signs in front of the locked gate, such as “No motorized vehicles,” “Please don’t block the gate.”

Trails

- Continue to enhance and maintain a trail network that connects to the Oyster River Forest. Maintain waterline as a trail/woods road.

- Consider developing a universally accessible trail (ADA specifications) and seek grant funding and build support among neighbors and community members. The following potential ADA trails are recommend for further study:

    - From the main gate to the Spruce Hole Bog.
    - Consider running another universally accessible trail from the main gate to the old foundation in the southeast corner. This would wind through a lovely stand of pitch pine.
    - Enhance parking area to meet ADA specifications.
    - Contact Emeritus at Sprucewoods to assess their interest in a potential universally accessible trail along the Service Road from their community into the Oyster River Forest and to the Spruce Hole Bog.

- Erect trail signs to the Spruce Hole Bog and monument.

Public Uses

- Consider changes to the town ordinance regarding hunting on town lands. The LCHIP Project Agreement requires that hunting be allowed on lands conserved with LCHIP funds. This applies to the Oyster River Forest. However, both the Oyster River Forest and the Spruce Hole Conservation Area are conducive to hunting given the relatively rural nature of the area. Hunting supports a traditional recreational activity, encourages use of local food, and helps control the deer population, thereby limiting the amount of deer browsing, which protects regenerating forests, woodland wildflowers, and shrub growth. The town might consider certain provisions such as no deer stands or no permanent deer stands, no baiting. In addition, NH Fish and Game works with towns to allow limitations on certain types of firearms (see http://www.eregulations.com/newhampshire/hunting/deer-hunting/. If a change is made to allow hunting, erect signs at key entrant points alerting visitors to hunting seasons and post information for hunters on what is allowed.

- Include information on the kiosk and trail maps that inform visitors of allowed public uses on trails: walking, snowshoeing, x-country skiing, mountain biking, but no motorized vehicles except for management purposes. No camping or fires. Consider no snowmobiles or horseback riding on the Spruce Hole Conservation Area to protect the property’s sensitive resources.

Forest/Habitat Management

The town-owned Spruce Hole Conservation Area had a recent timber harvest under the guidance of forester Charlie Moreno. Going forward, any forest management on the Spruce Hole Conservation Area and Oyster River Forest should be guided by a step-down forest management plan. A Forest Plan can reference much of the information on this Stewardship Plan, but should include a more detailed timber inventory and clear goals as to the purpose(s) of any future harvest. It should also cover both the Spruce Hole Conservation Area and the Oyster River Forest since the two properties are contiguous and have some similar forest conditions. Funds generated from forestry activities should be reinvested in the stewardship of the two properties.

The primary goals of any forest management on the Spruce Hole Conservation Area should be to:

- protect the Spruce Hole Bog
- protect the Spruce Hole Aquifer
- enhance wildlife habitat (i.e., mast crops)
- sustain the ecological characteristics of this forest type including the oak and pitch pine components.

The size, current conditions, and site capability of the Spruce Hole Conservation Area (together with the Oyster River Forest) provide opportunities for both active management and to allow some areas to be guided by natural processes, including natural disturbances and succession with no active management, except to control invasive species if found. The approximately 14-15 acres around and including the Spruce Hole Bog is recommended as an "ecological reserve" or natural area.

Specifically, the following recommendations are made related to any forest habitat management:

- Prior to any forest management, contract with a licensed forester to prepare a "step-down" plan. The Plan does not need to be a comprehensive forest management plan, but rather a silvicultural plan for the long-term management of these areas. The plan should delineate forest stands, access roads, log landings, and methods for avoiding impacts to existing woods roads and trails.

- Prior to initiating forestry treatments, systematically locate and remove all exotic, invasive plants in any proposed management area, when feasible. Currently, no invasive plants are known to occur on the Spruce Hole Conservation Area, but many are on abutting lands.

- Forest management should follow the guidelines in Good Forestry in the Granite State (Bennett 2010), with a particular emphasis on:

    - Protecting wetlands and wetland soil; follow recommended setbacks for each wetland type
    - Diversifying the vertical forest structure
    - Maintaining and managing for mature mast trees including red, white, and black oak.
    - Maintain the pitch pine component of the dry Appalachian oak forest
    - Retaining live and dead cavity trees, snags, and other large den or nest trees
    - Ensuring the retention of coarse woody debris during active harvests

- Use alternatives to petroleum-based oil, such as vegetable-based bar and chain oil to protect water resources.

- Leave the "ecological reserves" to develop through natural processes and disturbance, except to control for invasive species.

Table 3. Summary of Stewardship Recommendations for the Spruce Hole Conservation Area.

Location	Stewardship Activity	Notes
Boundaries	Annually walk property boundary	Especially boundaries with private landowners
Main gate on ORF	Update kiosk	New map, key features, allowed uses
Website	Update town website	New info on Stewardship Plan
Property-wide	Host a bioblitz	Fun, educational, informative
Property-wide	Engage community in volunteer workdays	As needed
Property-wide	Monitor for invasive plants	Especially along trails and disturbed areas
Trailheads	Add informational signs	Especially to guide visitors to the bog
Waterline	Restore/maintain as a trail	As part of route to Spruce Hole Bog
Near western boundary	Erect fence along edge of Spruce Hole Well property	To protect public safety and water supply
North of SHCA	Pursue additional land conservation with interested landowners	To protect the Spruce Hole Aquifer and Bog
Property-wide	Change town ordinance to allow hunting	Required by LCHIP funding on Oyster River Forest; Work with NHFG on hunting ordinance
Trail network	Consider a universally accessible trail from main gate on ORF to Spruce Hole Bog	Seek grant funding and community support
Southern 27 acres	Forest management plan (step-down silvicultural plan)	Work with licensed forester on future forest management
Around Spruce Hole Bog	Maintain ecological reserve/natural area	No active management, except to control invasive species

References

Ballestero, T.P., T.D. Lee, and S.D. Miller. 1995. Summary of 1994 efforts in the study of ground water near the Spruce Hole Bog. Unpublished report. University of New Hampshire and Town of Durham, NH.

Ballestero, T.P., and T.D. Lee. 2000. Final report for the hydrogeologic studies of the Spruce Hole Bog sand and Gravel Formation. University of New Hampshire, Durham, New Hampshire.

Bennett, K. P., editor. 2010. Good forestry in the Granite State: recommended voluntary forest management practices for New Hampshire (second edition). University of New Hampshire Cooperative Extension, Durham, New Hampshire.

Chandler, D. 1996. Insects and spiders. Chapter 4 *in* J. Taylor, T. Lee, and L.F. McCarthy (eds). New Hampshire's Living Legacy: The Biodiversity of the Granite State. New Hampshire Fish and Game Department, Concord, New Hampshire.

Debboun, M. 1983. An ecological study of early season mosquitoes (Diptera: Culicidae) in a New Hampshire kettle hole bog. M.S. Thesis, University of New Hampshire, Durham, NH.

Donaldson-Fortier, G.M. 1993. Oribatida (Acari) associated with three species of Sphagnum moss at Spruce Hole Bog, New Hampshire, USA. M.S. Thesis, University of New Hampshire, Durham, NH.

Emery & Garrett Groundwater, Inc. 2012. Final hydrogeologic investigation Town of Durham-University of New Hampshire groundwater development UNH/Durham production well dgd-pw2. http://www.ci.durham.nh.us/sites/default/files/fileattachments/towncouncil/spruce_hole_well_final_report_by_emery__garrett-march_2012.pdf

Miller, S.D. 1996. The vegetation and tree ring history of Spruce Hole Bog. Master's Thesis. University of New Hampshire, Durham, New Hampshire.

Mower, R. 2014. Durham, NH Conservation Commission excerpts of meeting minutes 1971 to 1989—timeline—relating to the Spruce Hole Bog and/or Spruce Hole Conservation Area.

New Hampshire Department of Agriculture. 2006. Guide to invasive upland plant species in New Hampshire. New Hampshire Department of Agriculture and New Hampshire Invasive Species Committee, Concord, New Hampshire. http://extension.unh.edu/forestry/Docs/invasive.pdf

New Hampshire Fish and Game Department. 2006. New Hampshire wildlife action plan. Concord, New Hampshire. http://www.wildlife.state.nh.us/Wildlife/wildlife.htm (2010 Map Update).

New Hampshire Natural Heritage Bureau. 2014. Report for Oyster River Forest and Spruce Hole Conservation Area. [A copy is included in Appendix E]

Oyster River Local Advisory Committee. 2014. Oyster River Management Plan. Prepared with assistance from Strafford Regional Planning Commission. Submitted to the NH Department of Environmental Resources. http://www.strafford.org/cmsAdmin/uploads/draft_oysterriver_cmp_ver1.pdf

Oyster River Watershed Association. 2014. Water quality of the Oyster River, New Hampshire, 2001-2011.
http://www.oysterriveriwp.com/pdf/ORWA%20VRAP%20WQ%20REPORT%20w%20ecoli%20v16.pdf

Oyster River Watershed Association. 2010. Oyster River nomination. Submitted to the Department of Environmental Services for designation to the New Hampshire Rivers Management and Protection Program By the Oyster River Watershed Association with Strafford Regional Planning Commission http://www.oysterriver.org/ORWA_final_submission_05272010.pdf.

Oyster River Watershed Association. 2001. Oyster River watershed management plan.
http://www.oysterriver.org/ORWA_ManagementPlanJune2001_OCR_no_maps.pdf

Sperduto, D., and B. Kimball. 2011. The nature of New Hampshire. University Press of New England, Lebanon, New Hampshire.

U.S. Census Bureau. 2010. United States 2010 census. Washington, D.C.

U.S. Department of Agriculture. 2001. Soil survey of Strafford County, New Hampshire. Natural Resource Conservation Service,
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/nh/soils/surveys/?cid=nrcs144p2_015739

Zankel, M. C., C. Copeland, P. Ingraham, J. Robinson, C. Sinott, D. Sundquist, T. Walker, and J. Alford. 2006. The Land Conservation Plan for New Hampshire's Coastal Watersheds. The Nature Conservancy, Society for the Protection of New Hampshire Forests, Rockingham Planning Commission, and Strafford Regional Planning Commission. Prepared for the New Hampshire Coastal Program and the New Hampshire Estuaries Project, Concord, New Hampshire; www.rpc-nh.org/coastal-conservation.htm